December 22, 1962.

To the Graduate Council:

I am submitting herewith a thesis written by S. Srinivasan entitled "Debeaking of Chicks". I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Poultry.

H. V. Shirley
Major Professor

We have read this thesis
and recommend its acceptance:

O E Goff

Lowell J Dickson

Accepted for the Council:

Hilton A. Smith
Dean of the Graduate School

# DEBEAKING OF CHICKS

---

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

---

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

S. Srinivasan

March 1963

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# INTRODUCTION

The tendency of chickens to peck at each other is inherent. This vice, called cannibalism, can take many forms. Cannibalism in baby chicks usually starts with toe picking or tail picking and feather pulling. In laying hens it frequently begins with feather pulling and soon takes the form of vent picking and may result in disemboweling the bird. Vent picking may also start as a result of prolapse in newly housed pullets.

Many environmental factors have been said to influence the natural cannibalistic tendency of chickens. Among the more important of these factors are: crowding, damp litter, high temperatures, nutritional deficiencies, high intensity of light and inadequate ventilation. It is generally thought that many of the so called "stress" factors may affect the incidence of cannibalism; that any factor that affects the comfort of the birds may also influence cannibalism.

While it is difficult to estimate the loss to the poultry industry resulting from cannibalism, it is, undoubtedly, a considerable amount. The vice may result in heavy mortality among chickens of all ages. The presence of pin feathers and bruises resulting from feather picking results in lowered market grades for broilers. Greater variability in growth rate and egg production rate results in flocks where cannibalistic activities exist. These activities also, very likely, mean poorer feed conversion in these flocks.

A number of practices have been used by poultrymen, with varying degrees of success, in attempting to control cannibalism in their flocks. Some of those most commonly used are: red light bulbs and red window glass, the feeding of extra salt, the feeding of cabbages or other similar items which provide something for the chickens to pick at, special "anti-pick" salves, and "specs". The latter are mechanical devices designed to interfere with the bird's vision. Also a number of drugs with tranquilizing effects have been used. The most generally accepted practice is that of debeaking. This involves the removal of a portion of the beak of the chicken.

The debeaking of chickens requires the consideration of many factors such as the type of debeaking equipment, the age of the bird when debeaked, the amount of the beak to be removed, the temperature of the cutting blade, and the angle of cut.

While many methods and procedures are presently employed in the debeaking of chicks, no one method or procedure has met with the complete approval by all poultrymen.

## OBJECTIVES

Experiments were conducted for the purpose of evaluating some of the variables frequently associated with the practice of debeaking chicks. Factors studied were:

(1) The quantity of beak removed.

(2) The temperature of the cutting blade.

(3) The length of the exposure time of the chick's beak to the cutting blade.

(4) The effect of floor space per chick on the incidence of cannibalism.

(5) The effect of feeder space per chick on the incidence of cannibalism.

(6) Social position of debeaked and non-debeaked chicks.

Criteria used to measure these factors included: mortality, growth rate, feed consumption, feather coverage, social organization and regrowth of the beak.

## LITERATURE REVIEW

Experiments dealing with debeaking have largely been concerned with the relationships of the quantity of the beak removed and the age of removal with the growth rate, feed efficiency, incidence of cannibalism, and market grade of the chickens. The effects of debeaking upon the social organization of flocks has been the subject of a few studies.

Medium to heavy debeaking of chicks at four weeks of age was found by Quisenberry and Draper (1946) to reduce the growth rate to eight weeks to a very slight degree. Debeaking was reported as being effective in controlling cannibalism in this experiment.

Darrow and Stotts (1954) in their experiment with 30,000 broiler chicks, removed approximately one-third to one-half of the upper beak at three weeks of age. Their results at eight weeks indicated that debeaking reduced feather picking and there was an improvement in the percentage of A grade carcasses by 11.4 percent. Their experiment also showed an improvement in feed conversion by 0.1 pound per pound body weight gain. Debeaking of the chicks at one day of age had no adverse effect on the average weight or mortality.

Camp et al. (1955) in an experiment with 1,200 broiler chicks subjected to block type debeaking and the removal of one-third to one-half of the upper and lower beak indicated

better growth in the males. The results were similar, regardless of age of debeaking, that is, at one day of age or at five weeks of age. The use of a slanting type of debeaking at one day of age by these workers was unsuccessful as it resulted in a retarded growth rate. Feed efficiency appeared to be better with either type of debeaking. The feather score was significantly better among the debeaked birds.

In a study with New Hampshire and crossbred chicks, Combs (1955) reported that debeaking had no detrimental effects on growth rate, feed efficiency, or mortality but improved feather condition at market weight of birds to nine weeks and three days of age. The chicks in the experiment were electrically debeaked at one day of age. The amount of the beak that was removed was not stated.

In a study involving 28,642 broiler chicks, Brown (1955) found an improvement in feed utilization by 0.1 pound of feed among the birds that were debeaked by removal of one-third to one-half of the maxilla. These data showed no adverse affect on average weight or on mortality among the debeaked birds.

Lanson (1956) removed one-third of the upper beak of day-old broiler chicks and found that improved feed efficiency resulted. The removal of one-third of the upper beak and the tip of the lower beak had no effect on subsequent growth rate. The debeaked birds consumed less feed in this experiment as compared to the controls and the feed cost per pound of gain

was slightly less for the debeaked birds. He found no evidence of feather picking in his flocks or losses due to cannibalism.

Approximately 3,000 broiler chicks were selected for study of various methods of debeaking by Huston et al. (1956). Their results, with reference to feather score, showed a significant improvement of the debeaked birds versus the non-debeaked birds. However, their results showed no improvement in body weight or feed efficiency resulting from debeaking. These workers also stated that it was unnecessary to remove more than one-third of the beak to prevent its regrowth to normal length by the time chicks were ten weeks of age. Removal of the tip of beak reduced feather picking as much as did other methods.

Long (1957) in his experiment with 5,100 broiler chicks on various types of debeaking, observed that removal of two-thirds of the beak significantly lowered the body weight and at the same time increased the number of pounds of feed required to produce one pound of broiler meat. There were no difference in mortality between the debeaked and non-debeaked chicks.

In a study with New Hampshire pullet chicks, Morgan (1957) found no detrimental effect upon growth rate to eight weeks or five months of age from the removal of one-third or one-half of the upper beak at one day of age. Less mortality occurred among the debeaked birds as compared to the non-debeaked birds.

Lonsdale et al. (1957), using 5.100 chicks found no significant effect upon body weight or feed conversion of the removal

of one-third of the maxilla and mandible at one day of age. Removal of two-thirds of the maxilla and mandible retarded growth.

Berry and Smyth (1959) in their study with 2,400 broiler chicks, after testing the effectivness of various methods of debeaking, from one day of age to ten weeks of age with one square foot of floor space per bird, recommended debeaking at ten days of age over debeaking at one day of age. These workers removed one-third of the upper beak at one day of age, one-third of the maxilla and the tip of mandible seared at one day of age, one-third of each maxilla and mandible removed at one day of age, one-third of the maxilla removed and tip of the mandible seared at ten days of age and one-third of the upper beak removed at ten days of age. Their data showed the greatest mortality among the non-debeaked birds and the least among the birds debeaked at ten days of age. Debeaked birds had a lower body weight at marketing but gave a better feed efficiency. Feed efficiency for the birds debeaked at ten days of age was better than those debeaked at one day of age.

Keene et al. (1959), in a study on broiler chicks, found no adverse effects from one to ten days of age resulting from the removal of one-third of the upper and lower beak at one day of age.

In a study on broiler chicks, Nair (1961) found that the removal of two-thirds of the upper and one-half of the lower beak at one day of age by use of an electric debeaker had no

significant effect upon growth rate to four weeks of age. Debeaking by this method resulted in a permanent amputation of the beak.

Bramhall (1962), in two trials, debeaked White Leghorn chicks at six days and eleven weeks of age and found no significant difference in body weights between the two treatments at twenty weeks. However, he found that growth of the chicks debeaked at six days was retarded to seven, eleven and sixteen weeks of age. Two-thirds removal of the maxilla was necessary for permanent debeaking in these experiments.

Guhl (1956) in a study on peck order, observed no significant difference in the peck frequency and paired fights between debeaked and non-debeaked hens. He also reported that debeaking had no effect on the formation of peck order or bossiness.

The study by Hale (1948) gave no indication that debeaking resulted in lessened social tensions among mature White Leghorn hens. Following the removal of one-half or more of the upper beak hens developed a social hierarchy in typical White Leghorn fashion. Once organized, the debeaked flock showed a considerably higher peck frequency than did the control flocks. Out of a total of forty-eight paired encounters between debeaked and normal hens twenty-nine were won by the debeaked hens. The debeaked hens of these experiments were observed as being incapable of injuring other hens or of plucking feathers.

Sherwood and Milby (1956) debeaked male New Hampshire

chicks at one day of age. One-third to one-half of the upper and lower beak was removed. No differences in regard to fertility were found between the debeaked and non-debeaked males.

Aggressiveness among birds within a flock has been related by a number of workers to the level of the gonadal hormones. Allee and Collins (1938) found that by injecting testosterone propionate daily into hens low in the peck-order, these hens were able to move to the top of the social organization. Similar results were obtained by Allee et al. (1939), who injected male hormones daily and by Douglis (1948), who implanted male hormones. Williams and McGibbon (1956), however, reported no changes within the peck-order of hens implanted with gonadal hormones.

## METHODS AND MATERIALS

Broiler type chicks were used in all experiments. They were sexed and vaccinated with Newcastle and bronchitis vaccines at one day of age using the intraoccular method. The chicks, within sexes, were assigned at random to the various treatments. Electric hover-type brooders were used in Experiment I and infra-red lamps in all other experiments. Wood shavings were used as litter. The standard poultry farm chick starter and growing mashes were fed. Feed and water was available to the chicks ad libitum.

Debeaking in these experiments was performed by use of a Lyon Electric-Debeaker. The debeaking procedure is illustrated in Figure 1. The fraction of the beak removed in the various experiments refers to that portion of the beak measured from its tip to the anterior edge of the nares. During the debeaking process the head of the chick was held at an obtuse angle to the cutting blade so that slightly less of the lower beak than of the upper beak was removed. For the purpose of brevity subsequent mention of the various debeaking treatments will refer only to that portion of the upper beak removed.

### Experiment I

Three brooder houses designated as B, C, and D, and each containing four pens, were used in a study involving four treatments and a total of 2,248 chicks.



Figure 1. A day-old chick in the process of being debeaked with an electric debeaker.

House B was a solar type house with solar glass in the front wall, insulated walls and forced ventilation. House C was a windowless house with insulation and forced ventilation. House D was of the conventional type with no insulation or mechanical ventilation. As the three houses differed in size, adjustments were made in chick numbers so as to provide on square foot of floor space per chick in each house. Feeder space was also equalized in all pens.

The chicks were debeaked and wingbanded at one day of age. Equal numbers of males and females were placed on each treatment. The experiment was initiated December 4, 1961, and was concluded when the chicks were eight weeks of age.

The design of the Experiment is shown in Table I.

For the purpose of measuring feed wastage, feeders were placed on specially constructed boxes at the time the chicks were two weeks of age. The dimensions of these boxes were 72 inches in length, 22 inches wide, and 6 inches in depth. The tops of the boxes were constructed of one inch mesh welded wire. The contents of each box, after screening to remove debris, was weighed at weekly intervals. Feed troughs were filled only to the halfway mark.

At four weeks two randomly selected samples of twelve chicks of each sex were group weighed from each pen. At eight weeks individual body weights were obtained.

Mortality and feed consumption was recorded by pens.

TABLE I

DESIGN OF EXPERIMENT I

| Brooder house | Pen No. | No. Chicks[1] | Treatments |
|---|---|---|---|
| B | 1 | 168 | Control |
| | 2 | 168 | 2/3 beak removed |
| | 3 | 168 | 1/2 beak removed |
| | 4 | 168 | 1/4 beak removed |
| C | 1 | 194 | 2/3 beak removed |
| | 2 | 194 | Control |
| | 3 | 194 | 1/2 beak removed |
| | 4 | 194 | 1/4 beak removed |
| D | 1 | 200 | 1/2 beak removed |
| | 2 | 200 | 1/4 beak removed |
| | 3 | 200 | Control |
| | 4 | 200 | 2/3 beak removed |

[1]These numbers provided one square foot floor space per day-old chick.

Daily observations were made of the chicks to note any incidence of cannibalism in its various forms. Individual observations on the extent of the regrowth of the beak of the chicks of each treatment were made at eight weeks of age.

Experiment II

Trial 1. The purpose of this experiment was to study the variables involved in the process of debeaking chicks. A total of 180 chicks were placed in a total of ten treatments. These treatments are listed in Table II.

The experiment was initiated December 29, 1961. Each treatment group consisted of ten males and ten females. The chicks were grown in two pens and the chicks of various treatments were wing banded and randomly assorted between the pens. The dimensions of the pens were 9 feet two inches by 12 feet and four inches.

An electric debeaker was used for all treatments except 1 and 2 where the beaks were snipped off with a pair of shears. The temperature of the blades in the other treatments were measured by two methods. For the medium hot blade the rheostat of the debeaker was adjusted so as to give a blade on the verge of producing a glow and with a power consumption of sixty watts. For the hot blade the setting was such as to give a cherry red glow and a consumption of eighty-five watts.

The one-half and the two-thirds beak removal treatments at one day of age are illustrated by Figures 2 and 3.

TABLE II

DESIGN OF EXPERIMENT II

| Treatment No. | Treatments | Beak in contact with the blade (seconds) | No. chicks Trial 1 | No. chicks Trial 2 |
|---|---|---|---|---|
| 1 | Cold 1/2 beak removed | | 18 | 40 |
| 2 | Cold 2/3 beak removed | | 18 | 40 |
| 3 | Medium hot 1/2 beak removed | 1 | 18 | 40 |
| 4 | Medium hot 1/2 beak removed | 2 | 18 | 40 |
| 5 | Medium hot 2/3 beak removed | 1 | 18 | 40 |
| 6 | Medium hot 2/3 beak removed | 2 | 18 | 40 |
| 7 | Hot 1/2 beak removed | 1 | 18 | 40 |
| 8 | Hot 1/2 beak removed | 2 | 18 | 40 |
| 9 | Hot 2/3 beak removed | 1 | 18 | 40 |
| 10 | Hot 2/3 beak removed | 2 | 18 | 40 |



Figure 2. The appearance of the beak of a day-old broiler type chick debeaked at one day of age. One-half of the beak was removed using an electrical debeaker.



Figure 3. The appearance of the beak of a day-old broiler type chick debeaked at one day of age. Two-thirds of the beak was removed using an electrical debeaker.

Measurements taken included mortality, individual body weights at eight weeks of age, and the condition of the beaks at eight weeks. The beaks were classified according to the amount of regrowth. A sample of five birds of each treatment was selected at random for the beak observations.

Trial 2. Treatments and procedures were the same in this trial as in Trial 1 except that twenty male and twenty female chicks were used in each treatment group. The birds were grown in four pens with an equal number of each treatment group in each pen. The trial was started on August 17, 1962, and was concluded when the birds were eight weeks of age. Body weights were obtained at four weeks and eight weeks of age. Observations were made at eight weeks of age on the amount of regrowth of the beak of each chick.

Experiment III

A total of 1,800 chicks with seven treatments were used in this experiment. The objective was to compare the performance of debeaked birds versus non-debeaked birds under a number of conditions. These conditions were: debeaked and non-debeaked birds grown in separate pens, debeaked and non-debeaked birds grown intermingled in the same pens, differences in floor space per bird, and differences in feeder space per bird.

All chicks that were debeaked had two-thirds of their upper and one-half of their lower beak removed at one day of age. The floor space allotment per chick was 1.2 square feet

with the exception of those pens with restricted floor space as designated in Table III. The birds in the restricted pens were alloted 0.6 square feet floor space each. All chicks with the exception of those of two pens were alloted 2.4 linear inches of feeder space per chick. Two pens, with restricted feeder space, had 1.2 linear inches per chick.

The design of the experiment showing the distribution of the chicks to the pens and the various treatments is given in Table III.

Mortality and feed consumption to eight weeks of age was recorded by pens. At eight weeks the birds were individually weighed.

Each bird was scored as to the feather condition of its back at eight weeks. A modification of the method reported by Darron and Warren (1943) was used. Each bird was given a score ranging from zero for the well feathered bird up to four for the extreme bareback condition. The standards used are illustrated in Figures 4 to 7.

Experiment IV

Social hierarchy has been a much studied phenomenon in poultry. The social structure of a flock may be related to the vice of cannibalism. Two trials were conducted for the purpose of studying the effects of debeaking on the social organization within a group of chickens.

Trial 1. Twenty male chicks were divided into two groups

TABLE III

DESIGN OF EXPERIMENT III

| Pen No. | Chicks per pen | Treatments[1] |
|---|---|---|
| 1 & 2 | 100 | non-debeaked |
| 3 & 4 | 100 | debeaked |
| 5 & 6 | 100 | 1/2 of chicks debeaked, 1/2 non-debeaked grown intermingled |
| 7 & 8 | 200 | non-debeaked, floor space restricted |
| 9 & 10 | 200 | debeaked, floor space restricted |
| 11 & 12 | 100 | debeaked, feeder space restricted |
| 13 & 14 | 100 | non-debeaked, feeder space restricted |

[1]All debeaked chicks had 2/3 of their beak removed at one day of age. Chicks were provided 1.2 sq. ft. floor space each in all pens except 7, 8, 9 and 10 which had .6 sq. ft. per chick.

Pens 11, 12, 13 and 14 were provided with 1.2 linear inch of feeder space per chick. All other pens were provided with 2.4 linear inches per chick.



Figure 4. An eight week old broiler with a feather score of one.



Figure 5. An eight week old broiler with a feather score of two.

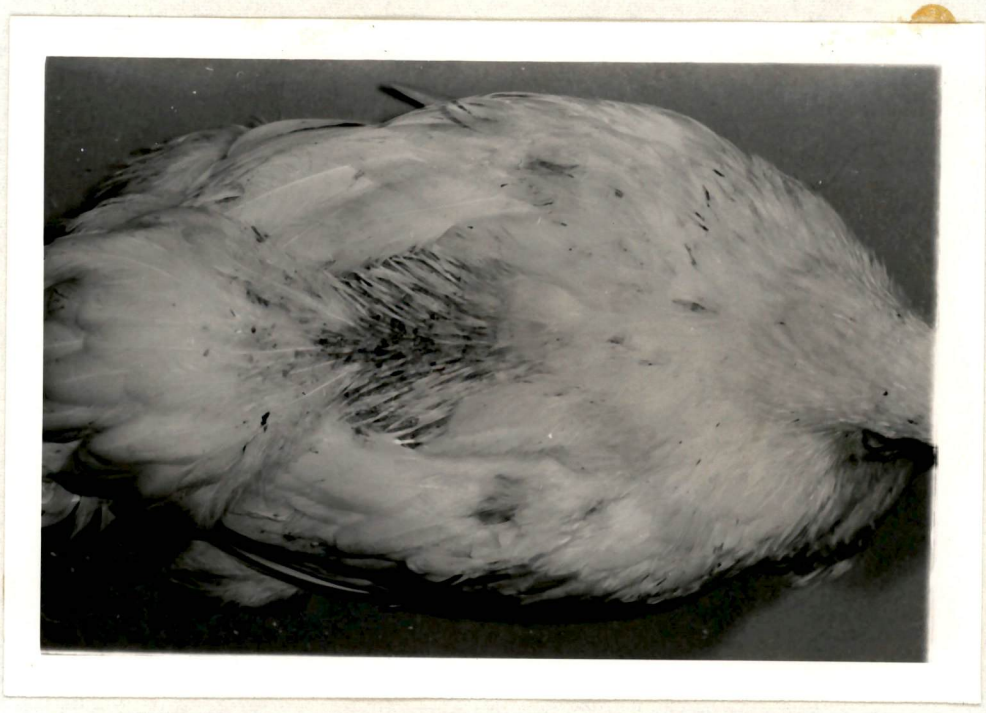


Figure 6. An eight week old broiler with a feather score of three.



Figure 7. An eight week old broiler with a feather score of four.

of ten each. Those of group 1 were debeaked at one day of age. Two-thirds of the beak of each chick was removed. The two groups were reared together in a pen containing approximately 120 square feet. Beginning when the chicks were five weeks of age daily observations for a period of twenty minutes on the number of pecks rendered and received by each of the two groups were made. Chicks were identifiable by groups but not as individuals. Observations were made for 26 days.

Trial 2. Twenty male chicks were reared together in the same pen to six weeks of age. At this time the chicks were marked so that each could be identified from a distance. Beginning at six weeks and continuing for seven days, daily observations for periods of twenty minutes each were made on the number of pecks given and received by each bird. From this information an attempt was made to establish the social position of each bird within the flock. From this array of birds a sample of ten were selected to be a cross section with representatives at all levels of the social organization. These selected birds were debeaked at seven weeks of age. Beginning at the eighth week daily observations were again made for a period of 12 days and the social position of each bird was again determined.

The analysis of variance method, according to Snedecor (1956) was used for statistical analysis of all data with the exception of that pertaining to social organization. For the latter the chi square method was used. Duncan's Multiple Range

Test (1955) was used as a test for statistical significance of mean differences.

## RESULTS AND DISCUSSION

### Experiment I

Growth rate. The weight gains of the chickens debeaked at one day of age are summarized in Tables IV and V. In this experiment, the mean weight of chicks that had one-fourth of the upper beak and tip of the lower beak removed was significantly greater at four weeks of age. Nair (1961) found no difference in four week weights between chicks with the tip of the beak removed and those with two-thirds removed. However, there was no significant difference in the eight week body weights of chicks among the treatmens in this experiment. These results are similar to those obtained by Combs (1955), Lanson (1956), Morgan (1957), Brown (1955), Camp et al. (1955), and Lonsdale et al. (1957). However, removal of two-thirds of the beak by Long (1957) and Lonsdale et al. (1957) resulted in retarded growth, whereas in the experiment reported herein no retardation of size at eight weeks were found from this treatment.

Feed conversion, feed wastage, and mortality. The feed conversion, feed wastage, and mortality of the chicks of various treatments are summarized in Table VI. Feed conversion of the chicks to eight weeks of age was significantly better in the one-fourth and tow-thirds debeaked groups. Improvement in feed conversion has also been found by Lanson (1956), where one-third of the upper beak of chickens was removed and by Long (1957) who removed two-thirds of the beak.

TABLE IV

BODY WEIGHTS AT FOUR WEEKS OF AGE OF CHICKS DEBEAKED AT ONE DAY OF AGE. EXPERIMENT I

| Treatment | Average weights (oz.)[1] | | |
|---|---|---|---|
| | Males | Females | Combined sexes[2] |
| Non-debeaked | 21.2 | 18.6 | 19.9 [b] |
| 1/4 debeaked | 22.4 | 19.1 | 20.8[a] |
| 1/2 debeaked | 21.6 | 18.9 | 20.2 [b] |
| 2/3 debeaked | 21.7 | 18.7 | 20.2 [b] |

[1]Weights were obtained on two groups of twelve birds, selected at random of each sex and of each treatment.

[2]Averages in this column with different superscripts are significantly different as determined by Duncan's Multiple Range Test. P = .05.

TABLE V

BODY WEIGHTS[1] AT EIGHT WEEKS OF AGE OF CHICKS DEBEAKED AT ONE DAY OF AGE. EXPERIMENT I

| Treatment | Average Weights (oz.) | | | | | |
|---|---|---|---|---|---|---|
| | Males | | Females | | Combined sexes | |
| | No. | Av. Wt. | No. | Av. Wt. | No. | Av. Wt.[2] |
| Non-debeaked | 240 | 53.1 | 240 | 44.7 | 480 | 48.9[a] |
| 1/4 debeaked | 240 | 54.7 | 240 | 44.8 | 480 | 49.8[a] |
| 1/2 debeaked | 240 | 54.4 | 240 | 44.5 | 480 | 49.5[a] |
| 2/3 debeaked | 240 | 53.2 | 240 | 44.5 | 480 | 48.9[a] |

[1] Birds individually weighed to nearest ounce.

[2] Averages with the same superscript are not significantly different at the 5 percent level of probability.

TABLE VI

FEED CONVERSION, FEED WASTAGE AND MORTALITY TO EIGHT WEEKS OF AGE. EXPERIMENT I

| Treatment | Lbs. feed / lbs. gain[1] | Feed wastage[1] (oz.)[2] | Mortality per cent[1] |
|---|---|---|---|
| Non-debeaked | 2.34 [b] | 267[a] | 4.2[a] |
| 1/4 | 2.26[a] | 285[a] | 5.2[a] |
| 1/2 | 2.36 [b] | 259[a] | 4.6[a] |
| 2/3 | 2.28[a] | 193[a b] | 3.5[a] |

[1]Averages with different superscripts are significantly different at the 5 percent level of probability as determined by Duncan's Multiple Range Test.

Feed wastage was not deducted from feed consumed in calculating feed conversion.

[2]Per 100 chicks.

No significant differences were found between the amounts of feed wasted by the four treatment groups. The average feed wastage per chick for the entire experiment was two and one-half ounces.

Mortality to eight weeks of age was similar in all groups. Frequent observations of the chicks revealed no evidence of cannibalism in any of the groups.

Beak regrowth. Observations were made but not recorded on each bird as it was weighed at eight weeks to determine the amount of regrowth of the beak. In the two-thirds debeaked groups almost all birds showed no regrowth. In the one-half debeaked groups approximately fifty percent showed little or no regrowth. All of the one-fourth group showed complete regrowth of the beak.

Experiment II

Trial 1. Growth rate. The weight gains of the chickens debeaked at one day of age under various treatments are summarized in Table VII. In this experiment, the growth rate of chicks that had two-thirds of the lower beak removed in contact with the hot blade for two seconds was significantly lower at eight weeks of age.

Mortality. A total of twelve chicks died during the experiment out of a total of 180 chicks. Mortality was not associated with treatment.

TABLE VII

BODY WEIGHTS[1] AT EIGHT WEEKS OF AGE OF CHICKS DEBEAKED AT ONE DAY OF AGE. EXPERIMENT II

| Blade temperature | Time exposed (sec.) | Amt. of beak removed | Body weights (oz.) Males No. | Males Av. wt. | Females No. | Females Av. wt. | Combined sexes No. | Combined sexes Av. wt.[2] |
|---|---|---|---|---|---|---|---|---|
| Cold | -- | 1/2 | 9 | 53.7 | 8 | 44.5 | 17 | 49.1[a] |
| Cold | -- | 2/3 | 10 | 53.6 | 8 | 43.9 | 18 | 48.7[a] |
| Medium | 1 | 1/2 | 8 | 53.1 | 8 | 45.9 | 16 | 49.5[a] |
| Medium | 2 | 1/2 | 9 | 53.2 | 6 | 44.8 | 15 | 49.0[a] |
| Medium | 1 | 2/3 | 10 | 52.9 | 7 | 44.8 | 17 | 48.8[a] |
| Medium | 2 | 2/3 | 10 | 52.8 | 7 | 42.6 | 17 | 47.7[a] |
| Hot | 1 | 1/2 | 9 | 51.4 | 7 | 45.6 | 16 | 48.5[a] |
| Hot | 2 | 1/2 | 9 | 54.1 | 8 | 44.2 | 17 | 49.2[a] |
| Hot | 1 | 2/3 | 10 | 52.0 | 8 | 44.6 | 18 | 48.3[a] |
| Hot | 2 | 2/3 | 9 | 42.8 | 8 | 41.1 | 17 | 41.9[b] |

[1]Birds individually weighed to nearest ounce.

[2]Averages with different superscripts are significantly different at the 1 percent level of probability as determined by Duncan's Multiple Range Test.

Beak regrowth. The measurements of the beaks are summarized in Table VIII. Figures 8 to 18 give examples of the beak condition at eight weeks of age of chicks receiving each treatment.

Trial 2. Growth rate. The weight gains of the chickens debeaked at one day of age are summarized in Tables IX and X. In this experiment, the growth rate of chickens that had two thirds of the upper beak and half of the lower beak removed in contact with the hot blade for two seconds was significantly lower at four weeks of age and eight weeks of age.

Mortality. A total of eleven chicks died during the experiment out of a total of 400 chicks. Mortality was not associated with any one treatment.

Beak regrowth. The measurements of the beaks are summarized in Table XI.

The data secured in trials 1 and 2, show that several factors must be considered in debeaking chicks if permanent debeaking is to result. It was found that in order to obtain a high percentage of permanently debeaked chicks that the cutting blade must have a temperature of medium to hot and that approximately two-thirds of the beak must be removed. It was also found that the length of time the beak was exposed to the cutting blade had some effect upon the amount of regrowth of the beak. It appears that in order to obtain the permanent debeaked condition it is necessary that heat be applied in close proximity to the base of the beak. In this experiment where a heated blade was

TABLE VIII

REGROWTH OF BEAKS AT EIGHT WEEKS OF BIRDS DEBEAKED AT ONE DAY OF AGE. EXPERIMENT II, TRIAL 1

| Treatment | | | |
|---|---|---|---|
| Blade temperature | Time exposed (sec.) | Amt. of beak removed | Percentage of birds showing regrowth of the beak[1] |
| Cold | -- | 1/2 | 100 |
| Cold | -- | 2/3 | 80 |
| Medium | 1 | 1/2 | 60 |
| Medium | 2 | 1/2 | 60 |
| Medium | 1 | 2/3 | 60 |
| Medium | 2 | 2/3 | 40 |
| Hot | 1 | 1/2 | 40 |
| Hot | 2 | 1/2 | 40 |
| Hot | 1 | 2/3 | 20 |
| Hot | 2 | 2/3 | 20 |

[1]Based on five birds randomly selected from each treatment.



Figure 8. The appearance of the beak of a typical eight week old broiler chick not debeaked.



Figure 9. The appearance of the beak of a typical eight week old broiler chick debeaked at one day of age. One-half of the beak was removed using a cold blade.



Figure 10. The appearance of the beak of a typical eight week old broiler chick debeaked at one day of age. Two-thirds of the beak was removed using a cold blade.



Figure 11. The appearance of the beak of a typical eight week old broiler chick debeaked at one day of age. One-half of the beak was removed keeping the beak in contact with a medium hot blade for one second.



Figure 12. The appearance of the beak of a typical eight week old broiler chick debeaked at one day of age. One-half of the beak was removed keeping the beak in contact with a medium hot blade for two seconds.



Figure 13. The appearance of the beak of a typical eight week old broiler chick debeaked at one day of age. Two-thirds of the beak was removed keeping the beak in contact with a medium hot blade for one second.



Figure 14. The appearance of the beak of a typical eight week old broiler chick debeaked at one day of age. Two-thirds of the beak was removed keeping the beak in contact with a medium hot blade for two seconds.



Figure 15. The appearance of the beak of a typical eight week old broiler chick debeaked at one day of age. One-half of the beak was removed keeping the beak in contact with a hot blade for one second.



Figure 16. The appearance of the beak of a typical eight week old broiler chick debeaked at one day of age. One-half of the beak was removed keeping the beak in contact with a hot blade for two seconds.



Figure 17. The appearance of the beak of a typical eight week old broiler chick debeaked at one day of age. Two-thirds of the beak was removed keeping the beak in contact with a hot blade for one second.



Figure 18. The appearance of the beak of a typical eight week old broiler chick debeaked at one day of age. Two-thirds of the beak was removed keeping the beak in contact with a hot blade for two seconds.

TABLE IX

BODY WEIGHTS[1] AT FOUR WEEKS OF AGE OF CHICKS DEBEAKED AT ONE DAY OF AGE. EXPERIMENT II, TRIAL 2

| Treatment | | | Males | | Females | | Combined sexes | |
|---|---|---|---|---|---|---|---|---|
| Blade temperature | Time exposed (sec.) | Amt. of beak removed | No. | Av. wt. | No. | Av. Wt. | No. | Av. wt.[2] |
| Cold | -- | 1/2 | 20 | 533.1 | 21 | 496.6 | 41 | 514.8[a] |
| Cold | -- | 2/3 | 20 | 513.2 | 18 | 484.3 | 38 | 498.9[ab] |
| Medium | 1 | 1/2 | 17 | 525.8 | 17 | 451.7 | 34 | 488.7[abc] |
| Medium | 2 | 1/2 | 20 | 525.9 | 15 | 493.8 | 35 | 509.8[a] |
| Medium | 1 | 2/3 | 15 | 514.4 | 20 | 451.8 | 35 | 483.1[abcd] |
| Medium | 2 | 2/3 | 21 | 484.3 | 22 | 426.0 | 43 | 455.1[bcde] |
| Hot | 1 | 1/2 | 18 | 537.5 | 16 | 487.7 | 34 | 512.6[a] |
| Hot | 2 | 1/2 | 18 | 554.9 | 19 | 471.5 | 37 | 513.2[a] |
| Hot | 1 | 2/3 | 18 | 495.6 | 20 | 395.7 | 38 | 445.6[cde] |
| Hot | 2 | 2/3 | 19 | 408.0 | 22 | 381.5 | 41 | 394.7[f] |

[1]Birds individually weighed to nearest gram.

[2]Averages with different superscripts are significantly different at the five percent level of probability as determined by Duncan's Multiple Range Test.

TABLE X

BODY WEIGHTS[1] AT EIGHT WEEKS OF AGE OF CHICKS DEBEAKED AT ONE DAY OF AGE. EXPERIMENT II, TRIAL 2

| Treatment | | | Body weights (oz.) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Males | | Females | | Combined sexes[2] | |
| Blade temperature | Time exposed (sec.) | Amt. of beak removed | No. | Av. wt. | No. | Av. wt. | No. | Av. wt. |
| Cold | -- | 1/2 | 17 | 54.8 | 17 | 45.8 | 34 | 50.3$^{ab}$ |
| Cold | -- | 2/3 | 17 | 53.6 | 17 | 47.4 | 34 | 50.5$^{ab}$ |
| Medium | 1 | 1/2 | 17 | 53.4 | 17 | 43.5 | 34 | 48.5$^{ab}$ |
| Medium | 2 | 1/2 | 17 | 54.9 | 17 | 46.1 | 34 | 50.5$^{ab}$ |
| Medium | 1 | 2/3 | 17 | 50.9 | 17 | 42.3 | 34 | 46.7$^{ab}$ |
| Medium | 2 | 2/3 | 17 | 51.4 | 17 | 41.2 | 34 | 46.3$^{ab}$ |
| Hot | 1 | 1/2 | 17 | 55.2 | 17 | 44.7 | 34 | 49.9$^{ab}$ |
| Hot | 2 | 1/2 | 17 | 58.1 | 17 | 43.5 | 34 | 50.8$^{a}$ |
| Hot | 1 | 2/3 | 17 | 50.3 | 17 | 40.4 | 34 | 45.4$^{b}$ |
| Hot | 2 | 2/3 | 17 | 43.2 | 17 | 36.8 | 34 | 40.0$^{c}$ |

[1]Birds individually weighed to nearest ounce.

[2]Averages with different superscripts are significantly different at the five percent level of probability as determined by Duncan's Multiple Range Test.

TABLE XI

REGROWTH OF BEAKS AT EIGHT WEEKS OF AGE OF BIRDS DEBEAKED AT ONE DAY OF AGE. EXPERIMENT II, TRIAL 2

| Treatments | | | | Beak condition at eight weeks[1] | | |
|---|---|---|---|---|---|---|
| Blade temperature | Time exposed (sec.) | Amt. of beak removed | Sex | No regrowth | Some growth | Complete regrowth |
| Cold | -- | 1/2 | M | 5.8 | -- | 94.1 |
| | | | F | -- | -- | 100.0 |
| Cold | -- | 2/3 | M | -- | 70.6 | 29.4 |
| | | | F | -- | 58.8 | 41.2 |
| Medium | 1 | 1/2 | M | -- | 5.9 | 94.1 |
| | | | F | -- | 5.9 | 94.1 |
| Medium | 2 | 1/2 | M | -- | 35.3 | 67.7 |
| | | | F | -- | 11.8 | 88.2 |
| Medium | 1 | 2/3 | M | 70.6 | 29.4 | -- |
| | | | F | 100.0 | -- | -- |
| Medium | 2 | 2/3 | M | 100.0 | -- | -- |
| | | | F | 100.0 | -- | -- |
| Hot | 1 | 1/2 | M | -- | 100.0 | -- |
| | | | F | 52.9 | 41.2 | 5.9 |
| Hot | 2 | 1/2 | M | 35.3 | 64.7 | -- |
| | | | F | 64.7 | 35.3 | -- |

TABLE XI (cont.)

| Treatments | | | | Beak condition at eight weeks[1] | | |
|---|---|---|---|---|---|---|
| Blade temperature | Time exposed (sec.) | Amt. of beak removed | Sex | No regrowth | Some growth | Complete regrowth |
| Hot | 1 | 2/3 | M | 100.0 | -- | -- |
| | | | F | 100.0 | -- | -- |
| Hot | 2 | 2/3 | M | 100.0 | -- | -- |
| | | | F | 100.0 | -- | -- |

[1] In percentage.

not used there was regrowth of the beak of almost one hundred percent of the chicks.

It was also found that the process of debeaking day-old chicks can affect their growth rate. In Trial 1 and 2 those lots of chicks receiving the hot-two-third-two seconds treatment had a significantly lower average body weight at eight weeks than did the other lots. This was also true at four weeks in Trial 2. These results indicate that a high percentage of permanently debeaked chicks will not result if no more than one-half of the beak is removed using a blade medium to hot in respect to temperature and also that the conditions necessary for a high percentage of permanently debeaked chicks may result in a reduction in growth rate.

Experiment III

Growth rate. The eighth week average body weights of debeaked and non-debeaked chicks grown under various conditions are given in Tables XII and XIII.

Chicks receiving 1.2 square foot of floor space and 2.4 linear inches of feeder space per chick, averaged 49.1 ounces each for the non-debeaked birds as compared to 43.6 ounces for the debeaked birds. Non-debeaked birds in pens providing .6 square feet of floor space averaged 45.9 ounces while the debeaked birds in this comparison averaged 40.4 ounces. Non-debeaked birds provided with only 1.2 linear inches of feeder space each averaged 46.4 ounces. Debeaked birds in this comparison averaged

TABLE XII

BODY WEIGHTS AT EIGHT WEEKS OF AGE OF CHICKS DEBEAKED AT ONE DAY OF AGE. EXPERIMENT III

| Treatments | | | Body weights[1] (oz.) | | |
|---|---|---|---|---|---|
| Beak | Sq. ft. floor space per chick | Linear in. feeder space per chick | Males[2] | Females[2] | Combined sexes[3] |
| Non-debeaked | 1.2 | 2.4 | 54.5 | 43.5 | 49.1[a] |
| Debeaked | 1.2 | 2.4 | 49.9 | 38.2 | 43.6[c] |
| Debeaked & non-debeaked | 1.2 | 2.4 | 51.9 | 42.0 | 47.4[ab] |
| Non-debeaked | .6 | 2.4 | 50.6 | 39.7 | 45.9[bc] |
| Debeaked | .6 | 2.4 | 49.3 | 33.2 | 40.4[d] |
| Non-debeaked | 1.2 | 1.2 | 50.8 | 40.8 | 46.4[b] |
| Debeaked | 1.2 | 1.2 | 43.7 | 34.6 | 40.6[d] |

[1]Birds individually weighed to nearest ounce.

[2]Ninety-four chicks per group.

[3]Averages with different superscripts are significantly different at the 5 percent level of probability as determined by Duncan's Multiple Range Test.

TABLE XIII

BODY WEIGHTS AT EIGHT WEEKS OF AGE OF DEBEAKED AND NON-DEBEAKED CHICKS GROWN INTERMINGLED IN SAME PENS. EXPERIMENT III

| Treatments | Body weights (oz.)[1] | | | | | |
|---|---|---|---|---|---|---|
| | Males | | Females | | Combined sexes[2] | |
| | No. | Av. wt. | No. | Av. wt. | No. | Av. wt. |
| Debeaked | 49 | 51.3 | 48 | 39.9 | 97 | 45.6 [b] |
| Non-debeaked | 45 | 54.7 | 46 | 43.4 | 91 | 49.1[a] |

[1] Birds individually weighed to nearest ounce.

[2] Averages in this column with different superscripts are significantly different as determined by Duncan's Multiple Range Test, p = .01.

40.6 ounces. The differences between the two means in each of the three comparisons mentioned above are statistically significant. It could be concluded that debeaking as practiced in this experiment had an inhibiting effect upon growth.

Table XIII gives the weights of the debeaked and non-debeaked birds grown intermingled in the same pens. The non-debeaked birds averaged 5.5 ounces more than the non-debeaked birds. In comparison, the difference between the non-debeaked and the debeaked birds grown separately, but with conditions equal otherwise, was 3.5 ounces.

Data presented in Table XII show that both floor space restriction and feeder space restriction resulted in a decreased rate of growth.

In opinion of the writer, based upon previous experiments reported herein and on investigations conducted previously at this station, that the severity of debeaking of the chicks in this experiment was greater than that anticipated and desired. It is felt that slightly more than two-thirds of the beak of the chicks was actually removed. This could account for the reduction in growth rate obtained as compared to the first experiment and also for the large number of birds whose nares were involved (see Figure 18). Considering the factors of growth rate and the permanency of debeaking, the optimal amount of the beak to remove in debeaking day-old chicks probably lies between one-half and two-thirds.

Feed conversion. The pounds of feed required per pound

of gain for each of the treatment groups is shown in Table XIV. No differences were found in the feed efficiency of pens of debeaked birds compared to pens of non-debeaked birds. The pens in which the birds received 0.6 square foot of floor space had the best feed efficiency of all groups. Results of a similar nature were obtained by Nair (1961), who found that broilers receiving 0.5 sq. feet of floor space had better feed efficiency than those receiving .75 square feet or 1.0 square feet of floor space per chick. The feed efficiency of the pens where the debeaked and the non-debeaked birds grown intermingled was the poorest of all the treatment groups but not significantly different from the debeaked or non-debeaked chicks with the same amount of floor space per chick on 1.2 linear inches of feeder space per chick.

Barebacks. The highest incidence of barebacks in this experiment occured among the non-debeaked birds with restricted floor space (see Table XIV). The percentage of birds in these two pens showing some degree of barebackness was 11.8 percent. Practically all of the barebacks of this treatment, however, occured in the pen located on the south or sunny side of the house. In this pen 21.7 percent of the birds were barebacks and this figure, as tested by the chi-square method, was statistically different from the percentages of the other pens in the experiment.

From the results of this experiment it can readily be

TABLE XIV

FEED CONVERSION, INCIDENCE OF BAREBACKS, AND MORTALITY AT EIGHT WEEKS OF AGE. EXPERIMENT III

| Beak | Sq. ft. floor space per chick | Linear in. feeder space per chick | Lbs. feed / lbs. gain[1] | Incidence of barebacks % of birds/classification 0 | 1 | 2 | 3 | 4 | 1-4 | Mortality[1] percent |
|---|---|---|---|---|---|---|---|---|---|---|
| Non-debeaked | 1.2 | 2.4 | 2.17$^{ab}$ | 100 | -- | -- | -- | -- | 0 | 5.0$^{a}$ |
| debeaked | 1.2 | 2.4 | 2.16$^{ab}$ | 100 | -- | -- | -- | -- | 0 | 7.0$^{a}$ |
| debeaked & non-debeaked | 1.2 | 2.4 | 2.39$^{c}$ | 100 | -- | -- | -- | -- | 0 | 3.0$^{a}$ |
| non-debeaked | .6 | 2.4 | 2.06$^{a}$ | 88.2 | 3.5 | 2.3 | 4.0 | 2.0 | 11.8[2] | 4.2$^{a}$ |
| debeaked | .6 | 2.4 | 2.01$^{a}$ | 98.4 | -- | -- | .5 | -- | 1.1 | 5.5$^{a}$ |
| debeaked | 1.2 | 1.2 | 2.23$^{bc}$ | 100 | -- | -- | -- | -- | 0 | 10.0$^{a}$ |
| non-debeaked | 1.2 | 1.2 | 2.27$^{bc}$ | 100 | -- | -- | -- | -- | 0 | 9.0$^{a}$ |

[1]Averages with different superscripts are significantly different at the 5 percent level of probability as determined by Duncan's Multiple Range Test.

[2]Chi-square = 461.73 significant at p = .01. The high incidence of barebacks in this treatment were accounted for almost entirely by the replicate pen on the south side of the brooder house.

seen that debeaking of chicks would be more advantageous under conditions which have a tendency to promote cannibalism. The conditions of limited floor space, excessive light and/or higher room temperature apparently were responsible for the high incidence of barebacks in the one pen. In the crowded pen on the same side of the house, serving as a control pen, the occurrence of barebacks or cannibalism was zero among the debeaked chicks.

Mortality. The percent mortality of birds of each of the treatments is given in Table XIV. While differences in these percentages are not statistically significant, it might be of some interest to note that the mortality in the four pens where feeder space was limited was higher than in the other pens of the other treatments.

Experiment IV

Trial 1. The average number of pecks given and received by the debeaked and non-debeaked groups of birds is presented in Table XV. The data show that the non-debeaked birds averaged 9.7 pecks rendered for the observation period as compared to 6.3 pecks for the debeaked birds. The difference between these two means is statistically significant. As there was no significant difference between the pecks received by the two groups, it is apparent that the two groups rendered their pecks indiscerminately in regard to whether their victims are debeaked or not.

Trial 2. The results of this trial are shown in Table XVI. Some of the birds rating high in social position at seven

TABLE XV

FREQUENCIES[1] OF PICKS OF DEBEAKED AND NON-DEBEAKED CHICKS REARED INTERMINGLED. EXPERIMENT IV, TRIAL 1

| Treatments | No. chicks | Pecks rendered (Av. per bird) | Pecks received (Av. per bird) |
|---|---|---|---|
| Non-debeaked | 10 | 9.7 | 7.4 |
| Debeaked | 10 | 6.3 | 8.6 |
| Difference | | 3.4** | 1.2 |

[1]Observations made for 20 min/day for 26 days commencing at 5 wks. of age.

**Statistically significant at P = .01 as tested by Chi-Square.

TABLE XVI

THE EFFECTS OF DEBEAKING UPON MAINTENANCE OF SOCIAL POSITION. EXPERIMENT IV, TRIAL 2

| Social rank | Array[1] of birds according to peck order | |
|---|---|---|
| | Before debeaking (6th-7th week) | After debeaking (12 days) |
| 1 | 1,* 3 | 2, 9 |
| 2 | 7,* 14* | 7* |
| 3 | 5* | 13, 15, 17 |
| 4 | 10 | 1* |
| 5 | 6 | 20* |
| 6 | 2 | 3, 16* |
| 7 | 17 | 4*, 18* |
| 8 | 4*, 11 | 10 |
| 9 | 20* | 8 |
| 10 | 12*, 15, 19* | |
| 11 | 13 | |
| 12 | 18* | |
| 13 | 8 | |
| 14 | 9, 16* | |

[1]In order of social dominance.

[2]Denotes birds debeaked at the end of seventh week.

weeks of age were found occupying a lower position at the end of the second observation period also some of those ranking low in social aggressiveness during the first period occupied a higher position during the second period. This was so regardless of whether the birds were debeaked or not. While these results may be considered inconclusive, they gave indications that debeaking had little influence upon the social status for the group as a whole.

## SUMMARY

A total of 4,820 broiler-type chicks was used in a series of four experiments designed to study methods of debeaking day-old chicks and the effects of debeaking upon growth rate, mortality, feed conversion, feed wastage, barebacks, and peck order.

Experiment I consisted of four treatments: control, one-fourth of beak removed, one-half of beak removed, and two-thirds of beak removed. Debeaking was performed at one day of age. At four weeks the one-fourth debeaked groups was significantly heavier than the other three groups. At eight weeks of age differences in body weight were no longer significant. Feed conversion was best in groups having one-fourth and two-thirds of the beak removed. No significant differences were found in feed wastage or mortality between the four groups.

In Experiment II chicks were debeaked at one day of age using combination of three cutting blade temperatures: cold, medium, and hot; one and two seconds contact times of the beaks to the blade, and two degrees of beak removal: one-half and two-thirds. In both of two trials the chicks that had two-thirds of their beak removed using a hot blade with an exposure time of two seconds were significantly lighter in body weights at eight weeks of age. It was found that if a cold cutting blade was used in the debaking process, regrowth of the beaks occured by eight weeks of age. This was true regardless of whether one-

half or two-thirs of beak was removed. It was also found that to obtain a high percentage of chicks at eight weeks of age with no regrowth of the beak the removal of two-thirds of the beak was necessary using a blade with medium temperature.

In Experiment III debeaked and non-debeaked birds were compared under a number of conditions. In all comparisons of this experiment the nondebeaked birds were heavier at eight weeks than the debeaked birds. Birds grown to 8 weeks of age, given 0.6 square feet floor space each were lighter in weight than were those receiving 1.2 square feet of floor space each. Reducing the feeder space per chick from 2.4 inches to 1.2 inches also resulted in reduced size at 8 weeks of age. Of the non-debeaked birds in one group receiving .6 square feet of floor space each 20.7 percent were classified as barebacks whereas 1.1 percent barebacks occured among debeaked birds with this amount of floor space. The pounds of feed required per pound of weight was less at .6 square feet per bird than at 1.2 square feet of floor space. Debeaked birds were found to grow as well when intermingled with non-debeaked birds as they did when grown in pens where all the birds were debeaked.

When non-debeaked and debeaked birds were reared in the same pen it was found in Experiment IV that the non-debeaked birds rendered more pecks than the debeaked birds. There was no difference in the number of pecks received per bird by the two groups. In Trial 2 of Experiment IV a study was conducted

to determine the effect of debeaking upon a flock with an established social order. Social positions of birds apparently were not altered by debeaking at seven weeks of age.

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# APPENDIX

ANALYSIS OF VARIANCE OF BODY WEIGHTS IN TABLE I

| Source of Variance | Degrees of freedom | Mean square | F value | F test |
|---|---|---|---|---|
| Total | 47 | | | |
| Sex | 1 | 14,595.20 | | |
| Treatment | 3 | 213.40 | 4.55 | * |
| Sex x treatment | 3 | 47.07 | | |
| Pens tr. alike | 16 | 69.92 | | |
| Error | 24 | 46.94 | | |

*Significant at five percent level of probability.

ANALYSIS OF VARIANCE OF BODY WEIGHTS IN TABLE II

| Source of variance | Degrees of freedom | Mean square | F value | F test |
|---|---|---|---|---|
| Total | 1919 | | | |
| Sex | 1 | 40,868 | | |
| Treatment | 3 | 89.33 | 2.28 | NS |
| Sex x treatment | 3 | 70.67 | | |
| Pens treated alike | 16 | 117.69 | | |
| Error | 1896 | 39.26 | | |

NS not significant.

ANALYSIS OF VARIANCE OF FEED EFFICIENCY IN TABLE III

| Source of variance | Degrees of freedom | Mean square | F value | F test |
|---|---|---|---|---|
| Total | 11 | | | |
| Treatments | 3 | 0.0217 | 21.7 | ** |
| Replications | 2 | 0.1062 | | |
| Error | 6 | .001 | | |

**Significant at one percent level of probability.

ANALYSIS OF VARIANCE OF FEED WASTAGE IN TABLE IV

| Source of variance | Degree of freedom | Mean square | F value | F test |
|---|---|---|---|---|
| Total | 11 | | | |
| Treatments | 3 | 4808.0024 | 1.1227 | NS |
| Replications | 2 | 7630.6139 | 1.9435 | NS |
| Error | 6 | 3926.2262 | | |

NS not significant.

ANALYSIS OF VARIANCE OF MORTALITY IN TABLE V

| Source of variance | Degrees of freedom | Mean square | F value | F test |
|---|---|---|---|---|
| Total | 11 | | | |
| Treatments | 3 | 3.78 | 0.42 | NS |
| Replications | 2 | 32.25 | 3.57 | NS |
| Error | 6 | 9.03 | | |

NS not significant.

ANALYSIS OF VARIANCE OF BODY WEIGHTS IN TABLE VI

| Source of variance | Degree of freedom | Mean square | F value | F test |
|---|---|---|---|---|
| Total | 167 | | | |
| Sex | 1 | 2536.26 | 101.4 | ** |
| Treatments | 9 | 91.42 | 3.65 | ** |
| Sex x treatment | 9 | 23.46 | 0.94 | NS |
| Error | 148 | 25.01 | | |

**Significant at one percent level of probability.
NS not significant.

ANALYSIS OF VARIANCE OF BODY WEIGHTS IN TABLE VII

| Source of variance | Degrees of freedom | Mean square | F value | F test |
|---|---|---|---|---|
| Total | 375 | | | |
| Sex | 1 | 152010.22 | 28.01 | ** |
| Treatments | 9 | 44983.07 | 8.29 | ** |
| Sex x treatment | 9 | 20283.52 | 3.74 | ** |
| Error | 356 | 5426.68 | | |

**Significant at one percent level of probability.

ANALYSIS OF VARIANCE OF BODY WEIGHTS IN TABLE VIII

| Source of variance | Degrees of freedom | Mean square | F value | F test |
|---|---|---|---|---|
| Total | 339 | | | |
| Sex | 1 | 7529.41 | 175.02 | ** |
| Treatments | 9 | 397.81 | 9.25 | ** |
| Sex x treatment | 9 | 45.61 | 1.05 | NS |
| Error | 320 | 43.02 | | |

**Significant at one percent level of probability.

NS not significant.

ANALYSIS OF VARIANCE OF BODY WEIGHTS IN TABLE IX

| Source of variance | Degrees of freedom | Mean square | F value | F test |
|---|---|---|---|---|
| Total | 1315 | | | |
| Treatment | 6 | 2101.63 | 68.54 | ** |
| Sex | 1 | 41532.25 | 1354.61 | ** |
| Block | 1 | 113.80 | 3.71 | NS |
| Sex x treatment | 6 | 216.90 | 7.07 | ** |
| Sex x block | 1 | 0.05 | | NS |
| Treatment x block | 6 | 109.35 | 3.57 | ** |
| Error | 1294 | 30.66 | | |

**Significant at one percent level of probability.

NS not significant.

ANALYSIS OF VARIANCE BODY WEIGHTS IN TABLE X

| Source of variance | Degrees of freedom | Mean square | F value | F test |
|---|---|---|---|---|
| Total | 187 | | | |
| Treatment | 1 | 512.04 | 14.53 | ** |
| Sex | 1 | 5864.36 | 166.41 | ** |
| Block | 1 | 37.53 | 1.06 | NS |
| Sex x treatment | 1 | 37.77 | 1.07 | NS |
| Error | 183 | 35.24 | | |

**Significant at one percent level of probability.

NS not significant.

ANALYSIS OF VARIANCE OF FEED EFFICIENCY IN TABLE XI

| Source of variance | Degrees of freedom | Mean square | F value | F test |
|---|---|---|---|---|
| Total | 13 | | | |
| Treatment | 6 | 0.035 | 5.20 | * |
| Block | 1 | 0.100 | 1.49 | NS |
| Error | 6 | 0.0067 | | |

*Significant at five percent level of probability.

NS not significant.

ANALYSIS OF VARIANCE OF MORTALITY IN TABLE XII

| Source of variance | Degrees of freedom | Mean square | F value | F test |
|---|---|---|---|---|
| Total | 13 | | | |
| Treatment | 6 | 2.36 | 0.335 | NS |
| Block | 1 | 11.17 | 1.590 | NS |
| Error | 6 | 7.04 | | |

NS not significant