BEAK TRIMMING EFFECTS ON BEHAVIORAL PATTERNS, WEIGHT GAINS AND EGG PRODUCTION OF THREE STRAINS OF EGG-TYPE PULLETS DURING THE REARING AND FIRST EIGHTEEN-WEEK LAYING PERIODS

by

Hsu-Yuan Lee

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James V. Craig

Major Professor

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INTRODUCTION

Although both animal welfarists and producers see beak trimming as causing stress (Gentle, 1986), it is generally thought to be desirable, when properly done, for pullets that are to be kept for egg production in well-lighted housing (Consortium, 1988). Beak trimming reduces the risk of cannibalism and feather pecking (e.g., Carson, 1975; Lee and Reid, 1977; Lee, 1980). Even in the absence of cannibalism, beak trimming appears to have beneficial effects by reducing feed usage (Andrade and Carson, 1975; Lee and Reid, 1977; Blokhuis et al., 1987), improving feed efficiency (McDaniel and Brewer, 1973; Lee, 1980), reducing feather damage (Camp et al., 1955; Hughes and Michie, 1982; Denbow et al., 1984) and lowering laying house mortality (Carson, 1975; Lee and Reid, 1977). However, some studies have indicated that beak trimming depressed growth rate (Andrade and Carson, 1975) and body weight (e.g., Slinger et al., 1962; Blokhuis et al., 1987) of pullets during the rearing phase, especially within 2 to 4 weeks after beak trimming; and beak-trimmed pullets tended to lay smaller eggs (Slinger and Pepper, 1964; Andrade and Carson, 1975; Lee, 1980).

Eskeland (1981) reported that beak-trimmed White Leghorn pullets laid more eggs, had lower mortality, and had better feed conversion than pullets with intact beaks.

Also, fewer of these hens suffered the adverse effects of low social status (e.g., frightened running and being out of egg production). From measurements of corticosterone levels and organ weights, Eskeland further concluded that intact-beak pullets were under greater stress. Gleaves and Struwe (1987, and personal communication), also using corticosterone levels and organ weights as indicators of long-term stress, obtained similar results. Nevertheless, none of the studies collected information on beak trimming effects on behavioral patterns or fearfulness when different genetic strains were used.

The objectives of this study were: (a) to examine beak trimming effects on growth, behavioral patterns, and egg production during a 3-week period after beak trimming and during the first part of the laying period and (b) to determine whether beak trimming effects were consistent over three experimental stocks during the rearing and laying phases.

LITERATURE REVIEW

Effects of Beak Trimming on Growth Rate and Market Grade

Andrews and Goodwin (1969) beak-trimmed broiler chicks of 13 strains at 1 or 10 days of age, and found no difference in body weight or feed efficiency among beak-trimmed and control groups. Nevertheless, Andrews (1977), using the same technique in another study, found that an intact-beak group was heavier at 8 weeks of age than the beak-trimmed groups. No difference in feed efficiency was noted among the three groups in both studies.

In contrast, both Darrow and Stotts (1954), who trimmed the upper beaks of broilers at 3-weeks old, and Camp et al. (1955), who block debeaked broiler chicks at 1-day or 5-weeks old, reported that broiler chicks with 1/3 to 1/2 of the beak removed had equal (or better) growth rate (of males), better feed efficiency, better feather score, and higher market grade than intact-beak birds. Both Vondell and Ringrose (1957) and Harter-Dennis and Pescatore (1986) reported that beak trimming of day-old broiler chicks had either no effect or only a modest depressing effect on body weight gains and the feed utilization efficiency was improved by beak trimming.

Slinger et al. (1962) and Slinger and Pepper (1964) noted that beak trimming White Leghorn pullets at 8 weeks of age (removed 2/3 of the upper and 1/3 of the lower mandible) retarded physical development as measured by body weight at 20 weeks of age. Beane _et al_. (1967) beak-trimmed day-old commercial Leghorn chicks and got similar results on growth performance. Carson (1975) indicated that SCWL pullets beak-trimmed at the time of placement (1 or 2 days old) had significantly reduced body weight through 51 weeks of age. Lee (1980) also demonstrated that beak-trimmed SCWL pullets consumed significantly less feed and had superior feed efficiency as compared to intact-beak pullets. Blokhuis _et al_. (1987) measured body weights and total feed consumption of Warren SSL pullets of two beak forms (removed 1/3 of the beaks or not at 45 days of age) or at 17 weeks of age. The results suggested that birds with intact beaks were significantly heavier and consumed more feed than beak-trimmed birds.

Gentle _et al_. (1982) presented results indicating that removing 1/3 of the beak in adult hens caused a temporary fall in feed intake and reduced feeding efficiency (number of pecks per gram of pellets digested). Body weight was reduced also for at least 6 weeks. Deaton _et al_. (1987, 1988) demonstrated that beak trimming reduced feed intake and growth rate of both egg-strain pullets (debeaked at day-old and 70 days of age) and broiler roasters (removed various amounts of beaks at 50 days of age), especially when fed firm pellets.

For male turkeys, Denbow _et al_. (1984) found that beak trimming had no significant effect on body weight or feed efficiency. In another study, Leighton et al. (1985) indicated that 16-week body weights, feed consumption, and 8 to 16 weeks weight gains of turkey hens were all reduced in the beak-trimmed group whereas feed efficiency and live market quality were not influenced.

Effects of Beak Trimming on Egg Production

Hargreaves and Champion (1965) reported that severe beak trimming (block debeaking just in front of the nostrils) of SCWL pullets at 18 weeks of age delayed sexual maturity, reduced egg production, feed consumption, and body weight gain. However, removing 1/2 of the beaks did not cause any significant loss in egg production.

Both Beane et al. (1967) and Carson (1975) indicated that age at first egg was significantly delayed in pullets which were beak-trimmed at day-old, and no effect was noted on egg size or egg production among different beak treatments. Andrade and Carson (1975), in another study, pointed out that pullets being beak-trimmed at 12 or 16 weeks of age produced carry-over effects into the egg production period of reduced egg size and delayed sexual maturity.

Lee and Reid (1977) and Lee (1980) reported that removing 2/3 of the upper beak at day-old or at 4 or 8 weeks of age caused a reduction in egg weight and feed consumption, and an improvement in feed efficiency, but did not influence hen-day egg production and egg quality. Yannakopoulos and Tserven-Gousi (1986) found no beak trimming effect on hen-day egg production, egg weight, or egg shell quality of chickens which had part of the beaks removed at 18 days of age.

Eskeland (1977, 1981) found that removing 1/3 of the upper beak at 18 weeks of age increased the laying percentage and improved the feed efficiency of pullets significantly. But the effect of beak trimming seemed to decrease as the experiments proceeded further.

Effects of Beak Trimming on Behavioral Patterns

Gentle *et al*. (1982) noted that the feed pecking rate of beak-trimmed pullets rose sharply after beak trimming, then declined to the pre-operative value after 3 weeks. Denbow *et al*. (1984) found that beak trimming significantly increased nonagonistic feather pecking of male turkeys, but had no significant effect on feather pulling. For turkey hens, Leighton *et al*. (1985) reported that beak trimming significantly increased the frequency of both feather pecking and feather pulling at 12 and 16 weeks of age. Nevertheless, Hughes and Michie (1982) indicated that plumage damage and loss were significantly reduced in beak-trimmed pullets since the pecks were not as effective as those of intact-beak pullets.

Eskeland (1977) demonstrated that beak-trimmed pullets increased resting time significantly, and the proportion of low social rank hens was lowered. From another similar study, Eskeland (1981) found that the amount of time the beak-trimmed birds spent nesting was increased significantly, and the characteristic frightened running of low social status hens was rarely observed.

Slee, Duncan and Breward (unpublished observations reported by Gentle, 1986) noted that beak trimming reduced the frequency of feeding, ground scratching, and dust bathing activities of pullets. They also observed that the frequencies of beak-related activities, such as preening and environment pecking, decreased immediately after beak trimming and was reduced for at least 5 weeks after the operation.

In Hale's study (1948), the beak-trimmed flock showed a considerably higher agonistic pecking frequency than the control flocks, but a relatively large number of pecks by dominant hens in the debeaked flock failed to elicit any response in subordinates. Furthermore, he found no indication that beak trimming resulted in lessened social tensions.

Effects of Beak Trimming on Mortality

Andrews (1977) debeaked broiler chicks at 1 and 10 days of age (removing 1.6 to 3.2 mm, and 3.2 mm of the top beak, respectively), and found no difference in mortality among three groups. Also, Darrow and Stotts (1954) removed 1/3 to 1/2 of the upper beak at 3 weeks of age, and Harter-Dennis and Pescatore (1986) trimmed the maxilla 1.8 or 1.2 mm from the end of the nostril at day-old, did not find beak trimming effect on mortality of broilers.

Blokhuis et al. (1987) used Warren SSL pullets of two beak forms (removed 1/3 of both upper and lower beaks or not) in their study and no difference in mortality between beak treatments was noted.

Carson (1975) using SCWL pullets, which were removed 1/2 to 2/3 of the beak or not at the time of placement, found that non-debeaked controls had significantly higher mortality than debeaked pullets. Eskeland (1981) and Denbow et al. (1984) also obtained similar results in pullets which had 1/3 of the upper beak trimmed at 18 weeks of age, and in male turkeys which were trimmed at day-old, respectively. However, Leighton et al. (1985) found no difference between beak treatments in mortality of turkey hens which were trimmed at day-old.

Lee and Reid (1977) and Lee (1980), who removed 2/3 of the upper beak of SCWL chicks, and Gleaves and Struwe (1987), who removed chicks' beaks at 10-days old, suggested that beak trimming did not significantly influence mortality of pullets during the growing period, but it reduced laying house mortality significantly. Lee and Reid also indicated that day-old beak trimming effectively prevented the occurrence of cannibalism.

Genetic Effects on Pecking and Fearful Behavior and Response to Beak Trimming

Both Hughes and Duncan (1972) and Cuthbertson (1980) concluded that feather-pecking and other pecking behavior had an inherited component, which agreed with earlier findings by Richter (1954). Robinson (1979) demonstrated also that there were genetic effects on mortality due to cannibalism among the Hyline, SPB Queen, and Walsh Speedilay 251 strains used in his study.

Bray *et al.* (1960) reported that the White Rock and Rhode Island Red breeds were more sensitive to beak treatment than the White Leghorn and New Hampshire breeds in terms of decreases in egg production.

Pullets of the Y_1 and Y_2 strains differed in the level of fearfulness (nervousness and duration of immobility), feather condition score, and corticosteroid level (Craig *et al.*, 1983 and 1986). The Y_2 strain, having more fearful hens, suffered greater feather damage.

MATERIALS AND METHODS

Genetic Stocks

Chicks of three experimental White Leghorn strains, Y_1, Y_2, and the North Central Randombred (NCR), were used. The Y_1 and Y_2 stocks, selected for increased part-year egg mass (Craig et al., 1982), are moderately inbred (inbreeding coefficients of about 0.25) and differ strikingly in escape and avoidance behavior (Craig et al, 1983) and in several productivity measures (Craig and Milliken, 1989). In contrast, the NCR population, based on crosses among six commercial White Leghorn hybrids (Garwood et al., 1980), is essentially noninbred and is a different stock than that from which the Y_1 and Y_2 stocks were derived.

Rearing Phase

- Management and Environment

Four hundred and forty female chicks of each genetic stock, hatched November 21, 1987 at the Avery research Center, Kansas State University, were wing-banded, vaccinated for Marek's disease, and placed in 12 brooding-rearing pens (four pens/genetic stock) on the day they hatched.

The concrete-floor, translucent-curtain-sided brooder house was located on a North-South axis and was heated by a gas-fired brooder in each pen. Pens were 305 x 366 cm, allowing 1013 cm^2 floor space/pullet. The floor was covered with wood-shaving litter and each pen had a draft shield, two fountains and three water cups, three egg flats (filled with starter feed), and three 91-cm feeder troughs. The draft shield, fountains, and egg flats were removed when chicks were 10 days of age. Feeders were changed to three 122-cm troughs at 2 weeks and three round, 132 cm circumference tube-type feeders at 8 weeks. Therefore, feeder space/chick from hatching to 2 weeks, from 2 to 8 weeks, and after 8 weeks were 5, 6.7, and 3.6 cm/pullet, respectively. Feed, in the form of mash, and water were provided ad libitum. Special care was taken during the 4 to 7 week period to keep feed troughs approximately one-fourth to one-third full to minimize feed wastage while providing adequate depth so that beak-trimmed pullets could feed without difficulty.

Natural light entered through the curtains for different amounts of time daily because of seasonal change. Artificial lights (one 90 W bulb per pen) were on 10 h daily from 0715 until 1715 h before 12 weeks. Lights were on from 0645 until 1715 h between 12 and 15 weeks, and then from 0615 until 1715 h after 15 weeks. Lights were turned on by automatic timer 25-30 min before sunrise and off at about sunset during the observation period from 4 to 7 weeks. At 16 weeks, the lights were turned on about 15 min before sunrise and off about 75 min before sunset.

Pens along east and west walls were divided into two blocks by a central aisle (each block had six experimental pens). Within each block, three paired-pen sections were allocated randomly to the three genetic stocks. One pen of each pair was assigned randomly to be the pen for "beak-trimmed" (BT) pullets, whereas the other was for "intact-beak" (IN) pullets. Beginning when chicks were 24 days of age, beaks of BT pullets were trimmed with an electric cauterizing debeaker, which made a V-shape cut as viewed from the side. About half of the upper mandible and a little less of the lower mandible were removed. Chicks in two pens from both blocks of the same section of the house were trimmed during the same day, and BT chicks of two pens in each of the three sections were trimmed during three consecutive days. The experimental design is shown in Table 1.

- Behavioral Observations

Twelve of the 110 chicks per pen were selected randomly on the basis of their wing-band numbers and marked for observation. Alcohol-based stains were applied on chicks' backs, using four colors (red, green, purple, and black) and three patterns within each color (one stripe, two stripes, and a cross) for ease of identification. In each pen, 10 of the 12 marked chicks were observed, and the

Table 1. Experimental design for comparing genetic and beak treatment effects on chicks during the rearing phase[1]

	Beak trimmed			Intact beak			
Strain	No. pens	No. chicks per pen	No. chicks per treatment	No. pens	No. chicks per pen	No. chicks per treatment	No. chicks Total
Y_1	2	110	220	2	110	220	440
Y_2	2	109	218	2	109	218	436
NCR	2	110	220	2	110	220	440
Total	6	---	658	6	---	658	1316

[1] Chick numbers were adjusted at 4 weeks of age.

other two were kept as spares.

Two observers sat back-to-back and observed pullets within paired-pens within the same section of the house simultaneously. Each observer focused on one marked bird at a time and recorded its activity at 12-second intervals for 5 minutes (25 recordings/chick); the observer then focused attention on the bird with the corresponding marking in the adjacent pen and recorded its activity in the same way. The order of observations for each color marking was randomized for each observation period. After 20 chicks in the paired pens (10/pen) had been observed by one observer in one block, the observers switched places and repeated the same procedures a second time.

Observations were started 3 to 5 minutes after artificial lights were turned on for the day. Observation sessions were carried out 1, 7, 14, and 21 days after beaks were trimmed and at 16 weeks.

Activities recorded and their descriptions are given in Table 2. When data were processed, feeding and the non-aggressive pecking behaviors were combined into "pecks of all kinds", and standing and crouching behaviors were combined into "inactivity".

- Other Measurements

All marked chicks (12/pen) were weighed before beak treatment (whether trimmed or not) and soon after each behavioral observation (at 7, 14, and 21 days later), and at 18 weeks of age. Feed used per pen was measured weekly for 1, 2, and 3 weeks after beaks were trimmed in half of the pens.

- Statistical Analysis

The experimental design during the rearing phase was the "split-plot design" with genetic stocks as whole plot factors and beak treatments as sub-plot factors. Both genetic stock and beak treatment were assigned completely at random. Ages were the sub-plot factors under beak treatment; while times of the day were the sub-plot factors under age.

Mean frequency of each behavioral activity and means of other measurements from experimental units (pens) were used

Table 2. Activities recorded when observing behaviors of pullets during the rearing phase

Activity (Code)	Description
Feed (F)	Pecking at feed in the feed trough.
Drink (D)	Obtaining water at the cup.
Stand (S)	Standing and idle, looking about or with eyes closed.
Crouch (Cr)	Lying or sitting, breast on floor, looking about or with eyes closed, not performing any other behavior.
Preen (Pr)	Grooming own feathers with the beak while standing or crouching.
Comfort activity (Cm)	Stretching legs or wings, wing flapping, ruffling feathers, shaking, dust bathing.
Non-aggressive pecking at	
Litter (PL)	Pecking at litter (usually with intermittent scratching).
Feathers (PF)	Pecking or preening-like acts directed to another bird's feathers.
Conspecifics (PC)	Pecking at other bird's foot or shank or cleaning other bird's beak.
Inedible (PI)	Pecking at wire, trough, wall, etc.
Move (MW)	Walking, at least two successive steps.
Spar (Sp)	Apparently playful fighting movements, but without physical contact.
Frolic (Fr)	Apparently spontaneous activity or when stimulated by others; running with wings raised; may carry an object in the beak.
Agonistic acts (A)	Hard head or neck pecking, threatening, chasing, fighting, or avoiding; as either deliverer or receiver.
Cannibalistic acts (CA)	Pecking at vent, skin, muscle, or exposed internal organs.
Other (O)	Any activity not included in the list above

to test for the effects of genetic stocks, beak treatment, age, and/or time of the day by using the Analysis of Variance (ANOVA) procedure in the Statistical Analysis System (SAS, 1982). However, the behavioral results are shown in percentages (frequency/250 "scans" x 100).

The statistical model was:

$$Y_{ijklm} = u + Blk_i + S_j + e_{ij} + B_k + (S \times B)_{jk} + v_{ijk} + A_l + (S \times A)_{jl} + (B \times A)_{kl} + (S \times B \times A)_{jkl} + w_{ijkl} + T_m + (S \times T)_{jm} + (B \times T)_{km} + (S \times B \times T)_{jkm} + (A \times T)_{lm} + (S \times A \times T)_{jlm} + (B \times A \times T)_{klm} + (S \times B \times A \times T)_{jklm} + z_{ijklm}$$

where u = mean;

Blk = block (row), i = 1 or 2;

S = genetic strain, j = Y_1, Y_2, or NCR;

B = beak treatment, k = BT or IN;

A = age, l = 4, 5, 6, 7, or 16 weeks of age;

T = time of day, m = early morning or late morning;

S x B = genetic by beak treatment interaction;

S x A = genetic by age interaction;

B x A = beak treatment by age interaction;

S x B x A = genetic by beak treatment by age interaction;

S x T = genetic by time of the day interaction;

B x T = beak treatment by time of the day interaction;

S x B x T = genetic by beak treatment by time of the day interaction;

A x T = age by time of the day interaction;

S x A x T = genetic by age by time of the day interaction;

B x A x T = beak treatment by age by time of the day interaction;

S x B x A x T = genetic by beak treatment by age by time of the day interaction;

e_{ij} = error term used to test genetic effect;

v_{ijk} = error term used to test beak effect and genetic by beak interaction;

w_{ijkl} = error term used to test age effect and the interactions involving age; and

z_{ijklm} = error term used to test the effect of time of the day and the interactions involving time effect.

When multiple comparisons were involved and significance was indicated, differences among treatment means were tested by Fisher's Least Significant Difference procedure (LSD).

Non-aggressive pecking (except litter pecking), running, flying, sparring, frolicking, agonistic acts, and cannibalistic acts occurred so rarely that they were not normally distributed. Therefore, they were not analyzed.

Laying Phase - Cages

- Management and Environment

Ninety-six pullets of each genetic stock by beak treatment combination were transferred to a curtain-sided, natural-ventilated laying house and weighed individually at 18 weeks of age (Mar 29, 30, and 31, 1989, for Y_1, Y_2, and NCR strains, respectively). Four rows of cages with 24 cages per row, had a feeder trough along the front of the cages and watering cups shared between cages. Cages were 50.8 cm wide and 45.7 cm deep in a back-to-back, two-level, stair-like arrangement. Each cage received six pullets from the same rearing pen and allowed 387 cm^2 floor space and 8.47 cm feeder space per bird. All pullets were given badges on left wings with the cage number on one side, and a letter A, B, C, D, E, or F on the other side, for ease of identification. Four adjacent-pair cages per row were distributed randomly for each genetic stock, with different beak forms randomly assigned to each of the paired cages. Only the cages in rows 1, 2, and 3 were experimental units, while pullets in row 4 were used to supply replacement birds. The experimental design is shown in Table 3.

Feed was provided ad libitum in the form of mash. Water was obtained when a pullet's beak depressed a trigger-release mechanism within water cups. Artificial lights were on from 0600 until 2000 h daily. Dead birds were taken out and the causes of death were recorded (if known) daily. In experimental cages (rows 1, 2, and 3), dead birds were replaced by pullets of the same treatment from row 4 cages between 19 and 25 weeks of age. Vacancies in cages of replacement pullets were then filled by pullets of the same treatment combination from floor pens to maintain the density and environment. Birds from floor pens were not used as replacements after being moved to cages. Replacement of birds dying was stopped at 25 weeks of age due to the shortage of spare pullets.

Table 3. Experimental design for comparing genetic and beak treatment effects on pullets in cages during the laying phase

	Beak trimmed			Intact beak			
Strain	No. cages per row	No. pullets per cage	No. pullets per treatment[1]	No. cages per row	No. pullets per cage	No. pullets per treatment[1]	No. chicks Total
Y_1	4	6	72	4	6	72	144
Y_2	4	6	72	4	6	72	144
NCR	4	6	72	4	6	72	144
Total	12	---	216	12	---	216	432

[1] Three rows of cages were used for experimental pullets.

- Egg Production

The number of eggs laid was recorded on 3 consecutive days weekly for three 6-week periods, from 19 to 37 weeks of age. Because of replacement of birds dying during the first 6-week period, there were typically 18 hen days for each cage for the 3-day weekly egg collection recording when pullets were 19-25 weeks of age. This constraint alters the meaning of the terms hen-day rate of lay and hen-housed rate of lay relative to the commonly used definitions applied when replacement is not used. Hen-day egg production (rate of lay), age at maturity (estimated by age in week when 50% hen-day egg production was reached), and hen-housed egg production were calculated. Egg weights were measured during the fourth week of each period by bulk weighing of one or two days' eggs from each cage. Egg masses were calculated for each period by multiplying egg weight by hen-housed egg production.

- Behavioral Observations

At 24 weeks of age, 4 days before behavioral observations began, pullets with badges marked A, B, or C were painted across the back with an alcohol-based red, green, or purple stain, respectively, for ease of identification.

The observer sat in front of the division between paired cages, waited until all of the birds appeared to return to normal activities, then observed the pullets using a scanning technique. Behaviors of the marked pullets (3/cage) in the paired cages were scanned and the activity of each individual was recorded at 20 seconds intervals over a 6-minute period (54 recordings/cage). The order of observations for each color marking was fixed as red, green, and purple, for ease of scanning; while the order of observation for each row was assigned randomly. Observations were done over three consecutive days, with one row of pullets being observed per day.

Activities recorded and their descriptions are given in Table 4. When processing data, feeding and the non-aggressive pecking behaviors were combined into "pecks of all kinds", while standing, crouching, and looking behaviors were combined into "inactivity". Frequencies of each activity per cage were used to test for genetic and beak treatment effects. However, the results are presented in percentages (frequency/54 "scans" x 100).

-Other Measurements

At 21 and 22 weeks of age, all birds in experimental cages were scored twice for nervousness, using a modified scoring procedure based on Hansen's descriptions (Hansen, 1976), Table 5. The observer repeated the procedure for each pair of cages by moving to face the division between adjacent paired cages and then scored the paired cages simultaneously. The order of testing within rows of cages was allocated randomly. Mean scores of the two Hansen's tests were used for analysis.

Table 4. Activities, codes, and descriptions recorded when observing behaviors of pullets in cages during the laying phase

Activity (Code)	Description
Feed (F)	Pecking at feed in the feed trough.
Drink (D)	Obtaining water at the cup.
Stand (S)	Standing and idle, looking about or with eyes closed.
Crouch (Cr)	Lying or sitting, breast on floor, looking about or with eyes closed, not performing any other behavior.
Look (L)	Looking down to the floor, searching-like.
Preen (Pr)	Grooming own feathers with the beak while standing or crouching.
Comfort activity (Cm)	Stretching legs or wings, wing flapping, ruffling feathers, shaking.
Non-aggressive pecking at	
Feathers (PF)	Pecking or preening-like acts directed to another bird's feathers.
Conspecifics (PC)	Pecking at other bird's foot or shank or cleaning other bird's beak.
Inedible (PI)	Pecking at wire, trough, etc.
Move (M)	Walking, crawling, jumping, etc.
Agonistic acts (A)	Hard head or neck pecking, threatening; as either deliverer or receiver.
Cannibalistic acts (CA)	Pecking at vent, skin, muscle, or exposed internal organs.
Other (O)	Any activity not included in those listed above.

Table 5. Hansen's modified score for nervousness

Procedure	Description
1	The observer raises both arms from the sides to above the head.
2	Keep the arms so that they do not extend beyond the width of the cages being tested.
3	Lower the hands slowly (within 5 seconds).
4	Place the hands across the feed trough at 1/4 the distance from each end.
5	Assign scores based on the descriptions given below at the end of 10 seconds from the time of first movement to completion. Average the score of the six birds.

Score	Description
0	Calm, no nervous or evasive action.
1	Slightly nervous, mild evasive action, but no flightiness.
2	Moderately nervous, considerable evasive action with some flightiness.
3	Very nervous, persistent evasive action with flightiness and some squawking.
4	Hysterical episode with birds wildly flying about, squawking and trying to hide, continuing full 10 seconds.

After nervousness scores were obtained, at both 21 and 22 weeks of age, feather scores were measured by using the method described by Adams et al. (1978). Pullets without feather damage were scored 9, and those with bare backs and wings were scored 1. The intermediate levels of feather loss and damage were scored by integers between 9 and 1. Means of the two feather scores, on a cage basis, were used for analysis.

Duration of induced tonic immobility was measured between 22 and 23 weeks of age. Three out of four cages per treatment combination per row were selected randomly to use for testing. One bird from each selected cage, a pullet which had never been replaced, was brought to an isolated room and immobilization was induced. The process is described in Table 6. The frequency distributions for durations (seconds) of induced tonic immobility were skewed. Therefore, data were transformed into logarithms based on 10 and were analyzed to test for genetic and beak treatment effects.

Hen-days of survival were calculated on a cage basis for the second and third 6-week laying periods, with 6 birds per cage present initially and no replacement of those dying was provided. Body weights of marked birds (badges A, B, and C) were obtained individually at 24 weeks of age.

- Statistical Analysis

The experimental design for the caged pullets during the laying phase was a "split-plot design" with genetic stocks as whole plot factors and beak treatments as sub-plot factors. Four randomly distributed whole plots within

Table 6. Procedures used to determine duration of induced tonic immobility

Procedure	Description
1	Handle the bird carefully, and take it into an isolated room that is novel for it.
2	Lay the bird on its back on a Y-shape frame which is covered with a black cloth.
3	Restrain the bird's movement by holding its head and breast for 15 seconds.
4	Remove the hands and wait for 10 seconds to make sure the bird is immobilized, then start the stop-watch.
5	Stop the watch when the bird turns over and stands on its feet.
6	Record the duration of immobilization before standing.

each row were assigned to each of the three strains and beak treatments were located randomly within each whole plot.

The Analysis of Variance (ANOVA) procedure in the Statistical Analysis System (SAS, 1982) was used to test for genetic and beak treatment effects of each trait. The statistical model used to analyze body weight, egg production (excluding period effects), behaviors, nervousness score, feather score, and tonic immobility was:

$$Y_{ijkh} = u + Blk_i + S_j + e_{ijh} + B_k + (S \times B)_{jk} + v_{ijkh}$$

where u = mean;

Blk = block (row), i = 1 to 3;

S = genetic stock, j = Y_1, Y_2, or NCR;

B = beak treatment, k = BT or IN;

S x B = genetic by beak treatment interaction;

$_h$ = hth replication in the row;

e_{ijh} = error term used to test genetic effect; and

v_{ijkh} = error term used to test beak treatment effect and genetic stock by beak treatment interaction.

Drinking, crouching, preening, comfort activity, non-aggressive pecking, agonistic acts and cannibalistic acts were recorded so rarely that they were not normally distributed. Therefore, chi-square analyses were conducted to test for effects on those traits except Cm, PC, PI, A, and CA activities because of too many zero readings. Chi-square analyses were used also to test for genetic and beak treatment effects on mortality and on hen days of survival.

The statistical model used to analyze effects on egg production (including period effects) was:

$$Y_{ijklh} = u + Blk_i + S_j + e_{ijh} + B_k + (S \times B)_{jk} + v_{ijkh} + P_l + (S \times P)_{jl} + (B \times P)_{kl} + (S \times B \times P)_{jkl} + w_{ijklh}$$

where, in addition to previously defined terms,

P = period, l = 1 to 3;

S x P = genetic by period interaction;

B x P = beak treatment by period interaction;

S x B x P = genetic by beak treatment by period interaction; and

w_{ijklh} = error term used to test period (age) effect and interactions involving period effect.

When multiple comparisons were involved and significance was indicated, differences among treatment means were tested by Fisher's Least Significant Difference (LSD) procedure.

Laying Phase - Floor Pens

- Management and Environment

One hundred pullets of each genetic stock by beak treatment combination were transferred to a curtain-sided, fan-ventilated laying house and weighed individually at 18 weeks of age. The middle six pens in each of five rows, received 20 experimental pullets per pen, while the other pens received spare pullets and were left as "buffers', Table 7.

Table 7. Experimental design for comparing genetic and beak treatment effects on pullets in floor pens during the laying phase

	Beak trimmed			Intact beak			
Strain	No. pens per row	No. pullets per pen	No. pullets per treatment[1]	No. pens per row	No. pullets per pen	No. pullets per treatment[1]	No. chicks Total
Y_1	1	20	100	1	20	100	200
Y_2	1	20	100	1	20	100	200
NCR	1	20	100	1	20	100	200
Total	3	--	300	3	--	300	600

[1] Five rows of floor pens were used.

Two randomly distributed, paired pens per row were used for each genetic stock, with different beak forms randomly assigned to each of the paired pens. Pullets that had their backs marked during the rearing phase (12 birds per rearing pen), were separated equally into two laying pens. Each laying pen was 152.4 cm wide and 228.6 cm long and allowed 1742 cm^2 floor space for each bird. Twelve nests in three levels were located on one side of each pen. A round tube-type feeder, of 132 cm circumference, and an automatic watering cup, of 16.6 cm diameter, were placed in the front part of the pen. There was 6.6 cm feeder space for each pullet. Feed, in the form of mash, and water were provided _ad libitum_. Artificial lights were on from 0600 until 2000 h daily.

All pullets were given badges with identification numbers on right wings when housed. Dead birds were taken out and the causes of death (if known) were recorded daily. No replacements were provided in laying pens.

- Egg Production

The number of eggs laid was recorded on three consecutive days weekly from 19 to 25 weeks of age. Hen-day egg production (rate of lay) was estimated from weekly egg records. Age of maturity was calculated from the age (weeks) when 50% hen-day egg production was reached on a pen basis. Hen-housed egg production was based on data collected on pullets from 19 to 25 weeks of age. Egg weights were obtained at 22 weeks of age by bulk weighing of one or two days' eggs from each pen. Egg mass was calculated by multiplying egg weight by hen-housed egg production.

- Behavioral Observations

At 25 weeks of age, 4 days before behavioral observations, six pullets of each pen, which had stains on their backs, were repainted with purple, red, or green marks for ease of observation. The observer sat in front of the division between two paired pens and waited until all birds returned to normal activities before recording. With a fixed order of observation for color markings, the observer scanned the marked pullets within each of the two adjacent pens alternately and recorded their activities every 60 seconds for 6 minute (6 recordings per pullet; 36 recordings per pen). The procedure was applied to all experimental pens and repeated for three consecutive days, while the order of observation for each row was assigned randomly. Activities recorded and their descriptions are given in Table 8. When processing data, litter pecking and other non-aggressive pecks were analyzed separately, feeding and the non-aggressive pecking behaviors were combined into "pecks of all kinds", and standing, crouching, and roosting behaviors were combined into "inactivity". Frequencies of each activity per pen were used to test for genetic and beak treatment effects. However, the results are presented in percentages (frequency/108 "scans" x 100).

Table 8. Activities recorded when observing behaviors of pullets in floor pens during the laying phase

Activity (Code)	Description
Feed (F)	Pecking at feed in the feed trough.
Drink (D)	Obtaining water at the cup.
Stand (S)	Standing and idle, looking about or with eyes closed.
Crouch (Cr)	Lying or sitting, breast on floor, looking about or with eyes closed, not performing any other behavior.
Preen (Pr)	Grooming own feathers with the beak while standing or crouching.
Comfort activity (Cm)	Stretching legs or wings, wing flapping, ruffling feathers, shaking, dust bathing.
Non-aggressive pecking at	
Litter (PL)	Pecking at litter (usually with intermittent scratching).
Feathers (PF)	Pecking or preening-like acts directed to another bird's feathers.
Conspecifics (PC)	Pecking at other bird's foot or shank or cleaning other bird's beak.
Inedible (PI)	Pecking at wire, trough, wall, etc.
Move (MW)	Walking, at least two successive steps.
Agonistic acts (A)	Hard head or neck pecking, threatening, chasing, fighting, or avoiding; as either deliverer or receiver.
Cannibalistic acts (CA)	Pecking at vent, skin, muscle, or exposed internal organs.
Nest (N)	Any activity performed in the nest.
Roost (R)	Any activity performing on roost or on perch (in front of nest).
Other (O)	Any activity not included in those listed above.

Agonistic interactions of pullets in two rows of laying pens were observed and recorded three times when they were 28 weeks of age. Activities recorded and their descriptions are given in Table 9. The observer spent 10 minutes in front of each pen and recorded the frequency of each agonistic activity by using 5 counters which represented each of the 5 kinds of agonistic interactions. The order of observation within rows and between rows were completely random. Total frequency of each activity, on a pen basis, was used to test for genetic and beak treatment effects.

Table 9. Activities recorded when observing agonistic behaviors of pullets in floor pens during the laying phase

Activity (Code)	Description
Fight (F)	Fighting, involving two or more birds.
Peck with avoidance (P/A)	Aggressive peck with avoidance shown by the other pullet.
Chase with avoidance (Ch/A)	One pullet chasing another, usually following aggressive pecking or fighting.
Threat with avoidance (Th/A)	One pullet raising the head and showing threatening behavior with submissive behavior performed by the other pullet.
Avoidance (A)	Performing avoidance or submissive behavior without obvious aggressive behavior of the bird avoided.

- Other Measurements

Body weights of marked pullets, i.e., six birds of each pen, were obtained on individuals at 24 weeks of age.

Duration of tonic immobility was measured when pullets were 23 weeks of age. Two birds of each experimental pen, which were selected by badge number, were used in this test. The process is described in Table 6. The durations (seconds) were then transformed into logarithms based on 10 and the average of each pen was used to analyze for genetic and beak treatment effects.

- Statistical Analysis

The experimental design for floor-pen pullets during the laying phase was the "split-plot design" with genetic stocks as whole plot factors and beak treatments as sub-plot factors. The whole plots (adjacent-pair pens) were randomly assigned to the three genetic stocks and beak treatments were located randomly within each whole plot.

The Analysis of Variance (ANOVA) procedure in the Statistical Analysis System (SAS, 1982) was used to test for genetic and beak treatment effects of each trait. The statistical model used to analyze effects on body weight, egg production, general behaviors, agonistic behaviors, and tonic immobility was:

$$Y_{ijk} = u + Blk_i + S_j + e_{ij} + B_k + (S \times B)_{jk} + v_{ijk}$$

where u = mean;

Blk = block (row), i = 1 to 5;

S = genetic stock, j = Y_1, Y_2, or NCR;

B = beak treatment, k = BT or IN;

S x B = genetic by beak treatment interaction;

e_{ij} = error term used to test genetic effect; and

v_{ijk} = error term used to test beak treatment effect and genetic stock by beak treatment interaction.

Comfort activity, non-aggressive pecking, nesting, agonistic behaviors and cannibalistic acts were recorded so rarely that they were not normally distributed. Therefore, they were not analyzed.

When multiple comparisons were involved and significance was indicated, differences among treatment means were tested by Fisher's Least Significant Difference (LSD) procedure.

RESULTS

Rearing Phase

- Behavior

Effects of beak treatments, genetic strains, time periods, and ages on percentages of time spent in different behavioral activities are presented in Table 10. After beak trimming, BT birds were less active than those with intact beaks (35.8 vs. 25.8% inactivity); both standing and crouching were more common for BT than for IN pullets (24.5 vs. 17.7 and 11.3 vs. 8.1%, respectively). BT birds exhibited more comfort activity (1.4 vs. 0.8%), but performed less pecking of all kinds (42.5 vs. 52.9%). Beak treatment had no significant overall effect on frequency of feeding, litter pecking, drinking, preening, and moving. However, BT birds spent only 75% as much time as IN birds in feeding behavior (P=.09), Figure 1.

Genetic effects were detected as significant for feeding, litter pecking, and comfort activity; Y_2 pullets pecked more at feed but less at litter and exhibited less comfort activity than the other two strains, Figure 2.

During the early morning, pullets were more active in litter pecking, pecking of all kinds, standing and moving, but crouched and preened less and exhibited less total inactivity than in the late morning (28.0 vs. 33.6%), Figure 3.

Table 10. Effects of beak treatment, strain, time of the day and age on percentage of each behavioral activity for pullets at 4, 5, 6, 7, and 16 weeks of age

Comparison	Feed	Peck at litter	Pecks of all kinds	Drink	Stand
Beak form					
Trimmed (BT)	26.3	12.5	42.5	3.1	24.5
Intact (IN)	35.3	14.4	52.9	3.7	17.7
BT - IN	-9.0^{+}	-1.9	-10.4*	-.6	6.8*
Strain					
Y_1	29.4^{ab}	15.5^{a}	49.1	3.1	18.3
Y_2	36.6^{a}	9.7^{b}	49.1	3.6	21.1
NCR	26.5^{b}	15.2^{a}	44.9	3.6	23.9
Time					
Early morning	31.2	15.5	50.2	3.7	22.7
Late morning	30.4	11.4	45.2	3.1	19.5
E - L	.8	4.1***	5.0*	.6	3.2*
Age, wk					
4	38.1^{a}	13.9	55.5^{a}	2.6^{bc}	12.5^{c}
5	30.9^{b}	13.0	47.1^{b}	3.4^{bc}	18.6^{b}
6	32.1^{ab}	12.1	48.8^{b}	5.2^{a}	22.0^{b}
7	34.5^{ab}	13.2	50.6^{ab}	3.9^{ab}	18.3^{b}
16	18.5^{c}	15.1	36.5^{c}	2.1^{c}	34.0^{a}
Interactions[1]					
Beak x Strain					
Beak x Time				*	
Beak x Age	**	**			*
Strain x Time				*	
Strain x Age			*		
Time x Age				*	

Table 10. (Continued)

Comparison	Crouch	Inact-ivity	Preen	Comfort acts	Move
Beak form					
Trimmed (BT)	11.3	35.8	8.3	1.4	8.0
Intact (IN)	8.1	25.8	8.3	0.8	7.5
BT - IN	3.2**	10.0**	.0	.6**	.5
Strain					
Y_1	10.6	28.9	9.1	1.5^{a}	7.2
Y_2	9.2	30.3	7.4	0.8^{b}	8.0
NCR	9.4	33.3	8.3	1.0^{ab}	8.1
Time					
Early morning (E)	5.3	28.0	7.4	1.1	8.5
Late morning (L)	14.1	33.6	9.1	1.1	7.0
E - L	-8.8***	-5.6**	-1.7*	.0	1.5**
Age, wk					
4	13.2^{a}	25.8^{b}	6.7^{b}	0.9	7.7^{abc}
5	11.2^{ab}	29.8^{b}	8.0^{ab}	1.5	8.3^{ab}
6	6.5^{b}	28.5^{b}	6.5^{b}	1.0	9.1^{a}
7	10.4^{ab}	28.6^{b}	7.7^{b}	1.2	7.1^{bc}
16	7.3^{b}	41.4^{a}	11.8^{a}	0.8	6.7^{c}
Interactions[1]					
Beak x Strain				*	
Beak x Time	+				
Beak x Age		*			**
Strain x Time			*		
Strain x Age	+	+			*
Time x Age					

[1] No second order or higher interactions were present.

a,b,c Different letters indicate significant differences (P<.05).

+, P<.10; *, P<.05; **, P<.01; ***, P<.001.

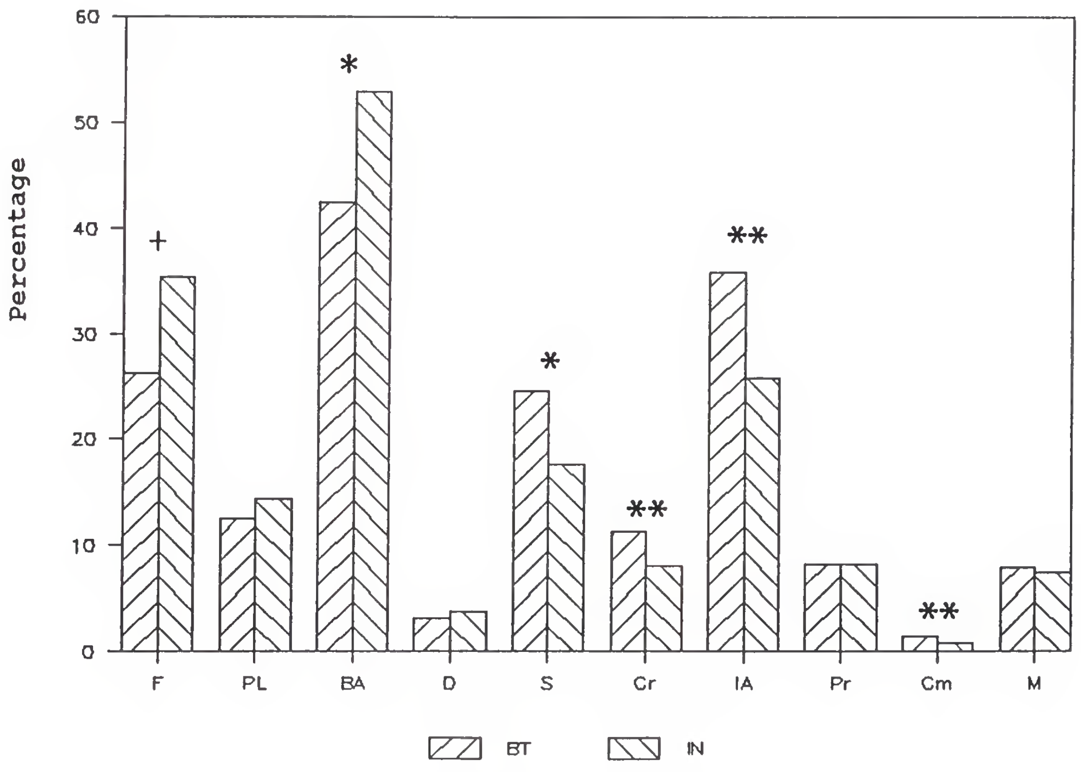

Figure 1. Percentage of time spent in each activity of pullets during rearing phase - beak treatment effect

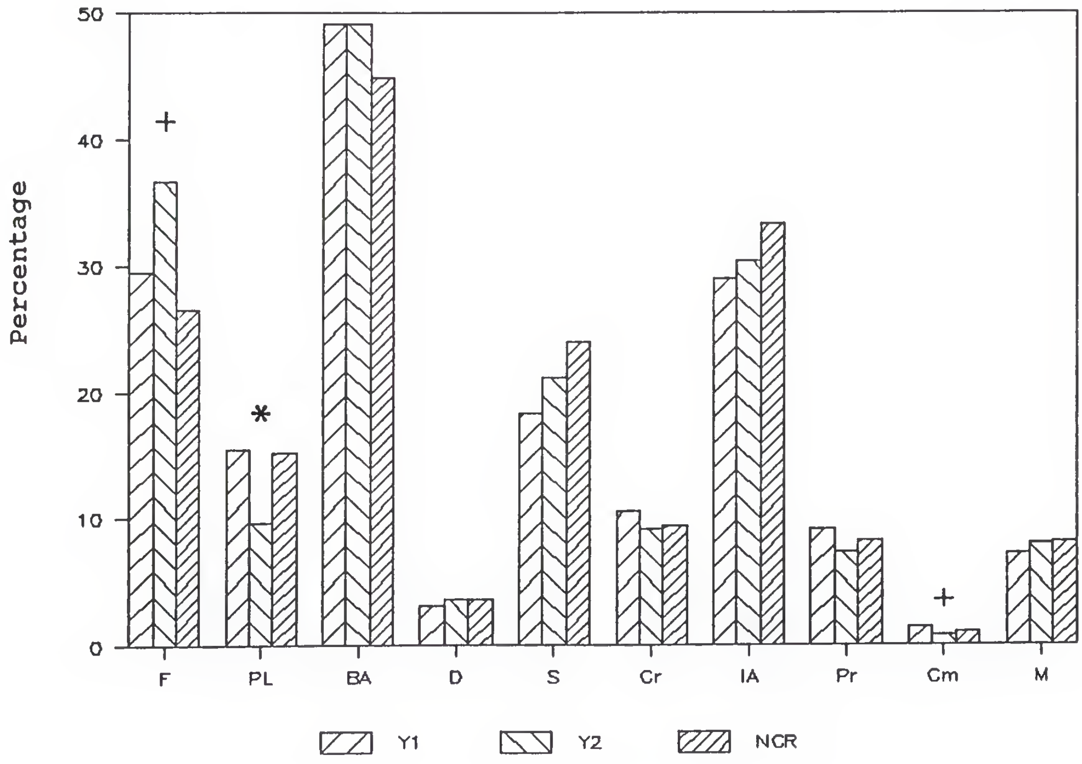

Figure 2. Percentage of time spent in each activity of pullets during rearing phase - genetic effect

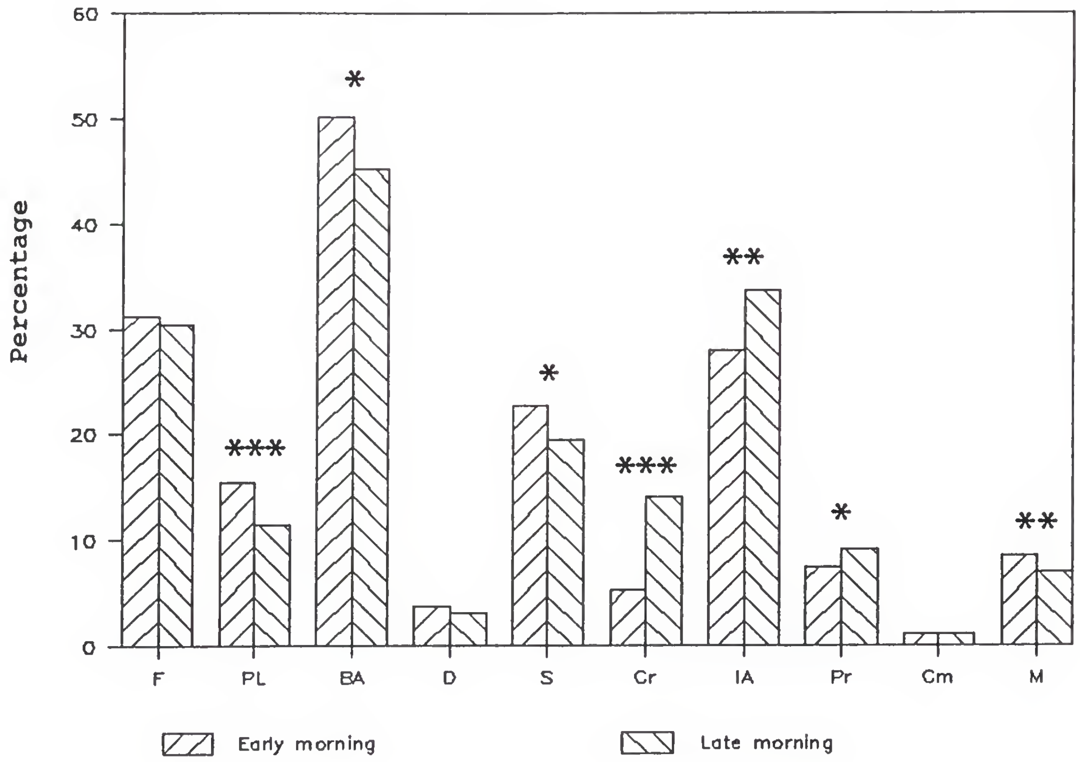

Figure 3. Percentage of time spent in each activity of pullets during rearing phase - time effect

As pullets grew older, the percentages of time spent in feeding, pecking of all kinds, and crouching generally decreased, whereas the amount of time spent in standing, inactivity, and preening increased. Time spent drinking and moving increased from 4 to 6 weeks, then decreased, Figure 4.

- Performance traits

Effects of beak treatment, genetic strains, and ages on body weight, weight gain, feed usage, and feed/gain ratio, from 4 to 7 weeks of age, are shown in Table 11. During the first 3 weeks after beak treatment, birds with intact beaks used more feed than those with trimmed beaks (42.4 vs. 37.1 g/d). No significant differences were detected in body weight, weight gain or feed/gain ratio, but BT pullets gained only 90% as much weight as IN pullets (P=.07). No genetic strain effects were found for body weight, weight gain, feed usage, and feed/gain ratio during the 4 to 7 weeks period. Body weight, weight gain, feed usage, and feed/gain ratio (feed required per unit of weight gain) all increased with age.

- Interactions

There were beak treatment by age interactions in feeding, litter pecking, standing, inactivity, and moving behaviors (Table 10), and in body weight, weight gain, and feed/gain ratio (Table 11). Because of these interactions, beak treatment effects were analyzed within ages, with the

Table 11. Effects of beak treatment, strain and age on body weights, weight gain, feed intake, and feed/gain ratio of pullets from 4 to 7 weeks of age

Comparison	Body weight (g)	Weight gain (g)	Feed usage (g/d)	Feed/gain ratio (g/g)
Beak form				
Trimmed (BT)	355	83.3	37.1	3.14
Intact (IN)	376	92.6	42.4	3.19
BT - IN	-21	-9.3^{+}	-5.3*	-.05
Strain				
Y_1	361	87.0	40.5	3.24
Y_2	353	88.1	38.9	3.08
NCR	382	88.8	39.9	3.18
Age (wk)				
4	239^{d}			
5	313^{c}	73.8^{b}	30.6^{c}	2.96^{b}
6	407^{b}	93.9^{a}	41.2^{b}	3.07^{b}
7	503^{a}	96.3^{a}	47.5^{a}	3.47^{a}
Interactions				
Beak x Strain				
Beak x Age	**	***		**
Strain x Age		+		*
B x S x A				+

a,b,c,d Different letters indicate significant differences (P<.05).

+, P<.10; *, P<.05; **, P<.01; ***, P<.001.

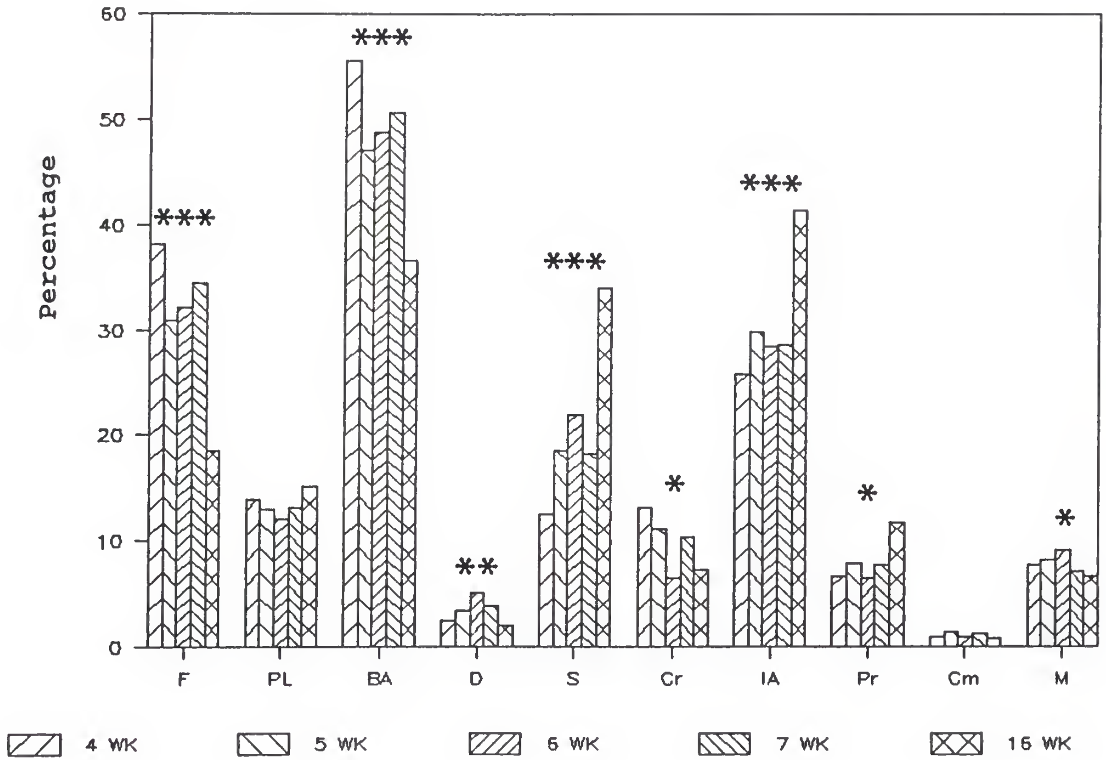

Figure 4. Percentage of time spent in each activity of pullets during rearing phase - age effect

results shown in Table 12. The only significant difference in feeding frequency occurred 1 week after beak trimming, when BT birds spent only about 53% as much time as IN birds in feeding. Effects of ages on standing behavior of pullets with the two beak forms were similar to that on feeding, i.e., the largest effect occurred 1 week after trimming.

BT birds performed less litter pecking (8.8 vs. 19%) and moving behavior (6.1 vs. 9.3%) than IN birds did on the first day after beak treatment (Table 12). No other significant difference appeared in moving behavior after that. However, BT birds also showed less litter pecking (12.3 vs. 17.8%) than IN birds at 16 weeks of age.

Frequencies of inactivity were higher in BT pullets than in IN pullets at 4, 5, 6, and 7 weeks of age (higher by 46, 76, 65, and 42%, respectively), but no difference was evident at 16 weeks of age.

IN pullets gained 35% more body weight than BT pullets during the first week after beak trimming, but no significant differences occurred thereafter (Table 13). No significant differences were found in within-age analyses between beak forms in body weight and feed/gain ratio during 4 to 7 weeks of age, although body weights of trimmed-beak birds were less by 24 to 30 g at 5, 6, and 7 weeks of age. Eighteen-week body weights were essentially identical for pullets with trimmed and intact beaks.

Table 12. Treatment combination means for activities in which beak treatment interacted with age

Activity	Age, wk	Beak form: Trimmed (BT)	Beak form: Intact (IN)	BT - IN
Feed, %	4	40.9	35.3	5.6
	5	21.3	40.4	-19.1*
	6	22.0	42.1	-20.1
	7	28.5	40.5	-12.0
	16	18.7	18.3	.4
Stand, %	4	12.3	12.7	-.4
	5	25.0	12.2	12.8**
	6	27.6	16.5	11.1*
	7	22.2	14.4	7.8*
	16	35.5	32.5	3.0
Peck at litter, %	4	8.8	19.0	-10.2**
	5	14.3	11.7	2.6
	6	12.9	11.3	1.6
	7	14.3	12.2	2.1
	16	12.3	17.8	-5.5*
Move, %	4	6.1	9.3	-3.2**
	5	8.5	8.0	.5
	6	9.4	8.7	.7
	7	8.1	6.2	1.9
	16	7.9	5.5	2.4
Inactivity, %	4	30.6	20.9	9.7*
	5	37.9	21.6	16.3*
	6	35.4	21.5	13.9*
	7	33.6	23.7	9.9**
	16	41.7	41.0	.7

*, P<.05; **, P<.01.

Table 13. Treatment combination means for performance traits in which beak treatment interacted with age

Trait	Age,wk	Beak form: Trimmed(BT)	Beak form: Intact(IN)	BT - IN
Body weight,g	4	238	240	-2
	5	301	325	-24
	6	394	420	-26
	7	488	518	-30
	18[1]	1277	1274	3
Weight gain,g	4-5	62.7	84.8	-22.1*
	5-6	92.8	95.0	-2.2
	6-7	94.5	98.0	-3.5
Feed/gain ratio, g/g	4-5	3.14	2.77	.37
	5-6	2.96	3.19	-.23
	6-7	3.32	3.62	-.30+

[1] Body weights at 18 weeks of age were analyzed separately.

+, P<.10; *, P<.05.

Table 14. Treatment combination means (% of time) for drinking activity in which time of day interacted with beak treatment and age

	Time: Early morning	Time: Late morning	E - L
Beak form			
Trimmed (BT)	3.9	2.3	1.6*
Intact (IN)	3.6	3.9	-.3
BT - IN	.3	-1.6*	
Age (wk)			
4	3.4	1.8	1.6*
5	3.8	2.9	.9
6	5.4	5.1	.3
7	4.9	2.9	2.0+
16	1.3	2.9	-1.6*

+, P<.10; *, P<.05.

The strain by age interactions, which occurred in moving, pecking of all kinds, and feed/gain ratio, showed no apparent trend with age within each trait. There were strain by time of day interactions in drinking and preening behaviors, which indicated that genetic stocks behaved differently in these two behaviors at different times of the day.

Drinking was the only activity that had both beak treatment by time of day and age by time of day interactions (Table 14). In the early morning, BT and IN pullets spent almost the same amount of time in drinking. However, in the late morning, BT pullets spent only 59% as much time in drinking as IN pullets. Chicks drank more in the early morning (3.4 vs 1.8%) than in the late morning at 4 weeks of age, but the trend was reversed at 16 weeks of age (1.3 vs. 2.9%).

Only comfort activity was detected as having a strain by beak treatment interaction, but it was probably of little importance because of the low frequency with which comfort activity occurred.

Mortality was very low (1.9%) from four to 18 weeks and did not differ between intact-beak and beak-trimmed pullets.

Laying Phase - Cages

- Egg Production

Genetic, beak treatment, and age effects on egg production during the three 6-week laying periods are shown in Table 15. No differences were found for ages of maturity, hen-day egg production, or egg weights between the two beak treatments. However, BT pullets had higher hen-housed egg production (63.1 vs. 54.6%) and greater egg mass (30.8 vs. 26.8 g) than IN pullets.

Genetic stocks differed in hen-housed egg production rates and egg weights only. The Y_2 strain had a higher hen-housed egg production rate (13% more), but a smaller egg size (3% less) than the other strains.

The period (age) effect appeared in every repeated measure. Pullets in period 2 (25 to 31 weeks) had the highest hen-day and hen-housed egg production rates and the highest egg mass among the three periods. Egg size in period 1 (19 to 25 weeks) was smaller than that in either period 2 or period 3 (31 to 37 weeks), while no difference was found between egg weights of period 2 and period 3.

- Behavior

Neither genetic nor beak treatment effects were found on general behavior patterns, except for looking and drinking behaviors which had significant beak treatment effects, Tables 16 and 17. BT pullets performed more looking behavior ($P<.01$) and drank less ($P<.05$) than IN

Table 15. Effects of beak form, strain, and period on egg production of caged pullets during three 6-week periods

Comparison	Age at 50% prod. (wk)	H-D prod. (%)	H-H prod. (%)	Egg wt. (g)	Egg mass (g/d)
Beak form					
Trimmed(BT)	21.2	71.8	63.1	48.7	30.8
Intact(IN)	21.1	69.8	54.6	49.0	26.8
BT - IN	.1	2.0	6.5***	-.3	4.0**
Strain					
Y_1	21.0	67.8	56.6^b	49.5^a	28.1
Y_2	21.2	73.2	63.7^a	47.8^b	30.7
NCR	21.4	71.5	56.3^b	49.2^a	27.8
Period, wk					
19 to 25		72.4^b	52.8^b	45.9^b	24.2^c
25 to 31		74.2^a	69.5^a	50.4^a	35.0^a
31 to 37		65.9^c	54.3^b	50.2^a	27.3^b
Interactions					
Beak x Strain					
Beak x Period		*	**		**
Strain x Period		***	***		**
B x S x P		**	+	+	

^{a,b,c} Different letters indicate significant differences (P<.05).

$^+$, P<.10; *, P<.05; **, P<.01; ***, P<.001.

Table 16. Effects of strain and beak form on percentage of time spent in frequently occurring activities of caged pullets

Activity	Strain			Beak form		
	Y_1	Y_2	NCR	BT	IN	BT-IN
Feeding	15.3	21.1	19.0	15.2	21.7	-6.5^{+}
Standing	50.2	47.0	47.2	49.1	47.2	1.9
Looking	6.5	4.4	6.1	7.5	3.9	3.6^{**}
Moving	3.7	5.2	3.6	4.3	4.1	.2
Pecks of all kinds	21.9	25.2	25.4	22.5	25.8	-3.3
Inactivity	62.9	57.3	59.7	62.8	57.2	5.6^{+}

$^{+}$, $P<.10$; **, $P<.01$.

Table 17. Statistical significance of infrequently occurring activities of caged pullets classified by strain and beak form and tested by Chi-Square

Activity	Factor	Significant level
Drinking	Strain	N.S.
	Beak form	P<.05[1]
Crouching	Strain	N.S.
	Beak form	N.S.
Preening	Strain	N.S.
	Beak form	N.S.
Feather pecking	Strain	N.S.
	Beak form	N.S.

[1] BT pullets < IN pullets.

pullets. Although of borderline significance, BT pullets appeared to spend less time in feeding (15.2 vs. 21.7%, P<.06), and had more inactive time (62.8 vs. 57.2%, P<.07) than IN pullets, Figures 5 and 6.

- Mortality

Beak trimming had a very highly significant effect, overall, in reducing the incidence of cannibalism when evaluated on a cage basis, Table 18. Eleven of 36 cages holding BT pullets (31%) had at least one pullet dead per cage from cannibalism whereas cannibalism occurred in 29 of 36 cages holding IN pullets (81%).

When genetic stocks were tested by pooling data from both BT and IN pullet cages, no genetic effect was detected. However, effects of beak treatment varied greatly among strains. Thus, in comparisons of cages holding BT and IN pullets, carried out within strains, indicated very highly significant and significant effects for the Y_1s and Y_2s, respectively, but no significant effect within the NCR strain.

Data on individual pullet mortality from cannibalism and hen-days survival per cage were analyzed within IN pullets only. Those results, presented in Table 19, indicated that Y_2 strain pullets had the least mortality (21 vs. 59 and 49 deaths for Y_2, Y_1 and NCR pullets, respectively, P<.10). Hen-days of survival per cage were

Table 18. Effects of strain and beak form on numbers of cages (and %) with one or more pullets dying because of cannibalism from 19 to 37 weeks of age

Strain	Beak form: Trimmed	Beak form: Intact	Difference between beak forms	Strain Average[1]
Y_1	3[2] (25%)	11 (92%)	***	14 (58%)
Y_2	2 (17%)	8 (67%)	*	10 (42%)
NCR	6 (50%)	10 (83%)	NS	16 (67%)
Totals	11 (31%)	29 (81%)	***	40 (56%)

[1] Differences among strains were not significant. (.10<P<.05).

[2] Each strain-beak form combination was represented in 12 cages.

*, P<.05; ***, P<.001; NS, not significant.

Table 19. Genetic effect on number of deaths and hen-day survival of intact-beak pullets in cages

	Strain: Y_1	Strain: Y_2	Strain: NCR	Difference
No. of pullets deaths[1]	59	21	49	+
Hen-day survival/cage[2]	358	448	356	*

[1] Number of deaths from 19 to 37 weeks of age.

[2] Counted from 24 to 37 weeks of age, 6 pullets/cage were present at 24 weeks.

+, P<.10; *, P<.05.

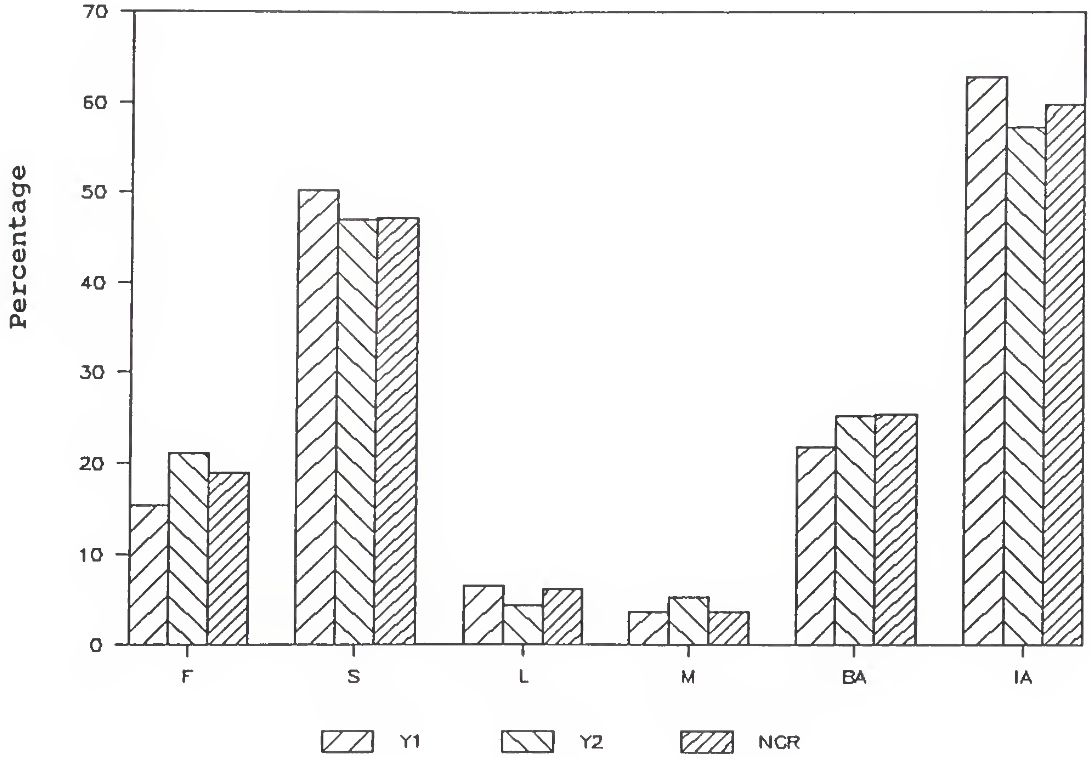

Figure 5. Percentage of time spent in frequently occurred activity of caged pullets during laying phase - genetic effect

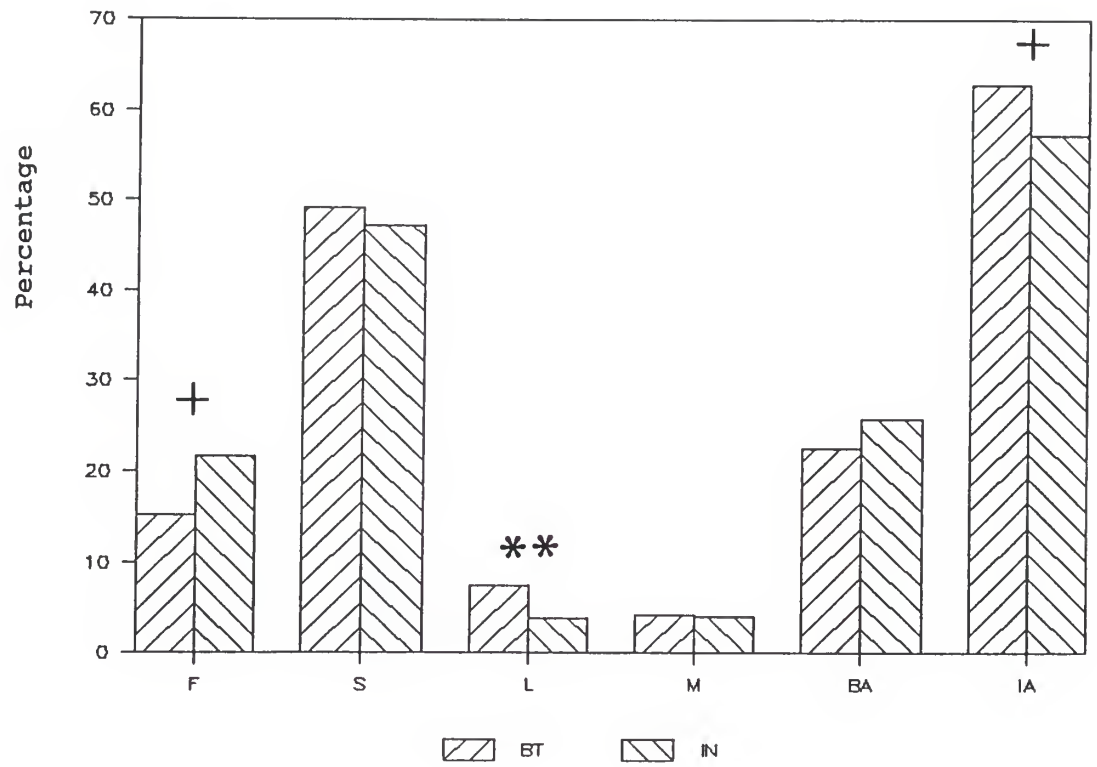

Figure 6. Percentage of time spent in frequently occurred activity of caged pullets during laying phase - beak treatment effect

448, 358, and 356 for Y_2, Y_1, and NCR pullets, respectively ($P<.05$).

- Other Measurements

Effects of genetic strain and beak treatment on body weight, weight gain, nervousness score, feather score, and duration of tonic immobility of pullets in laying cages are shown in Table 20.

Although IN pullets did not differ from BT pullets in 24-week-old body weights, nevertheless, IN pullets gained significantly more weight from 18 to 24 weeks of age (205 vs. 166 g, $P<.05$). There were significant genetic effects on 24-week body weight and on weight gain from 18 to 24 weeks of age.

The results of Hansen's scores for nervousness and feather condition scores indicated that BT pullets were significantly less nervous (scored 0.88 vs. 1.22 for BT and IN pullets, respectively), and had better feather condition scores than IN pullets (8.26 vs 8.08) by 4 weeks after being moved to laying cages. Genetic strains differed in these two traits also. The NCR pullets were the most nervous strain and had the poorest feather condition scores. Both the nervousness and feather condition scores of Y_1 pullets were intermediate between those of Y_2 and NCR pullets.

There were no genetic or beak treatment effects found

Table 20. Genetic and beak treatment effects on body weight, weight gain, nervousness score, feather score, and duration of induced tonic immobility of pullets in laying cages

Trait	Strain			Beak form		
	Y_1	Y_2	NCR	BT	IN	BT-IN
Body weight, g (24 weeks)	1386^{c}	1481^{b}	1532^{a}	1458	1474	-16
Weight gain, g (18-24 weeks)	138^{b}	268^{a}	151^{b}	166	205	-39*
Nervousness score	1.06^{ab}	0.73^{b}	1.35^{a}	0.88	1.22	-0.34**
Feather score	8.21^{b}	8.42^{a}	7.90^{c}	8.26	8.08	0.18*
Duration of induced tonic immobility $\log_{10}$ (sec)	2.32	2.41	2.55	2.44	2.41	0.03
(seconds)	(209)	(257)	(355)	(275)	(257)	(18)

a,b,c Different letters indicate significant differences among genetic strains (P<.05).

*, P<.05; **, P<.01.

on duration of induced tonic immobility between 21 and 22 weeks of age.

- Interactions

Genetic strain by beak treatment interactions were absent for all egg production traits, Table 15. However, both beak treatment by period and genetic strain by period interactions were present for hen-day, hen-housed egg production, and daily egg mass. Differences between the beak treatments of those production traits were all small and nonsignificant in period 1, Table 21. However, hen-housed egg production and daily egg mass of BT pullets were significantly higher than IN pullets in periods 2 and 3.

Although Y_2 strain pullets had non-significantly lower hen-day and hen-housed egg production and significantly smaller daily egg mass than Y_1 and NCR pullets in period 1, they performed best among the three strains in periods 2 and 3.

There was a genetic strain by beak treatment interaction (P=.06) on weight gain of 18 to 24-week-old pullets, Table 22. NCR pullets which had their beaks trimmed, gained only 51% as much weight as IN pullets of the same strain (P<.05). However, beak trimming had nonsignificant effects on weight gain in the Y_1 and Y_2 strains, where BT pullets gained 99% and 94% as much weight as IN pullets during the same six-week period.

Table 21. Treatment combination means for traits in which period interacted with beak treatment or genetic strains

Trait	Period	Strain Y_1	Strain Y_2	Strain NCR	Beak form BT	Beak form IN	BT-IN
Hen-day prod., %	1	73.6	71.3	72.2	72.6	72.2	.4
	2	69.1^{b}	78.4^{a}	75.1^{ab}	76.0	72.4	3.6
	3	60.6^{b}	70.0^{a}	67.2^{ab}	67.0	64.8	2.2
Hen-housed prod., %	1	57.0	51.1	50.4	53.6	52.1	1.5
	2	63.7^{b}	75.4^{a}	69.5^{ab}	74.4	64.6	9.8**
	3	49.2^{b}	64.6^{a}	49.1^{b}	61.4	47.2	14.2**
Egg mass, g	1	26.5^{a}	22.8^{b}	23.4^{ab}	24.6	23.9	.7
	2	32.6^{b}	37.2^{a}	35.2^{ab}	37.3	32.7	4.6*
	3	25.2^{b}	31.9^{a}	24.7^{b}	30.6	23.9	6.7**

*, P<.05; **, P<.01.

a,b Different letters indicate significant differences (P<.05).

Table 22. Treatment combination means for traits in which beak treatment interacted with strains

Trait	Strain	Beak form Trimmed(BT)	Beak form Intact(IN)	BT - IN
Weight gain, g (18-24 wk)	Y_1	137	139	-2
	Y_2	259	276	-17
	NCR	102	201	-99*

*, P<.05

Laying Phase - Floor Pens

- Egg Production

Genetic strain and beak treatment effects on egg production traits of pullets from 19 to 25 weeks of age are shown in Table 23. BT pullets matured earlier (21.1 vs. 21.5 weeks of age, P<.05), had higher rate of lay (79.1 vs. 74.8%, P=.05), higher hen-housed egg production (57.5 vs. 50.6%, P<.01), heavier eggs (45.0 vs. 44.4 g, P=.05), and greater egg mass (25.9 vs. 22.5 g, P<.01) than IN pullets.

Birds of the Y_1 strain matured earlier and had a lower hen-day egg production rate for the 6-week laying period than did pullets of the other strains. However, because of their earlier maturity, Y_1 pullets had a higher hen-housed egg production rate (56.0%) than either Y_2 (53.7%) or NCR (52.5%) pullets.

- Behavior

Genetic and beak treatment effects on general activities are shown in Table 24. Only feeding, standing behavior, and inactivity had beak treatment effects. BT pullets spent less time in feeding (14.6 vs. 19.3%, P=.07), exhibited more standing behavior (23.1 vs. 16.2%), and were significantly less active (42.8 vs. 31.5%) than IN pullets, Figure 7.

Genetic strains differed in percentages of time in feeding, crouching, non-aggressive pecking, and pecking of

Table 23. Effects of strain and beak form on egg production of floor-pen pullets within 6 weeks after housing

	Strain			Beak form			
Trait	Y_1	Y_2	NCR	BT	IN	BT-IN	SxB[1]
Age at 50% prod. (weeks)	20.8^b	21.6^a	21.6^a	21.1	21.5	-.4*	**
Hen-day prod. (%)	73.7^b	81.2^a	75.9^{ab}	79.1	74.8	4.3*	*
Hen-housed prod.(%)	56.0^a	53.7^{ab}	52.5^b	57.5	50.6	6.9**	**
Egg weight (g)	44.8	44.1	45.2	45.0	44.4	.6*	
Egg mass (g)	25.1	23.7	22.7	25.9	22.5	3.4**	*

[1] Significance level of strain by beak treatment interactions.

[a,b] Different letters indicate significant differences among genetic strains (P<.05).

+, P<.10; *, P<.05; **, P<.01.

Table 24. Effects of strain and beak form on percentage of time spent in major activities of floor pen pullets

Activity	Strain			Beak form		
	Y_1	Y_2	NCR	BT	IN	BT-IN
Feeding	10.8[b]	26.0[a]	13.9[b]	14.6	19.3	-4.7+
Drinking	2.0	2.6	2.1	1.8	2.7	-.9
Standing	18.2	18.6	22.0	23.1	16.2	6.9*
Crouching	3.0[b]	4.4[ab]	9.9[a]	6.2	5.3	.9
Preening	4.2	3.6	4.7	4.1	4.2	-.1
Moving	13.2	11.9	11.1	12.5	11.7	.8
Roosting	15.0	10.0	10.3	13.5	10.1	3.4
Litter pecking	17.2	11.4	13.3	14.0	14.0	.0
Non-aggressive pecking	2.4[b]	3.4[a]	2.7[ab]	2.9	2.8	.1
Pecks of all kinds	30.5[b]	40.8[a]	29.9[b]	31.5	36.0	-4.5
Inactivity	36.2	33.0	42.2	42.8	31.5	11.3***

+, P<.10; *, P<.05; ***, P<.001.

a,b Different letters indicate significant differences among genetic strains (P<.05).

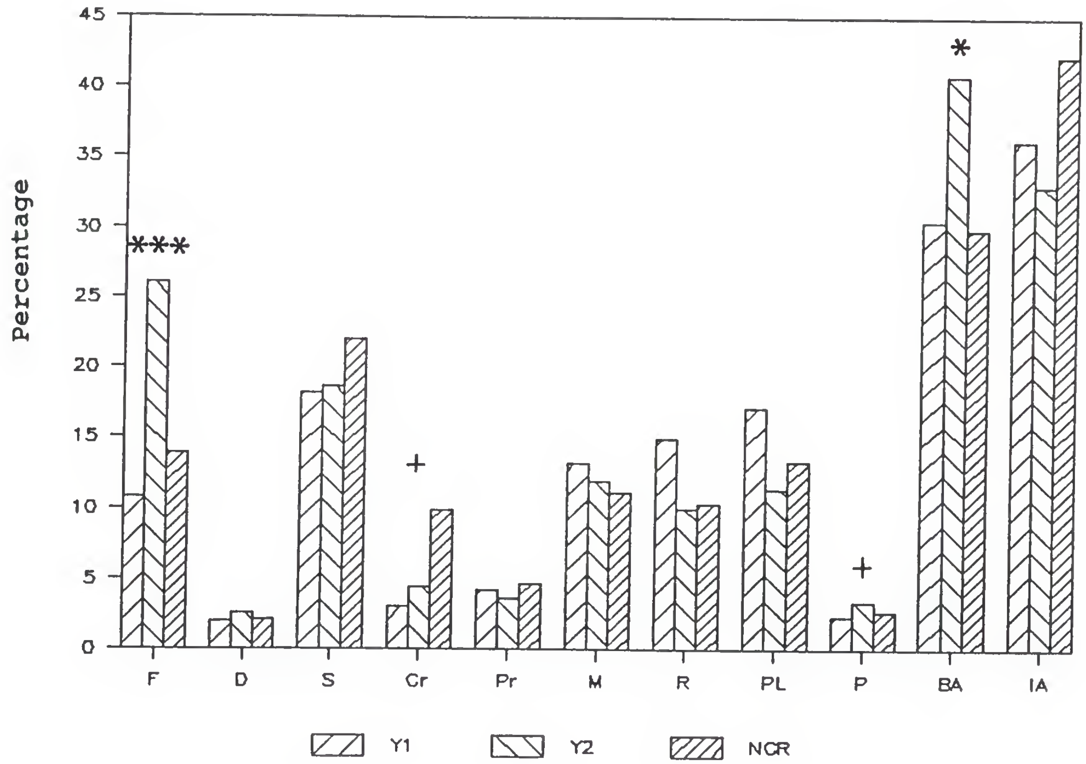

Figure 7. Percentage of time spent in each activity of floor-pen pullets during laying phase - genetic effect

all kinds. Y_2 pullets spent more time in feeding, non-aggressive pecking, and pecking of all kinds; while NCR pullets performed more crouching behavior than the others, Figure 8.

Neither genetic nor beak treatment effects were found for agonistic behavior at 28 weeks of age, Table 25.

- Other Measurements

BT and IN pullets were not statistically different in 24-week-old body weights and weight gains from 18 to 24 weeks of age, although IN pullets were heavier (1483 vs. 1456 g) and gained more weight (206 vs. 176 g) than BT pullets, Table 26.

Genetic strains differed in both body weights and weight gains. Y_1 pullets weighed the lightest among genetic strains at 24 weeks of age (1386 vs. 1483 and 1539 g), while Y_2 pullets gained more weight (263 vs. 141 and 169 g) than the others from 18 to 24 weeks of age.

Duration of induced tonic immobility of IN pullets was 100 seconds longer than for BT pullets ($P<.05$). However, no difference was found for this measurement among genetic strains.

Since the mortality of floor pen pullets was only 1.3% during the 6-week laying period, mortality data were not analyzed.

Table 25. Effects of strain and beak form on frequencies of agonistic interactions of floor pen pullets

Activity	Strain Y_1	Strain Y_2	Strain NCR	Beak form BT	Beak form IN	BT-IN
Peck/Avoid	12.8[1]	14.8	9.0	14.0	10.3	3.7
Chase/Avoid	3.8	1.8	1.0	2.5	1.8	.7
Threat/Avoid	7.8	13.3	5.3	6.2	11.3	-5.1
Avoid	6.3	5.3	3.3	3.5	6.3	-2.8
Total	30.5	35.0	19.0	26.3	30.0	-3.7

[1] Based on three 10-minute recordings for each pen observed.

Table 26. Genetic and beak treatment effects on body weight, weight gain, and duration of induced tonic immobility of pullets in laying pens

Trait	Strain Y_1	Strain Y_2	Strain NCR	Beak form BT	Beak form IN	BT-IN	SxB[1]
Body weight, g (24 wk)	1386[b]	1483[a]	1539[a]	1456	1483	-27	**
Weight gain, g (18-24 wk)	141[b]	263[a]	169[b]	176	206	-30	**
Duration of tonic immobility $\log_{10}$ (sec)	2.36	2.31	2.34	2.26	2.45	-.19*	
(seconds)	(229)	(204)	(219)	(182)	(282)	(-100)	

[1] Significance level of strain by beak treatment interactions.

[a,b] Different letters indicate significant differences (P<.05).

*, P<.05; **, P<.01.

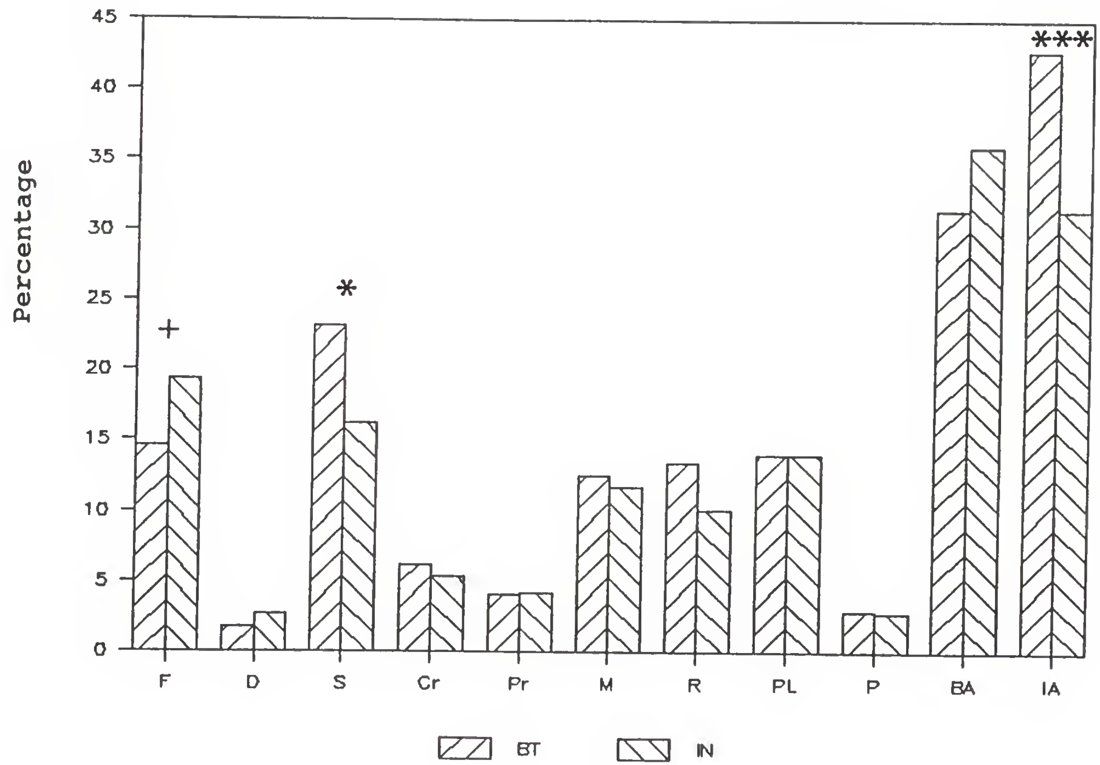

Figure 8. Percentage of time spent in each activity of floor-pens pullets during laying phase - beak treatment effect

- **Interactions**

Genetic strain by beak treatment interactions were found for age at maturity, hen-day and hen-housed egg production, and egg mass (Table 23), body weight at 24 weeks of age, and weight gain from 18 to 24 weeks of age (Table 26).

Beak treatment had no significant effect on egg production and performance traits for Y_1 pullets, Table 27. However, BT Y_2 pullets had hen-housed egg production and daily egg mass that were significantly greater than for IN Y_2 pullets, amounting to 56.1 vs. 51.2% and 25.0 vs. 22.4 g, respectively. Differences between BT and IN pullets of the NCR strain were all large and significant. Thus, BT pullets of the NCR strain matured 1.2 weeks earlier, had higher hen-day and hen-housed egg production rates (82.3 vs. 69.4%, and 60.9 vs. 44.0%), greater daily egg mass (27.6 vs. 19.8 g), but lighter body weight (1474 vs. 1605 g) and less weight gain (97 vs. 240 g) than did IN pullets.

Table 27. Treatment combination means for traits in which beak treatment interacted with genetic strain of floor pen pullets

Trait	Strain	Beak form: Trimmed(BT)	Beak form: Intact(IN)	BT-IN
Age of 50% prod. (week)	Y_1	21.0	20.6	.4
	Y_2	21.4	21.8	-.4
	NCR	21.0	22.2	-1.2**
Hen-day prod. (%)	Y_1	74.8	72.6	2.2
	Y_2	80.0	82.3	-2.3
	NCR	82.3	69.4	12.9*
Hen-housed prod. (%)	Y_1	55.4	56.6	-1.2
	Y_2	56.1	51.2	4.9*
	NCR	60.9	44.0	16.9**
Egg mass (g)	Y_1	25.1	25.1	.0
	Y_2	25.0	22.4	2.6**
	NCR	27.6	19.8	7.8*
BW at 24 week (g)	Y_1	1419	1353	66
	Y_2	1475	1490	-15
	NCR	1474	1605	-131*
Weight gain 18-24 week (g)	Y_1	154	128	26
	Y_2	275	251	24
	NCR	97	240	-143*

*, P<.05; **, P<.01.

DISCUSSION

Rearing Phase

Beak trimming significantly changed the behavioral patterns of chicks during the rearing phase. Birds with trimmed beaks were more inactive (39% more), performed more comfort related activities (75% more), and spent less time using their beaks (20% less) than IN pullets did. Eskeland (1981) found that hens whose beaks had been trimmed at 18 weeks of age had increased resting time, which is in agreement with our finding that chicks with beaks trimmed were less active. Preening behavior was not reduced in BT pullets of this study, which also agrees with Eskeland's results (1981).

Surprisingly, there was no significant difference in feeding behavior between pullets of the two beak treatments on the day after beak trimming, and, in fact, BT birds had a little higher feeding frequency than IN birds. Gentle et al. (1982) had a similar result from a small-scale study and suggested that birds with half of their upper beak removed had considerable mechanical difficulty in ingesting feed pellets immediately after beak trimming. At 1 week after beak trimming, BT birds spent only about 53% as much time as IN birds did in feeding. The large difference in time spent pecking at feed continued in the next 2 weeks (BT birds pecked at feed 52 and 70% as much as IN birds, respectively) but differences in weeks 6 and 7 were not significant. There was no suggestion of a difference in feeding activity at 16 weeks of age.

Beak trimming significantly reduced litter pecking and moving behavior on the day after the operation. BT pullets pecked less at litter (46% as much as IN) and made fewer movements (66% as much as IN) on the day after beak trimming. No differences in these two activities were found later, except that BT pullets performed less litter pecking at 16 weeks of age. Time spent in pecking at feed in the trough was not reduced significantly on the day after beak trimming, but decreased dramatically during the next three observations (7, 14, and 21 days after trimming). The litter pecking and feeding results, taken together, suggest that pain was present in the stumps of beak-trimmed pullets for at least the first 7 days. Blokhuis and van der Haar (1989) also observed reduced "ground pecking' following removal of one-third of the beak during the rearing period.

The effect of beak trimming on standing behavior was essentially opposite to that of feeding behavior. BT pullets spent twice as much time in inactive standing at 1 week after beak trimming, and the difference lasted to 7 weeks of age but gradually decreased, with no difference found at 16 weeks of age. Although no significant difference was detected in standing on the day after beak trimming, BT pullets were significantly more inactive than IN pullets, when standing and crouching data were pooled. Gentle (1986) suggested that the significant increase in resting behavior in trimmed-beak birds was similar to the inactivity following injury seen in both human beings and animals as reported by Wall (1979).

Although BT pullets spent less time feeding (25% less) and used less feed (12% less) than IN pullets during the 3-week period after beak trimming, the weight gains of BT birds were not statistically different, except during the first week following beak trimming. From non-measured behavioral observations, it appeared that birds with intact beaks were more likely to waste feed by scratching at feed in the troughs, jumping into and out of feeder troughs, and by tossing feed out of the trough. These observations may explain why IN pullets used more feed but did not gain more except from 4 to 5 weeks of age. Harter-Dennis and Pescatore (1986), Lee and Reid (1977), and Blokhuis et al. (1987) also suspected that part of the lower feed/gain ratio in BT birds was caused by lower feed wastage, though no quantitative measurements were made.

Few behavioral and performance differences were found between the genetic stocks tested in this experiment, and beak trimming effects were generally consistent among the genetic stocks. Several behaviors were affected by time of the day. For example, more pecks of all kinds and more standing and moving occurred in the early morning (0730-0930 h) whereas more crouching and preening were noticed in the late morning (0930-1130 h).

Laying Phase - Cages

In this study, caged pullets with half of their upper and slightly less of their lower beak removed at 4 weeks of age had significantly higher hen-housed egg production (16% higher) and daily egg mass (15% higher) than those of IN pullets from 19 to 37 weeks of age, while no differences were found in age of sexual maturity, hen-housed egg production, or egg weight. Other studies of beak-trimming effects on egg production traits have yielded somewhat inconsistent results, presumably because of differences in amount of beak removed, age when the procedure was done, and other unidentified variables, e.g., genetic stock used.

Hargreaves and Champion (1965) indicated that pullets with their beaks trimmed severely at 18 weeks of age had delayed sexual maturity and reduced egg production; however, pullets with beaks trimmed moderately (1/2) did not have any loss in egg production. Carson (1975), reported that sexual maturity was delayed in pullets which were beak trimmed at day-old, but no effect was noted on egg production. Lee and Reid (1977) found that removing 2/3 of the upper beak at day-old caused a reduction in egg weight, but had no effect on rate of lay. However, Morgan (1957) noted that New Hampshire pullets beak-trimmed at day-old (removed 1/3 to 1/2 of the beak) laid more eggs than intact-beak birds, and Eskeland (1977, 1981) using White Leghorns beak-trimmed at 18 weeks of age (removed 1/3 of the upper beak) increased the laying percentage also.

There were no beak trimming effects on egg production traits in period 1 when replacements for pullets which died were provided. However, hen-housed egg production and daily egg mass of BT pullets were significantly higher than IN pullets in period 2 (15% and 14% higher) and in period 3 (30% and 28% higher) when no replacements were provided. The results suggest that the high laying house mortality of IN pullets played an important role in those significant differences in periods 2 and 3 because the numbers of pullets present have an important effect on hen-housed egg production and daily egg mass.

The amount of beak trimming practiced reduced the incidence of mortality due to cannibalism significantly; 29 of 36 cages holding IN pullets (81%) had at least one bird dying of cannibalism as compared with 11 of 36 cages holding BT pullets (31%). Carson (1975) and Eskeland (1981) also found that non-debeaked controls had significantly higher mortality than beak-trimmed pullets during the laying phase.

Among the genetic strains used in this study, trimming beaks reduced the incidence of cannibalism more effectively in the Y_1 (reduced 73%, $P<.001$) and Y_2 (reduced 75%, $P<.05$) strain pullets than in NCR pullets (reduced 40%, non-significant). Even without beak trimming, Y_2 pullets had significantly longer hen-day survival than the other pullets. Hughes and Duncan (1972) and Robinson (1979) also indicated that differences existed among egg-type stocks in mortality from cannibalistic pecking when intact-beak pullets were kept in multiple-hen cages.

Ninety-seven percent of the deaths of caged pullets was caused by cannibalism in this study, and vent-cloacal pecking was the primary region involved (139 out of 159 dead, 87.4%). Differences in mortality between this and other studies could have resulted because of the different experimental stocks used or other unidentified environmental factors.

Wennrich (1974) pointed out that feather pecking and cannibalistic pecking were different from aggressive pecking. Blokhuis and Arkes (1984) suggested that feather pecking, which usually initiates cannibalistic pecking, originated as misdirected food pecking, and Blokhuis and van der Haar (1989) indicated that feather pecking should be consider as redirected ground pecking. Besides, Allen and Perry (1975) noted that one death from cannibalism was frequently followed by more in the same cage. My impression is that birds "learn" to deliver cannibalistic pecks from a cagemate who delivers the first cannibalistic peck, and perhaps also from the sight and sound associated with cannibalistic pecking of pullets in adjacent cages. Although the first occurrence of cannibalistic pecking may occur by chance, the taste of meat and blood obtained by pecking becomes a reward of this activity. Thus, cannibalism may spread in the layer house, after it first occurs.

BT pullets drank less and spent more time looking at the floor (92% more). Also, there were borderline significant differences in feeding behavior and inactivity; BT pullets spent less time feeding (30% less), but had more time in inactivity (10% more) than IN pullets. Eskeland (1977) also obtained similar results in terms of inactivity (resting time) in adult hens.

While BT and IN pullets did not differ in 24-week body weight, BT pullets gained significantly less weight (19% less) from 18 to 24 weeks of age. The difference in weight gain between the two beak treatments might be due to the non-significantly lower feeding frequency and higher egg production of BT pullets.

BT pullets were significantly less nervous in the present study and had better feather condition scores than IN pullets when kept in laying cages. Hughes and Michie (1982) also demonstrated that feather condition was significantly improved in BT pullets and were of the opinion that this was associated with reduced feather pecking. Nevertheless, no difference in feather pecking behavior between the two beak forms was found in this study. An additional possibility from the results of this study is that greater feather loss among IN pullets may have also resulted from their greater nervous behavior. However, in this study, no difference was found between BT and IN pullets in the duration of induced tonic immobility, which is another indication of fearful response.

In addition to beak treatment effects, genetic differences were found in egg weight, hen-housed egg production, body weight, weight gain, nervousness score, and feather score of pullets in cages. It is of special interest that although the stocks tested differed in many ways, no genetic strain by beak treatment interactions were detected for the egg production traits and general behavioral patterns measured in the caged pullets. Therefore, beak trimming effects were consistent for most traits among the genetic stocks used with the important exception of beak treatment effect on cannibalistic pecking and associated mortality.

Laying Phase - Floor Pens

For pullets in floor pens, beak trimming appeared to accelerate sexual maturity by 0.4 week, increased hen-day and hen-housed egg production (6% and 14% higher than IN birds, respectively), enlarged egg size (0.6 g heavier), and increased daily egg mass (15% more) during 19 to 25 weeks of age.

Because mortality of floor-pen pullets was very low (1.3%), the better egg production of BT pullets may have resulted largely from behavioral differences which reduced stress because of reduced activity and reduced fearful responses. BT pullets in floor pens were more inactive than IN pullets (36% more), and spent 43% more time in inactive standing. This result agrees with Eskeland's finding (1977 and 1981). There was a difference in frequency of feeding behavior between the two beak treatments ($P=.07$) indicating that BT birds spent only 76% as much time as IN birds in feeding, which is consistent with the results obtained with caged pullets. The duration of induced tonic immobility of IN pullets was 100 seconds longer than BT pullets ($P<.05$), which suggests that IN pullets were more fearful because of greater social tension than BT pullets. No other difference in behavior of floor-pen (BT and IN) pullets was detected. Blokhuis and van der Haar (1989) noted that the reduction of "ground pecking" following removal of one-third of the beak during the rearing period, which was also present in this experiment, was no longer present during the laying period in their floor-pen pullets, and that was also the situation in this study.

Although none of the agonistic behaviors were detected as differing statistically between BT and IN pullets, BT pullets performed more aggressive pecking (with another bird avoiding) and less threatening (with another bird avoiding) than in IN pullets. This suggests that the pecks of BT pullets were probably less effective and less painful than those delivered by IN pullets, as suggested earlier by Hale (1948).

Floor-pen pullets of the genetic strains used differed in age at sexual maturity, hen-day and hen-housed egg production, some behavioral activities, body weight and weight gain. The genetic strain by beak treatment interactions found for the floor-pen pullets in egg production traits, body weight, and weight gain indicated that beak trimming had larger effects in the NCR pullets than in Y_1 or Y_2 pullets. Within the NCR strain, BT birds matured 1.2 weeks earlier, had 19% higher hen-day and 38% higher hen-housed egg production, 39% higher daily egg mass, but lighter body weight at 24 weeks of age (92% as much weight as IN pullets), and gained 60% less from 18 to 24 weeks of age.

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APPENDIX

Table A-1. Analysis of variance for activities of pullets from 4 to 7 and 16 weeks of age

Source of variance	df	Feed	Drink	Stand	Crouch	Preen
		-----------	Mean squares	-------------		
Strain (S)	2	6757+	25.7	2009	151	181
Block (Blk)	1	270	42.0	34	677	30
Error A[1]	2	421	121.2	559	661	164
Beak (B)	1	15368+	69.0	8807*	1960**	0
S x B	2	125	60.0	147	53	184
Error C[2]	3	2498	39.6	383	43	244
Age (A)	4	8187***	222.1**	9587***	1172*	694*
S x A	8	1484	37.1	402	807+	168
B x A	4	5036**	54.3	1135*	729	151
S x B x A	8	1333	61.2	312	702	66
Error D[3]	24	834	49.4	331	396	168
Time (T)	1	124	69.0	1968*	14498***	538*
S x T	2	1374	113.4*	646	121	476*
B x T	1	173	170.4*	43	1050+	11
S x B x T	2	1166	29.2	318	199	29
A x T	4	114	76.5*	605	353	169
S x A x T	8	362	30.6	263	316	111
B x A x T	4	176	17.7	100	640	245
S xB xA xT	8	578	33.2	154	311	222
Error E[4]	30	802	28.4	389	359	121

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

[3] Error term for testing age effect and age related 2-way, and 3-way interactions.

[4] Error term for testing time effect and time related 2-way, 3-way, and 4-way interactions.

+, P<.10; * P<.05; **, P<.01; ***, P<.001.

Table A-1. (Continued)

Source of variance	df	Comfort	Peck at litter	Move	Pecks of all kinds	Inactivity
		Mean squares				
Strain (S)	2	34.4+	2670*	56.7	1502	1288
Block (Blk)	1	2.7	122	403.3	75	1015
Error A[1]	2	3.3	98	154.8	691	455
Beak (B)	1	76.8**	667	38.5	20515*	19076**
S x B	2	11.7*	461	70.7	426	56
Error C[2]	3	.9	410	109.8	1775	553
Age (A)	4	12.7	186	132.5*	7353***	5548***
S x A	8	2.9	206	118.5*	1685*	724+
B x A	4	9.6	1232**	178.6**	1058	1331*
S x B x A	8	4.3	378	24.0	1493*	791*
Error D[3]	24	15.9	209	36.1	598	321
Time (T)	1	.5	3297***	433.2**	4551*	5782**
S x T	2	19.6	343	53.4	527	604
B x T	1	4.0	279	116.0	29	667
S x B x T	2	5.3	203	7.4	333	409
A x T	4	18.3	112	28.0	49	1044
S x A x T	8	14.7	155	28.3	630	280
B x A x T	4	1.8	145	31.0	543	257
S xB xA xT	8	14.4	97	28.7	665	577
Error E[4]	30	10.2	211	41.7	716	473

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

[3] Error term for testing age effect and age related 2-way, and 3-way interactions.

[4] Error term for testing time effect and time related 2-way, 3-way, and 4-way interactions.

+, P<.10; *, P<.05; **, P<.01; ***, P<.001.

Table A-2. Analysis of variance for pullets of 4, 5, 6, 7, and 16 weeks of age -- feeding

Source of variance	df	Age (weeks) 4	5	6	7	16
		Mean squares				
Strain (S)	2	5073*	185	4566*	2563*	309
Block (Blk)	1	580	1601	113	417	1380
Error A[1]	2	269	1718	149	70	328
Beak (B)	1	1176	13728*	15201	5400	6
S x B	2	949	2233	1395	668	214
Error C[2]	3	362	673	3037	1865	549
Time (T)	1	104	122	308	3	43
S x T	2	611	8	638	1168	395
B x T	1	160	193	20	17	486
S x B x T	2	1523+	1098	522	140	197
Error D[3]	6	366	497	1357	566	1224

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

[3] Error term for testing time effect and time related 2-way, 3-way, and 4-way interactions.

+, P<.10; *, P<.05.

Table A-3. Analysis of variance for pullets of 4, 5, 6, 7, and 16 weeks of age -- drinking

Source of variance	df	Age (weeks) 4	5	6	7	16
		Mean squares				
Strain (S)	2	12.5	20.4	28.7	57.1	55.5*
Block (Blk)	1	37.5	9.4	2.0	65.3	2.0
Error A[1]	2	10.5	102.4	171.2	16.5	1.3
Beak (B)	1	1.5	63.4	45.4	112.7	63.4
S x B	2	.5	15.1	158.0*	88.3	42.9
Error C[2]	3	21.0	122.5	16.5	88.1	19.9
Time (T)	1	88.2*	35.0	3.4	140.2+	108.4*
S x T	2	.7	16.8	54.5	39.5	124.1*
B x T	1	54.0*	155.0	3.4	16.7	12.0
S x B x T	2	6.5	69.5	18.5	37.0	30.3
Error D[3]	6	6.8	61.1	26.6	33.5	14.0

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

[3] Error term for testing time effect and time related 2-way, 3-way, and 4-way interactions.

+, P<.10; *, P<.05.

Table A-4. Analysis of variance for pullets of 4, 5, 6, 7, and 16 weeks of age -- standing

Source of variance	df	Age (weeks) 4	5	6	7	16
		Mean squares				
Strain (S)	2	69.5	430	2055	25	1040
Block (Blk)	1	165.4	0	8	11	693
Error A[1]	2	142.1	193	403	1495	715
Beak (B)	1	5.0	6080**	4648*	2282*	330
S x B	2	3.3	85	444	542	322
Error C[2]	3	65.0	144	262	159	530
Time (T)	1	392.0**	468	150	182	3197+
S x T	2	370.5**	217	282	741	88
B x T	1	1.0	131	17	150	145
S x B x T	2	2.8	441	120	1	368
Error D[3]	6	19.1	506	321	462	637

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

[3] Error term for testing time effect and time related 2-way, 3-way, and 4-way interactions.

+, P<.10; *, P<.05; **, P<.01.

Table A-5. Analysis of variance for pullets of 4, 5, 6, 7, and 16 weeks of age -- crouching

Source of variance	df	Age (weeks) 4	5	6	7	16
		Mean squares				
Strain (S)	2	387	454	407	1565	568
Block (Blk)	1	794	17	155	338	11
Error A[1]	2	443	968	898	777	89
Beak (B)	1	3750**	486	287	160	193
S x B	2	1290*	626	460	351	132
Error C[2]	3	85	362	151	270	457
Time (T)	1	4267**	4428*	1107**	4988+	1121*
S x T	2	71	453	44	679	137
B x T	1	204	1734	145	888	641+
S x B x T	2	639+	410	113	170	110
Error D[3]	6	141	525	70	897	164

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

[3] Error term for testing time effect and time related 2-way, 3-way, and 4-way interactions.

+, P<.10; *, P<.05; **, P<.01.

Table A-6. Analysis of variance for pullets of 4, 5, 6, 7, and 16 weeks of age -- preening

Source of variance	df	Age (weeks) 4	5	6	7	16
		Mean squares				
Strain (S)	2	259.3+	138.3	45.2	24.5	384.5
Block (Blk)	1	32.7	48.2	360.4	10.7	77.0
Error A[1]	2	17.8	369.5	55.5	60.7	610.7
Beak (B)	1	130.7	37.5	1.0	280.2	155.0
S x B	2	153.8	4.6	43.2	107.2	138.7
Error C[2]	3	166.1	216.1	79.5	142.3	182.8
Time (T)	1	20.2	160.2	7.0	0.0	1027.0*
S x T	2	75.5	312.8	208.7	234.5	90.2
B x T	1	20.2	400.2	9.4	10.7	551.0*
S x B x T	2	43.0	147.8	91.5	162.7	472.7*
Error D[3]	6	52.8	120.9	119.3	233.8	78.3

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

[3] Error term for testing time effect and time related 2-way, 3-way, and 4-way interactions.

+, P<.10; *, P<.05.

Table A-7. Analysis of variance for pullets of 4, 5, 6, 7, and 16 weeks of age -- comfort activity

Source of variance	df	Age (weeks) 4	5	6	7	16
		Mean squares				
Strain (S)	2	8.17	6.76	4.29	13.5	13.17
Block (Blk)	1	8.17	6.00	7.04	22.0	1.50
Error A[1]	2	3.17	42.13	4.54	21.8	3.50
Beak (B)	1	.17	20.17	7.04	77.0	10.67
S x B	2	.17	5.04	1.54	17.5	4.67
Error C[2]	3	.33	9.75	4.21	40.2	11.33
Time (T)	1	8.17	28.17	2.04	7.0	28.17^{+}
S x T	2	3.17	36.79	.79	36.5	1.17
B x T	1	2.67	.67	3.38	2.0	2.67
S x B x T	2	1.17	18.04	3.88	29.5	10.17
Error D[3]	6	2.25	16.58	5.63	21.4	4.92

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

[3] Error term for testing time effect and time related 2-way, 3-way, and 4-way interactions.

$^{+}$, P<.10.

Table A-8. Analysis of variance for pullets of 4, 5, 6, 7, and 16 weeks of age -- litter pecking

Source of variance	df	Age (weeks) 4	5	6	7	16
		Mean squares				
Strain (S)	2	895	230	373	795	1202
Block (Blk)	1	222	198	0	198	353
Error A[1]	2	609	117	201	113	445
Beak (B)	1	3927**	260	96	165	1148*
S x B	2	371+	384	100	229	892*
Error C[2]	3	47	432	198	107	58
Time (T)	1	630+	1134+	662	1247*	74
S x T	2	143	38	284	165	331
B x T	1	210	187	104	165	193
S x B x T	2	82	85	292	24	109
Error D[3]	6	130	270	190	140	323

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

[3] Error term for testing time effect and time related 2-way, 3-way, and 4-way interactions.

+, P<.10; *, P<.05; **, P<.01.

Table A-9. Analysis of variance for pullets of 4, 5, 6, 7, and 16 weeks of age -- moving

Source of variance	df	Age (weeks) 4	5	6	7	16
		Mean squares				
Strain (S)	2	22.8	3.5	288.2	80.8	135.4
Block (Blk)	1	247.0	51.0	40.0	63.4	60.2
Error A[1]	2	91.5	131.2	50.2	36.1	47.5
Beak (B)	1	376.0**	7.0	18.4	135.4	216.0
S x B	2	46.8+	37.2	1.5	79.6	1.6
Error C[2]	3	5.4	88.8	41.1	60.9	48.1
Time (T)	1	155.0	287.0*	57.0	26.0	20.2
S x T	2	5.3	40.2	61.2	8.8	51.0+
B x T	1	57.0	155.0+	7.0	15.0	6.0
S x B x T	2	28.3	46.2	25.2	10.8	11.6
Error D[3]	6	52.5	30.5	86.8	26.2	12.6

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

[3] Error term for testing time effect and time related 2-way, 3-way, and 4-way interactions.

+, P<.10; *, P<.05; **, P<.01.

Table A-10. Analysis of variance for pullets of 4, 5, 6, 7, and 16 weeks of age -- pecks of all kinds

Source of variance	df	4	5	6	7	16
		Age (weeks)				
		Mean squares				
Strain (S)	2	1825*	1154	2870+	1803	589
Block (Blk)	1	24	273	620	14	150
Error A[1]	2	55	1965	280	206	1041
Beak (B)	1	2282	9009*	9923+	2993	542
S x B	2	2410	543	1626	160	1660+
Error C[2]	3	640	882	1323	1239	238
Time (T)	1	963+	693	1442	1233	417
S x T	2	88	10	473	2256	221
B x T	1	33	551	104	104	1411
S x B x T	2	725	1435	580	41	215
Error D[3]	6	224	954	782	748	872

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

[3] Error term for testing time effect and time related 2-way, 3-way, and 4-way interactions.

+, P<.10; *, P<.05.

Table A-11. Analysis of variance for pullets of 4, 5, 6, 7, and 16 weeks of age -- inactivity

Source of variance	df	Age (weeks) 4	5	6	7	16
		Mean squares				
Strain (S)	2	679	606	805	1979	116
Block (Blk)	1	234	24	92	468	876
Error A[1]	2	92	1075	370	319	572
Beak (B)	1	3480*	10004*	7245*	3651**	18
S x B	2	1386*	250	659	140	784+
Error C[2]	3	133	553	718	57	117
Time (T)	1	2072**	2017	2072*	3267	532
S x T	2	118	106	543	905	50
B x T	1	234	913	63	308	176
S x B x T	2	566+	1469	421	151	112
Error D[3]	6	139	552	267	1038	371

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

[3] Error term for testing time effect and time related 2-way, 3-way, and 4-way interactions.

+, P<.10; *, P<.05; **, P<.01.

Table A-12. Analysis of variance for body weight, weight gain, feed usage, and feed/gain ratio of pullets from 4 to 7 weeks of age

Source of variance	df[4]	Body weight	df[5]	Weight gain	Feed usage	Feed/gain ratio
		Mean squares				
Strain (S)	2	3723	2	10.2	7.61	.079
Block (Blk)	1	3693	1	12.2	2.35	.006
Error A[1]	2	1044	2	175.6	8.27	.112
Beak (B)	1	5023	1	774.7+	249.43*	.023
S x B	2	306	2	59.2	1.21	.162
Error C[2]	3	3665	3	96.5	8.40	.184
Age (A)	3	157176***	2	1836.8***	880.78***	.867***
S x A	6	34	4	80.6+	3.12	.129*
B x A	3	496**	2	375.1***	3.10	.398**
S x B x A	6	35	4	13.2	1.22	.093+
Error D[3]	18	63	12	27.3	1.29	.036

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

[3] Error term for testing age effect and age related 2-way, and 3-way interactions.

[4] Age: 4, 5, 6,and 7 weeks of age.

[5] Age: 4-5, 5-6, and 6-7 weeks of age.

+, P<.10; *, P<.05; **, P<.01; ***, P<.001.

Table A-13. Analysis of variance for pullets of 4, 5, 6, 7, and 18 weeks of age -- body weight

Source of variance	df	4 wk	5 wk	6 wk	7 wk	18 wk
		-----------		Mean squares		-------------
Strain (S)	2	911+	776	1076	1161	24007*
Block (Blk)	1	690	1008	919	1102	721
Error A[1]	2	80	182	273	784	723
Beak (B)	1	7	1728	2107	2670	24
S x B	2	6	43	56	152	410
Error C[2]	3	440	826	1207	1378	626

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

+, $P<.10$; *, $P<.05$.

Table A-14. Analysis of variance for pullets of 4-5, 5-6, and 6-7 weeks of age -- weight gain

Source of variance	df	4-5 week	5-6 week	6-7 week
		---------	Mean squares	----------
Strain (S)	2	61.8	82.3	27.3
Block (Blk)	1	24.1	4.1	10.1
Error A[1]	2	98.6	17.3	137.6
Beak (B)	1	1474.1*	14.1	36.8
S x B	2	61.1	1.3	23.3
Error C[2]	3	69.1	37.6	38.4

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

*, $P<.05$.

Table A-15. Analysis of variance for pullets of 4-5, 5-6, and 6-7 weeks of age -- feed usage

Source of variance	df	4-5 week	5-6 week	6-7 week
		---------	Mean squares	---------
Strain (S)	2	13.16	.375+	.314
Block (Blk)	1	1.66	.441	.496
Error A[1]	2	3.65	.022	10.682
Beak (B)	1	108.48**	50.594*	96.560*
S x B	2	2.35	1.288	.011
Error C[2]	3	1.50	3.230	4.697

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

+, P<.10; *, P<.05; **, P<.01.

Table A-16. Analysis of variance for pullets of 4-5, 5-6, and 6-7 weeks of age -- feed/gain ratio

Source of variance	df	4-5 week	5-6 week	6-7 week
		---------	Mean squares	----------
Strain (S)	2	.193	.096	.047
Block (Blk)	1	.011	.010	.006
Error A[1]	2	.112	.019	.042
Beak (B)	1	.407	.156	.255+
S x B	2	.309	.002	.036
Error C[2]	3	.193	.048	.039

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

+, P<.10.

Table A-17. Analysis of variance for activities of pullets within first 6-week laying period -- cages

Source of variance	df	Activity					
		Feed	Stand	Look	Move	Pecks of all kinds	Inact-ivity
		Mean squares					
Strain (S)	2	67	23	8.6	5.3	27	54
Block (Blk)	2	58	13	33.3*	1.2	58	120
Error A[1]	31	59	36	6.8	3.4	59	50
Beak (B)	1	221+	18	68.1**	.2	57	162+
S x B	2	20	1	8.4	3.9	25	51
Error C[2]	33	58	46	9.1	2.1	50	45

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

+, P<.10; **, P<.01.

Table A-18. Analysis of variance for egg production traits of pullets during the first three 6-week laying periods -- cages

Source of variance	df[4]	Age at 50%	df[5]	H-D prod.	H-H prod.	Egg wt	Egg mass
		Mean squares					
Strain (S)	2	1.26	2	559	1240*	55*	180+
Block (Blk)	2	.06	2	22	181	20	59
Error A[1]	31	1.27	31	341	114	12	72
Beak (B)	1	.13	1	228	3928***	7	864**
S x B	2	2.04+	2	350	206	13	49
Error C[2]	33	.80	66	319	327	11	86
Period (P)			2	1368***	6146***	414***	2235***
S x P			4	283***	901***	3	214***
B x P			2	47*	761**	2	172**
S x B x P			4	47**	267+	3+	65
Error D[3]			99	12	130	2	32

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

[3] Error term for testing period effect and period related 2-way, and 3-way interactions.

[4] One time measure.

[5] Three laying periods recorded.

+, P<.10; *, P<.05; **, P<.01; ***, P<.001.

Table A-19. Analysis of variance for hen-day, hen-housed egg production, egg weight, and daily egg mass of pullets in cages -- within periods

Source of variance	df	H-D prod. 1	H-D prod. 2	H-D prod. 3	H-H prod. 1	H-H prod. 2	H-H prod. 3
		Mean squares					
Strain (S)	2	33	534	557	321	825*	1896**
Block (Blk)	2	320	0	84	230	73	79
Error A[1]	31	106	173	240	165	203	308
Beak (B)	1	3	235	84	39	1747**	3664**
S x B	2	104	315	24	261	358	122
Error C[2]	33	127	154	204	112	213	330

Table A-19. (Continued)

Source of variance	df	Egg weight 1	Egg weight 2	Egg weight 3	Egg mass 1	Egg mass 2	Egg mass 3
		Mean squares					
Strain (S)	2	26.2^{+}	19.1^{+}	14.5	92.2^{+}	126.8	389.2*
Block (Blk)	2	5.1	5.2	25.3	69.2	10.2	42.6
Error A[1]	31	10.2	6.4	6.0	33.0	55.9	82.4
Beak (B)	1	.0	2.7	8.5	7.8	379.5*	820.8**
S x B	2	.9	16.7*	2.1	45.1	92.9	40.6
Error C[2]	33	6.8	4.2	5.4	26.1	62.3	84.5

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

$^{+}$, P<.10; *, P<.05; **, P<.01.

Table A-20. Analysis of variance for body weights and weight gains of pullets in laying cages

Source of variance	df	18 week body weight	24 week body weight	18-24 week weight gain
		Mean squares		
Strain (S)	2	285513***	131750***	122426***
Block (Blk)	2	1982	4170	904
Error A[1]	31	6661	7175	5806
Beak (B)	1	9940	4608	28085*
S x B	2	1007	13393	16602+
Error C[2]	33	5491	11789	5476

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

+, P<.10; *, P<.05; ***, P<.001.

Table A-21. Analysis of variance for fearfulness, feather condition, and duration of induced tonic immobility of pullets in laying cages

Source of variance	df[3]	Fearfulness score	Feather score	df[4]	Duration of induced tonic immobility
		-----------	Mean squares		-------------
Strain (S)	2	2.347**	1.649***	2	.231
Block (Blk)	2	10.014***	.045	2	.146
Error A[1]	31	.403	.083	22	.167
Beak (B)	1	2.170**	.587*	1	.009
S x B	2	.097	.045	2	.047
Error C[2]	33	.228	.104	24	.116

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

[3] Pullets from 72 cages were tested.

[4] Pullets from 54 cages were tested.

*, P<.05; **, P<.01; ***, P<.001.

Table A-22. Analysis of variance for activities of pullets within first 6-week laying period - floor pens

Source of variance	df	Activity					
		Feed	Drink	Stand	Crouch	Preen	Move
		Mean squares					
Strain (S)	2	752***	1.03	51	158+	3.60	13.6
Block (Blk)	4	57	1.22	39	23	6.08	7.2
Error A[1]	8	30	4.12	62	48	6.43	29.5
Beak (B)	1	193+	7.50	418*	9	.03	5.6
S x B	2	9	.30	13	10	18.53	46.4
Error C[2]	12	49	3.78	49	14	8.62	42.3

Table A-22. (Continued)

Source of variance	df	Activity				
		Peck at litter	Other pecks	Roost	Pecks of all kinds	Inactivity
		Mean squares				
Strain (S)	2	102	3.23+	92	442*	258
Block (Blk)	4	57	9.13	118	139	22
Error A[1]	8	57	.86	131	96	123
Beak (B)	1	0	.13	101	178	1116***
S x B	2	15	2.23	1	65	53
Error C[2]	12	41	11.78	42	106	28

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

+, $P<.10$; *, $P<.05$; ***, $P<.001$.

Table A-23. Analysis of variance for agonistic activities of pullets within first 6-week laying period - floor pens

Source of variance	df	Peck w/ avoid	Threat w/ avoid	Chase w/ avoid	Avoid	Total
		Mean squares				
Strain (S)	2	34.1	67.0	8.08	9.33	272
Block (Blk)	1	432.0	154.1	21.33	52.08	2080
Error A[1]	2	57.3	72.3	11.58	4.33	316
Beak (B)	1	40.3	80.1	1.33	24.08	40
S x B	2	11.1	42.3	2.08	10.33	160
Error C[2]	3	60.8	21.6	.50	9.58	105

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

Table A-24. Analysis of variance for egg production traits of pullets during the first 6-week laying period -- floor pens

Source of variance	df	Age at 50%	H-D prod.	H-H prod.	Egg weight	Egg mass
		Mean squares				
Strain (S)	2	2.13***	147+	32.3+	2.74	6.35
Block (Blk)	4	.42	44	32.8	1.26	5.27
Error A[1]	8	.09	41	9.7	4.06	5.03
Beak (B)	1	1.20*	139+	357.1**	3.14+	88.41**
S x B	2	1.60**	153*	210.9**	.39	38.75*
Error C[2]	12	.13	30	27.0	.69	5.70

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

+, P<.10; *, P<.05; **, P<.01; ***, P<.001.

Table A-25. Analysis of variance for body weights, weight gains, and duration of induced tonic immobility of pullets in floor pens

Source of variance	df	18 week body weight	24 week body weight	18-24 week weight gain	Duration of tonic immobility
		Mean squares			
Strain (S)	2	65436***	60136**	40712*	.006
Block (Blk)	4	2345	7649	9300	.107
Error A[1]	8	1062	5335	5832	.063
Beak (B)	1	132	5254	7053	.393*
S x B	2	3968+	24785**	23494**	.081
Error C[2]	12	1087	2674	2680	.053

[1] Error term for testing genetic effect.

[2] Error term for testing beak treatment effect and genetic by beak treatment interaction.

+, P<.10; *, P<.05; **, P<.01; ***, P<.001.

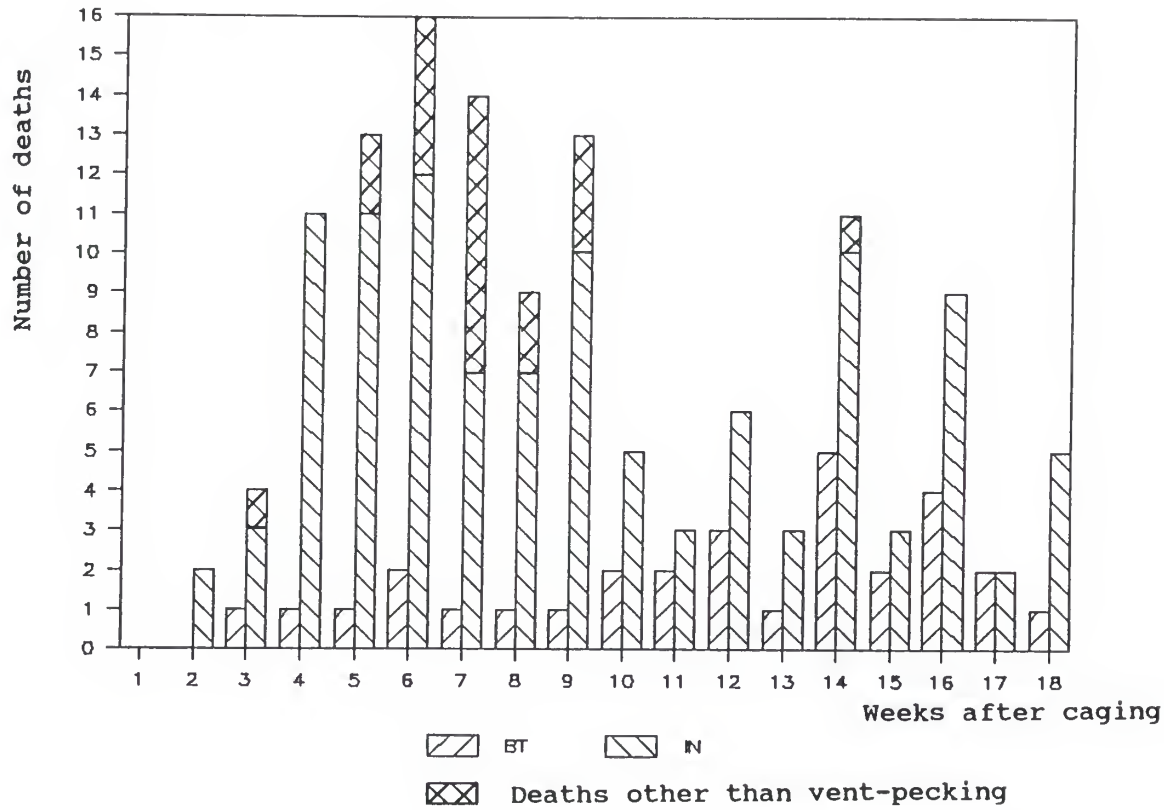

Figure A-1. Mortality of caged pullets due to cannibalism

BEAK TRIMMING EFFECTS ON BEHAVIORAL PATTERNS, WEIGHT GAINS AND EGG PRODUCTION OF THREE STRAINS OF EGG-TYPE PULLETS DURING THE REARING AND FIRST EIGHTEEN-WEEK LAYING PERIODS

by

Hsu-Yuan Lee

B.S., National Chung-Hsing University, R.O.C., 1985

AN ABSTRACT OF A MASTER'S THESIS

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White Leghorn pullets of three genetic stocks, Y_1, Y_2, and NCR, were used. In half of the birds of each stock, one-half of the upper and less of the lower mandibles were removed at 4 weeks of age by making a V-shaped cut.

Stocks differed in 18-week body weight, percentage of time pecking at litter or pecking at feed during the rearing phase and in egg production traits, mortality from cannibalism among intact-beak pullets, hen-days of survival, feather score, and nervousness during the laying phase. Y_2 pullets were the lightest among stocks and spent the least time pecking at litter but more time pecking at feed during the rearing period, gained more weight from 18 to 24 weeks of age, were less nervous, had better feather condition, and produced smaller eggs than other two strains of pullets.

During rearing, beak-trimmed pullets pecked less at feed, delivered fewer pecks of all kinds, stood more, crouched more, and showed more comfort activity than intact-beak birds. Beak treatment by age interactions were found for several behavioral patterns during the rearing phase. Differences found initially between beak-trimmed and intact-beak pullets tended to diminish with age, and none were present at 16 weeks, except for continued lower frequency of litter pecking by beak-trimmed pullets. Beak-trimmed pullets gained 90% as much weight as intact-beak pullets during the first 3 weeks after treatment and used

88% as much feed.

During the laying phase, beak-trimmed pullets kept in cages were more inactive, produced more eggs, but gained less weight, and had lower incidence of cannibalism than intact-beak pullets. Also, caged beak-trimmed pullets were less nervous and had better feather condition than those of intact-beak pullets. However, trimming the beaks to prevent cannibalism was less effective in caged NCR pullets than in Y_1 or Y_2 pullets.

For the pullets kept in floor pens, beak trimming increased inactivity, reduced feeding frequency, accelerated sexual maturity, increased hen-day and hen-housed egg production, and enlarged egg size during the early part of laying phase. Although beak-trimmed pullets were less fearful than intact-beak pullets, no differences were found in mortality or frequencies of agonistic behaviors between the two beak treatments.

From the results of this study, it is concluded that beak-trimmed pullets, although initially set back in growth and probably experiencing temporary pain in the stump of the beak, were under less social tension and had better welfare during the laying phase than intact-beak pullets.