The Effects of Beak Trimming and Claw Reduction on Growing and Early Laying Parameters, Fearfulness, and Heterophil to Lymphocyte Ratios

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ABSTRACT

Commercial equipment used by the turkey industry at hatch sterilizes the germinal tissue of the claw with microwave energy and the beak tissue with infrared energy. This effectively claw and beak trims the birds. To test this technique on chickens, one-half of two strains of 1,200 Leghorn chicks were each subjected to the claw reduction (RC) technique at hatch, while one-half retained intact claws (IC). The beaks of one-third of these treatments were reduced at hatch using the infrared technique (1-day), one-third were precision trimmed at 7 d of age (7-day), and one-third were not trimmed (IB). Body weight, weight gain, feed intake, feed conversion, mortality, and fearfulness were measured. Rearing followed standard commercial feeding and husbandry procedures. During the preliminary experiment, heterophil to lymphocyte ratios did not consistently differ significantly between treatments. The RC birds had significantly lower body weight, except from 3 to 6 wk and had significantly lower feed consumption from 8 to 18 wk. The 1-day beak trimmed (BT) birds had significantly lower body weight from 3 to 14 wk and ate less total feed by 4 wk. Subjective evaluation showed that the RC birds exhibited less fearfulness during the growing period than the IC birds. Throughout lay, the body weight of RC and BT birds was significantly affected. Feed consumption was not lessened for RC birds, but was for BT birds throughout lay. Egg production, egg quality, and mortality were not affected by either treatment.

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INTRODUCTION

Background

In their natural habitat, chickens traditionally use their claws and sharp beaks for defense and searching for food. However, the domestic hen housed in commercial laying cages does not need claws or sharp pointed beaks. Beak trimming of commercial laying hens is a standard husbandry practice. However, claw removal is not. Claws of laying hens in cages can grow longer than normal lengths because there is no opportunity for the hen to keep them worn down naturally. Postulating that sharp claws of any length may contribute to hysteria in chickens, Ruszler was the first to remove the claws of 23 wk old pullets in an attempt to control the hysteria phenomenon in a two year study begun in 1968 and reported in 1970. Although hysteria failed to develop, claw removal had other positive effects. Ruszler and Kiker (1975) pursued these effects by declawing chicks at 1 d of age in the hatchery as did Sefton (1976 and 1977), Compton *et al.* (1981), Goodling *et al*. (1984), Martin *et al*. (1976), and Satterlee *et al*. (1985). The procedure was successfully tested commercially between 1978 and 1980 (Coles and Martin, personal communication) but abandoned due to inaccuracies of the amputation procedure and the high labor costs. In 1993, computer controlled equipment called a microwave claw processor (Nova-Tech Engineering, Inc.) was introduced and eliminated these inaccuracies and reduced the labor cost to an acceptable level. Similar equipment called a poultry service processor (Nova-Tech Engineering, Inc., 1996) was also designed to beak trim 1 d old chicks in the hatchery. A study was developed to evaluate the effect of those two new technologies on newer Leghorn strains.

Claw Reduction

The average length of claws of laying hens housed in cages is about 36 mm, compared to only 30 mm for hens in aviaries (Taylor and Hurnik, 1994). The claws of laying hens housed in multi-bird cages are a potential source of injury, leaving the egg industry vulnerable to criticism by animal welfare claims that these claws may become caught in the cage. Pain from injury may also cause stress or hysteria. Scratch bars in the cages are being required in some European countries to allow the hen to keep the claw worn down naturally. Removing the three front claws of laying hens has been studied in an effort to reduce fearfulness and injuries. Claw removal has been adopted and widely practiced by the turkey industry in order to prevent carcass downgrading caused by scratching and tearing of breast tissue. In 1949, Marsden and Martin were the first to recommend turkey claw trimming using an electric debeaker (Owings *et al*., 1972). Claw reduction, also termed declawing, detoeing, toe clipping, toe trimming, and claw trimming may also have beneficial effects on growth and production parameters of laying hens.

Body weight and body weight gain have been affected by claw reduction. Pullets claw trimmed at 23 wk of age with a hot blade debeaker had an average final body weight that was 25 g lower at 72 wk than birds with claws (Ruszler and Quisenberry, 1979). Compton *et al.* (1981a) noted similar results, with body weights of the claw trimmed group being significantly lower than the control, until 20 wk of age. This early body weight reduction is thought to be caused by the initial stress of the trimming. These authors reported a similar pattern for body weight gain, in that the intact claw group gained most of its weight from 8 to 14 wk, whereas the trimmed group had a gain that was delayed to between 14 and 20 wk of age. Goodling *et al.* (1984) trimmed claws of chickens in the hatchery and also reported that the reduced claw birds had significantly lower body weight, but no difference in body weight gain throughout the growing period in two of three experiments. Four weeks following the onset of sexual maturity, claw trimmed birds also had significantly lower body weight (Compton *et al*., 1981b). However, not all studies have shown similar trends. In an initial claw reduction study, no significant difference was seen in body weight at 16 wk of age between claw trimmed and control pullets. In fact, claw trimmed birds were significantly heavier at 20 wk of age (Ruszler and Kiker, 1975). Owings *et al*. (1972) claw trimmed turkeys at 1 d of age and found no significant difference in body weight from the control. In turkeys, Proudfoot *et al*. (1979) found reduced claw birds had decreased body weight at 4 wk of age. Newberry (1992) reported a similar decrease, but not until 14 wk of age. Body weight differences between birds with intact or trimmed claws have varied between studies. Most often, lower body weight and gain have been observed as a result of claw reduction.

Feed consumption and efficiency have usually shown similar depressed results as body weights. In an early study, birds that were claw trimmed at 23 wk of age had significantly poorer feed conversion than controls (Ruszler and Quisenberry, 1979). Birds claw trimmed using a hot blade debeaker at 1 d of age showed no significant difference in feed consumption at 20 wk of age (Ruszler and Kiker, 1975). In a study conducted by Compton *et al.* (1981a), birds that were claw trimmed at 1 d of age ate significantly less feed than intact birds during the first 3 wk, but no differences were seen thereafter. This reduction in feed intake may have been due to the insult of the injury. Perhaps it takes the birds some time to come back to equal performance levels of the untrimmed birds when treated at such a young age. The authors also reported that the intact claw group had greater feed conversion from 8 to 14 wk of age, but the declawed group had greater feed conversion from 14 to 20 wk. Owings *et al*. (1972) reported no difference in feed conversion for the growing and laying periods in turkeys. Goodling *et al*. (1984) found decreased feed consumption, but no differences in feed conversion. When claw trimmed at 1 d of age with a hot blade debeaker, birds had significantly lower feed consumption during the first 4 wk of egg production. However, later in lay, there was no difference in feed conversion between trimmed and intact groups (Compton *et al*., 1981b). Martin *et al*. (1976) found that claw reduction improved feed conversion throughout the laying period. Most studies seemed to agree that reduced claw birds had depressed feed consumption during growout and into early lay. However, results vary concerning feed conversion.

When researching the effects of claw reduction, mortality is an important consideration. When claws were trimmed at 23 wk of age, mortality was higher than for the control. The stress of the procedure and the impreciseness of the early method may have been the cause for this increased death rate (Ruszler and Quisenberry, 1979). When turkeys were claw trimmed at 1 d of age, Owings *et al*. (1972) and Newberry (1992) found higher mortality during the first few weeks following the treatment. This elevated mortality may have been caused by toe pecking when the birds saw the wound, not allowing it to heal. However, in later studies when the claws of pullets were trimmed at 1 d of age, no significant effects on mortality during the growing period were reported (Compton *et al*., 1981a; Goodling *et al*., 1984). However, claw trimming has shown to be beneficial. During the initial part of production, mortality for the declawed group was significantly reduced (Compton *et al*., 1981b; Satterlee *et al*., 1985). If mortality levels do rise initially, perhaps improved rates during lay may offset the initial death rates.

Productivity is the bottom line for egg producers. When pullets were declawed at 23 wk of age using a hot blade debeaker, initial performance was lower than for the control.

However, the claw trimmed birds did overcome the setback, surpassing the production of intact claw birds (Ruszler and Quisenberry, 1979). When claw trimming was performed at hatch, Goodling *et al*. (1984) found no differences in production between trimmed and intact claw birds. Ruszler and Kiker (1975) found that when pullets were claw trimmed at 1 d of age using the same procedure as Ruszler and Quisenberry (1979), reduced claw birds matured 1 wk earlier than intact claw birds. Also, by 20 wk of age, birds claw trimmed at 1 d of age had produced a total of seven eggs, which was significantly greater than the one egg produced by the intact claw group (Compton *et al*., 1981a). Egg production remained significantly higher for the first 4 wk of production for the claw trimmed group (Compton *et al*., 1981b). Martin *et al*. (1976), Ruszler and Quisenberry (1979), and Satterlee *et al.* (1985) found overall increased production when birds were claw trimmed. Two of these studies also reported significantly increased income from trimmed hens due to the increase in egg production (Martin *et al*., 1976; Ruszler and Quisenberry, 1979). Hamm (1969) reported that egg production decreased with increased stress. His results suggest that perhaps the claw trimmed birds were under less stress than intact claw birds.

It seems logical that since egg numbers were higher for the claw trimmed birds in most of the above studies, egg size might decrease. Sefton (1977) and Goodling *et al*. (1984) reported that reduced claw birds had significantly lower egg size; Sefton specifically mentioned the reduced claw birds as producing significantly fewer extra large, but more medium eggs. Compton *et al*. (1981b) reported no difference between claw trimmed and intact groups after 22 wk of age for egg weights or specific gravities. This suggests that even with higher production and smaller egg size, claw trimming did not sacrifice shell quality.

Fearful behavior can have deleterious effects on growth and production. Consequences of fearfulness for laying hens include cannibalism, feather pecking or loss, either increased or decreased feed consumption, suffocation, disease susceptibility, trapping, hanging, bruising, skin lesions, decreased egg production, and decreased growth (Mills and Faure, 1990). Following the procedure used by Ruszler in 1968, Hansen (1969) reported the control of hysteria by removing claws from a flock of hens experiencing hysteria. Hansen (1976) reported hysteria as being "sudden wildly flying about, squawking, and trying to hide," which can persist for seconds, minutes, or even longer. This author also reported that fear can cause a drop in egg production of 10 to 40%. Some measures that are thought to arrest fearfulness include constant room temperature, high protein diet, niacin supplement, beak trimming, and claw reduction (Mills and Faure, 1990). Sefton (1976) reported that when fearful, two out of 10 groups had significantly decreased egg production from 60 to 64 wk of age, while another two of 10 groups had significantly decreased livability from 20 to 64 wk of age. When turkeys were declawed, it was reported that the claw trimmed birds were quieter than the control (Owings *et al*., 1972). Declawed birds have been observed to be less active and fearful than control birds even if under the same stressors (Compton *et al*., 1981a). Hansen (1976) reported that claw reduced birds did not develop hysteria, while nine out of 12 intact claw birds were seen to be hysterical. In a second experiment, Hansen (1976) started the study at 20 wk of age. Once a bird became hysterical, its claws were trimmed with a hot blade debeaker. Six of seven became calm within 3 wk. Ruszler and Kiker (1975) and Satterlee *et al*. (1985) also found claw trimmed chickens to be less fearful. Ruszler and Quisenberry (1979) varied from the results of the other studies in that they did not observe hysteria in either the 23 wk old declawed group or the control. This variance from other studies may have been the result of the calming effect created by the claw trimmed hens whose cages were randomly placed among the intact claw hens in the report by Ruszler and Quisenberry. Stress, which can be caused by fearfulness, has been seen to decrease feed and water intake. Therefore, most growth and production parameters will be negatively affected by fear. Short, single stresses have not appeared to be damaging, but prolonged stress could have damaging effects on growth and production (Hamm, 1969). Claw trimming may be beneficial in reducing fearfulness, subsequently having a positive impact on growth and production parameters.

Overall, claw reduction has not been shown to be detrimental to growth parameters or performance. However, since the hot blade procedure was imprecise and labor intensive, the concept has remained dormant until the development of the microwave claw processor, which uses microwave energy at 1 d of age to kill the germinal tissue from which the claw grows. This procedure either stops the claw growth or reduces the claw to a very short blunt stub and is also precise with minimal labor cost. A study is needed to determine the effects of the microwave treatment on high performance Leghorn strains.

Beak Trimming

Beak trimming, commonly termed debeaking, is the removal of approximately 25% of the anterior portion of the beak, and is a standard practice in the poultry industry, particularly for laying hens. Various beak trimming techniques have been used in commercial flocks. The 7 d precision procedure is favored and most often used in the industry, due to an apparent low level of stress on the chicks and improved performance during the lay period. Questions and concerns by animal welfare groups are being raised concerning beak trimming and whether it is a necessary practice. Some of these groups claim the practice is unnecessary and painful. On the other hand, producers say beak trimming is needed to prevent mortality and injury from cagemates by aggressive pecking and cannibalism.

Studies have shown that chickens have high densities of nociceptors in the beak, which may cause them to feel acute pain during and for a short time afterward trimming (Hughes and Gentle, 1995). Breward and Gentle (1985) and Gentle *et al*. (1990) conducted beak trimming by taking off one-third of the upper and lower beaks of adult birds and found that the trigeminal nerve was damaged. The authors reported that neuromas may form at the site of the scar tissue created by beak trimming, which may create "spontaneous neural activity" that might be felt as chronic pain throughout life. In 1997, Gentle *et al*. repeated their procedure, but beak trimmed pullets at 1 and 10 d of age for comparison with mature bird results. The authors reported that neuromas did not form in the beaks of the birds trimmed while young, at 1 or 10 d of age. They actually found that the sensory receptors that were amputated never regenerated. The need for beak trimming should be judged based on health, productivity, behavior, and physiology. Economics should be carefully balanced with bird welfare.

Craig and Lee (1990) reported that beak trimmed birds spent less time feeding and drinking, and therefore have reduced body weight. Other studies also showed reduced body weights (Lee and Reid, 1977; Blokhuis *et al*., 1987; Hughes and Gentle, 1995). Maizama and Adams (1994) reported that beak trimming at 7 or 10 d did not have a significant effect on body weight once the birds reached 16.5 wk of age. Andrade and Carson (1975) beak trimmed birds at 1 and 6 d and at 6, 8, 12, and 16 wk of age. Body weight at maturity was significantly less only for the 1 d and 12 wk trimmed birds. Body weight gain was depressed for 2 wk following trimming. Morgan (1957) trimmed beaks at 1 d of age, which had no effect on body weight up to 5 mo of age. Lee and Craig (1990), Craig (1992), and McKee and Harrison (1995) reported that beak trimmed birds had body weights and body weight gains no different than the control. Denbow *et al*. (1984) debeaked poults at 1 d of age using a Bio-Beaker and found no differences in body weight up to 20 wk of age between the trimmed group and the control. Struwe *et al.* (1992a) saw no differences during the first 7 wk, but trimmed birds had significantly lower body weight than controls through the rest of the growing period except for wk 15 and 21. Lee and Craig (1990) reported lower body weights from 18 to 24 wk of age for birds trimmed at 4 wk of age. Body weight gains were seen to be significantly lower than the control between 9 and 16 wk of age for pullets beak trimmed at 9 d of age (Craig *et al*., 1992). Renner *et al*. (1989) reported significantly lower body weight through growout for poults trimmed 1 mm anterior to the nostril at hatching when compared to birds debeaked with a hot blade debeaker in a standard manner at 11 d of age. When trimmed 1.5 mm from the nostril, body weight was reduced from 16 to 20 wk of age, and both treatment groups were lower at 8 wk of age than 11 d trimmed birds. Duncan *et al*. (1989), Carey (1990), and Cunningham and Mauldin (1996) reported reduced body weight shortly after beak trimming, but body weights returned to levels similar to the control by sexual maturity. Craig and Lee (1990) also reported initial setbacks in body weight gain, which rebounded to normal levels by 2 wk following beak trimming. Between 19 and 22 wk of age, birds trimmed at 1 or 10 d of age did not have significantly lower body weight than the controls (Glatz, 1990). Body weight reductions, significant or not, have not appeared to be detrimental. Even though the effects seem to mostly disappear by sexual maturity, body weight patterns may be connected to or affect other growth and production parameters.

When pullets were beak trimmed, feed consumption was most often seen to drop while feed conversion improved (Lee and Reid, 1977; Blokhuis *et al*., 1987; Lee and Craig, 1990; Hughes and Gentle, 1995). Carey (1990) reported decreased feed consumption only temporarily after trim. From 1 to 8 wk of age, 10-d beak trimmed birds ate and wasted less feed but had similar feed conversion to the control group. From 9 to 16 wk of age, these same birds did not have significantly different feed intake or efficiency (Craig, 1992). The results from Duncan *et al*. (1989) were similar, but the difference found between trimmed and control birds subsided at 5 wk of age. Pullets beak trimmed at 1 or 10 d of age were compared to each other and with a control group from 19 to 22 wk of age. Feed intake was least in the 1 d group, and no difference was seen between the 10 d and control groups. Feed conversion was best in the 1 d trimmed treatment, followed by the 10 d group and the control (Glatz, 1990). Andrade and Carson (1975) reported significantly reduced feed consumption for the 1 and 6 d and 8 and 12 wk trimmed treatments. Maizama and Adams (1994) did not find a significant difference in feed consumption during the laying period between 7 d, 10 d, and control groups. Denbow *et al*. (1984) found significantly increased feed consumption when beak trimmed poults were compared to intact beak poults from 12 to 18 wk, but not from 12 to 20 wk of age. These authors also found no difference in feed conversion up to 20 wk of age between the trimmed group and the control. Struwe *et al*. (1992a) observed higher feed consumption by the trimmed birds over the control at 7 wk of age, but at 21 wk the situation reversed, the control consuming more feed. The authors believed that the control birds may have eaten less feed in the beginning because they were initially more stressed during the growout period than the trimmed birds. These results differ from most other studies possibly due to a different environment causing higher levels of stress during this study. In a follow-up experiment, no difference in feed consumption was found during the day they were trimmed. However, during five of the first eight days, the trimmed birds had lower feed consumption, which was nonsignificant only from 9 to 14 d of age (Struwe *et al.*, 1992a). Beak trimming may have beneficial effects on feed intake and conversion. It appears from most studies that the younger the birds are when trimmed, the more the treatment seems to affect feeding parameters.

Mortality is a concern for producers, affecting both economics and bird welfare. Cunningham and Mauldin (1996) found decreased mortality in beak trimmed birds. Lee and Craig (1991) also reported lower mortality for beak trimmed birds versus intact during the growout. Reducing beaks to one-third that of intact beaks decreased losses due to cannibalism (Craig, 1992). Glatz (1990) observed slightly lower mortality for the 1 d trimmed group as compared to the 10 d trim and control. Debeaked poults had significantly decreased mortality from 12 to 20 wk of age (Denbow *et al*., 1984). Renner *et al*. (1989) reported significantly higher mortality for poults beak trimmed 1 mm anterior to the nostril as compared to control birds, but no difference when trimming was adjusted to 1.5 mm. Beak trimming at 7 and 10 d with a hot blade debeaker did not show any significant difference in mortality throughout the growing period (Maizama and Adams, 1994). Several other studies have shown no differences in mortality (Lee and Reid, 1977; Carey, 1990; Lee and Craig, 1990). However, there are concerns that the trimming procedure will cause an initial increase in mortality. Morgan (1957) found increased mortality for trimmed birds until 8 wk of age. Andrade and Carson (1975) reported significantly lower mortality than the control for all trimmed groups except for the 1 d group from 12 to 16 wk. The authors noted that beak trimming tended to cause a slight increase in mortality initially following treatment, possibly due to the wound or physical insult of the trimming. It may be that weaker birds could not withstand this insult so shortly after hatch. From the results of studies, it also seems that mortality due to the insult of trimming may diminish as the bird ages. The trend may actually reverse, with beak trimmed birds having decreased mortality later in life (Hughes and Gentle, 1995).

The ultimate goal of producers is to make a profit, so egg production, egg quality, and age at sexual maturity are important for economic success. Ruszler (1994) compared intact beaks with beak trimming at 7 d and 7 wk of age in a commercial egg flock. No significant differences were found in any production parameter. Lee and Reid (1977), Struwe *et al.* (1992b), and Maizama and Adams (1994) also found no differences in production. Despite no difference in hen-day percent production, the beak trimmed birds in the study by Lee and Reid (1977) did reach sexual maturity at a later age than intact birds. Delayed sexual maturity was also observed by Andrade and Carson (1975) when pullets were beak trimmed at 1 d of age. Morgan (1957) was the first to find improved egg production for beak trimmed birds. Glatz (1990) reported that pullets trimmed at 1 or 10 d of age did not lay significantly more eggs than the control during the first 4 wk of lay, 19 to 22 wk. However, the authors noted that there was no difference in "commercial sized eggs" (42-49 g). The control and 10 d trimmed hens laid significantly more extra large eggs than hens trimmed at 1 d of age, which laid significantly more medium eggs than the other two groups. Craig *et al*. (1992) found no difference in egg production, but decreased egg weights from 36 to 38 wk of age. These differences were not present from 46 to 48 wk of age, when birds were beak trimmed twice. Lee and Reid (1977), Carey (1990), and Struwe *et al*. (1992b) found no differences between the egg quality of trimmed and intact beak birds. In a study by Craig (1992), mean age at 50% production for both the trimmed and control groups was 21.4 weeks. Beak intact pullets had lower hen-day and hen-housed production and therefore less total egg mass, but the trimmed pullets laid smaller eggs. Lower egg size by beak trimmed birds may be correlated with lower body weights and feed consumption. Results concerning production have varied, and it is difficult to determine which trend is correct. Most studies have found no difference in production, but lower egg weights for beak trimmed layers.

Beak trimming can be beneficial for producers and birds. However, some of its side effects, such as lower body weight, smaller eggs, and the possibility of neuromas, are concerns of welfare groups. Perhaps there are alternate methods of trimming the beak or the possibility of genetically selecting for birds that do not need beak trimming. In the hatchery at 1 d of age the poultry service processor uses infrared energy to affect beak reduction similar to 7 d precision trimming. No research comparing 1 d beak trimming using infrared energy with 7 d precision trimming with a hot blade debeaker and non-trimmed beaks has been reported. This study was designed to compare these beak trimming techniques under standard commercial husbandry practices.

Stress and Heterophil to Lymphocyte Ratios

Beak and claw trimming are criticized for the stress they are thought to cause. However, claw trimming has been studied because it is thought to decrease stress. Selye reported that stress leads to defensive responses (Siegel, 1980). With beak trimming it is important to create as little stress as possible during trimming procedures, but still prevent regrowth of the beak (Maizama and Adams, 1994). Stress is usually perceived as being negative and associated with pain, disease, and suffering. Evaluating the ratio of heterophils to lymphocytes has been shown to be an accurate measure of stress levels (Zulkifli and

Siegel, 1994). Early stress could positively affect tolerance later in life, as correlated to lower heterophil to lymphocyte ratios (Zulkifli *et al*., 1995; 2000). Maxwell *et al*. (1991) reported that when birds were stressed at 6, 10, or 14 d of age, heterophil to lymphocyte ratios significantly increased. This increase could decrease disease resistance or cardiovascular function. However, because heterophils mostly guard against bacterial invasions and are the first leukocytes to respond to stress or bacterial invasion and lymphocytes also guard against other pathogens, high ratios could mean better bacterial resistance (Maxwell, 1993).

The adrenal gland, heart, and spleen are organs that are often studied when monitoring stress. The larger their size, the more stress the bird is thought to be in. Beak trimmed pullets initially showed no size difference in adrenal glands between the trimmed and control groups. However, at 21 wk of age, hearts and adrenal glands were significantly larger in the untrimmed group (Struwe *et al*., 1992a). In a following experiment, Struwe *et al*. (1992b) observed decreased adrenal and heart weights but no difference in spleen weights in mature beak trimmed birds. These results would suggest that the later stress of pecking which can occur with untrimmed beaks is more detrimental to bird well-being than the initial stress of beak trimming (Struwe *et al*., 1992b).

Donaldson *et al.* (1991) found increased blood glucose levels in beak trimmed birds, indicating that beak trimming was a stressor. Concerning claw reduction, Compton *et al*. (1981b) reported decreased plasma corticosterone levels in claw reduced birds during late lay thought to be because of decreased "intensity" of social interactions. Satterlee *et al*. (1985) and Donaldson *et al*. (1991) had similar findings of lower corticosteroid levels for claw reduced birds.

Glucocorticoids are most often used to determine stress. The procedure of comparing heterophil to lymphocyte ratios is sometimes preferable to corticosterone assessments because it is difficult to draw blood needed without triggering an immediate spike in corticosterone levels. Heterophil and lymphocyte levels do not change as a result of stress until 24 h post-stress. Heterophil to lymphocyte ratios have fairly low variability and are more reliable than corticosterone (Elston *et al*., 2000). They are "a good indicator of stress in real agricultural production settings" (McFarlane and Curtis, 1989). The more heterophils present in the blood, the more stress that bird is under. However, heterophil to lymphocyte ratios cannot be used until a week following hatch because young chicks have heterophilia and lymphopenia, with a ratio of 5.72 before hatch dropping to 1.77 at hatch (Zulkifli and Siegel, 1994). The normal range of heterophils to lymphocytes is around 0.5. The high range is 0.6 to 1.2. A very high ratio of 1.3 or higher would indicate a disease, and 0.2 to 0.3 is unusually low (Gross and Siegel, 1993).

Campo *et al*. (2001) noted that when heterophils and lymphocytes rose to a ratio of 0.42 compared to the control ratio of 0.35, the birds displayed poorer feather condition and less tonic immobility. Heterophil to lymphocyte ratios have been seen to decrease in beak trimmed birds (Hughes and Gentle, 1995). However, McKee and Harrison (1995) reported an increase in heterophil to lymphocyte ratios from 0.164 to 0.249 when beak trimmed. McFarlane and Curtis (1989) reported a nonsignificant rise from 0.63 to 0.67 in heterophil to lymphocyte ratios for beak trimmed pullets. However, few studies have been conducted concerning heterophil to lymphocyte ratios in response to claw reduction or beak trimming despite their apparent reliability.

MATERIALS AND METHODS

Cockerel Stress (Experiment 1)

Three hundred and eighty cockerel chicks were used for the preliminary stress assessing trial. The birds were placed into five treatment groups; control, beaked trimmed at 1 d of age using infrared energy, precision beak trimmed at 7 d of age (Lyon Electric Company, 1980), claw reduced at 1 d of age using microwave energy, and both claw reduced and beak trimmed at 1 d of age. At 7, 9, 11, 14, 17, and 21 d of age, blood was drawn from 12 randomly selected birds per treatment to assess stress levels by determining heterophil to lymphocyte ratios. A 2 d sample pattern the first week and a 3 d pattern the second week were chosen as the best to reduce bird handling without sacrificing accuracy. Each bird was decapitated to collect one ml of blood into tubes containing two to three drops of EDTA. One or two drops of blood from the tube were put on a glass slide and spread using a Morf Slide Spinner (Salem Specialties, Inc., Salem, VA). After spinning, the blood was allowed to air dry and was fixed with a Giemsa-May-Gruenwald staining procedure (Appendix A). Heterophils and lymphocytes were counted at 1000x using oil immersion until a total of both cell types equaled 60. Mean heterophil to lymphocyte ratios were assessed by dividing the number of heterophils by the number of lymphocytes for each slide and then averaged for each treatment. Standard growing procedures were followed in raising the cockerels to 3 wk of age, as described in detail for the second experiment.

Experiment 2

Growing Period. In order to carry out the primary study, twelve hundred pullets of each strain, Bovans (Centurion Poultry Inc., 2000) and Hy-Line W-98 (Hy-Line International, 2000), were housed in growing cages in four light controlled rooms. The claws of one-half of each strain were treated with microwave energy at 1 d of age to reduce or stop claw growth. The other half retained intact claws. In each of these two treatments, one-third was beak trimmed at 1 d of age using infrared energy, one-third was beak trimmed at 7 d of age using a hot blade precision cut trimmer, and one-third retained intact beaks. The microwave and infrared energy was generated with equipment using new technology with computerized control and developed specifically for the purpose of beak and claw trimming. All equipment used in Experiment 2 is the same as listed for Experiment 1.

All chicks were weighed and housed at 1 d of age at 98 cm^2/bird. Thirty-eight chicks were randomly assigned to each of 16 cages on the top tier of two 2.44 m commercial three-tiered brood/grow cage units. There were four rooms, each with two cage units. The intact claw birds were all placed in one cage unit and were separated with a black curtain from the reduced claw birds which were all placed in the other unit. This was done to prevent visual interaction and any possible influence of the different claw treatments' behavior on the other claw treatment group in each room. Cage floors were initially covered with newspaper to facilitate feeding and ease of movement for the new chicks. It was removed after 7 to 10 d. During the first 4 wk, the pullets were housed in the top tier at 98 cm^2/bird. At 4 wk of age, one-half of the birds were moved to the middle tier, and at 6 wk of age one-third of the pullets from each of the top and middle tiers were moved to the bottom tier. Standard commercial brooding and growing procedures were followed, which allowed 310 cm^2 of growing space per bird after 6 wk of age with 12 pullets per cage. At 18 wk of age, the pullets were transferred to laying cages.

Corn/soy diets (Appendix A) were fed *ad libitum* throughout the trial. The diets followed standard commercial procedures, with starter from 0 to 6 wk (20% protein, 1,330 kcal ME), grower from 7 to 12 wk (17% protein, 1,300 kcal ME), and developer from 13 to

18 wk (15% protein, 1,300 kcal ME). Mechanical feeder chain was placed in each feed trough to simulate commercial conditions. Water was allowed *ad libitum* with cup drinkers.

For the first 7 d, the pullets were given 22 h of light per day. During the second week, day length was reduced to 20 h, 18 h the third week, 16 h the fourth week, and 10 h by the fifth week which continued until preparation for lay. In this preparation, daylength was increased by 2 h at 18 wk, 1 h at wk 19 and 20, followed by 15-min increments per week until reaching 16 h of light per day at 28 wk of age (Appendix A). Light intensity was between 10 and 20 lumens.

Average chick weight was determined by group weighing each cage every week for the first 4 wk, every 2 wk from 4 to 8 wk of age, and every 4 wk thereafter until 18 wk of age. Body weight gains were calculated from these weights. Average feed consumption was measured every 4 wk or at a feed change starting at 4 wk of age. Feed conversion was calculated for these same periods. Mortality was recorded daily.

Fearfulness. In addition to daily observations by the farm technicians and the two primary investigators, groups of volunteers who were not involved with the research carried out subjective observations for fearfulness. The experience with chickens of the 20 volunteer observers selected at random ranged from none to professional levels and consisted of undergraduate students, faculty members, and campus visitors. The 20 volunteers were chosen randomly in order to reduce any possibility of individual biases relative to how chickens would be expected to act. To sample a broad range of perception, people with some understanding about chicken behavior ranging to those with none were chosen. They also were not informed of the treatments so that they did not know why they were rating fearfulness. Their training for this exercise consisted of instructions to score the level of bird activity based upon his or her perception of fearfulness using the descriptive scale from 1 to 10 found on the scoring form (Appendix A). Each observer stood in the room where they could observe both cage units (intact and reduced claw) at the same time while the testing individual (one of the primary investigators) performed four different activities. Each observer scored the level of fearfulness the pullets exhibited in two of the four rooms. Each activity was performed for 15 to 20 seconds, followed by a pause. The pause ranged in time from 15 to 60 s, depending on the time needed for the birds to return to normal behavior before performing the next activity. At least 5 min elapsed between observation periods of individuals or groups of two to three individual volunteers. Fearfulness, from Hurnik *et al.* (1995), is defined for this purpose as that reaction caused by a perception of danger which may include temporary immobility, hiding, escape, or vocalization. Fearfulness has also been referred to as hysteria or nervousness (Hansen, 1976).

The testing individual performed the four different activities in the following order: feeding the birds, walking by the cages, waving arms in front of the cages, and waving a broom over the cages. The response was scored with level 1 being totally calm and 10 representing total fearfulness. If the birds did not react at all to the activities, they were given a fearfulness score of 1. If the birds were easily disturbed and moved wildly about the cage, stepping all over cagemates, and did not calm down immediately after the fear stimulating activities ceased, they were scored a fearfulness score of 10. Any activity that varied in fear level between the two extremes was subjectively marked as the appropriate rating between 1 and 10.

Laying Period. At 18 wk of age, the pullets were moved to cage laying facilities. Again, claw treatment groups were separated by a black curtain. Treatment groups were randomly assigned within each cage unit. Water was provided *ad libitum* with nipple drinkers. Half of each treatment was allowed 348 cm^2/bird and half was housed at 465 cm^2/bird. The differences in density were not considered for this study because their effects are not usually expressed until later in lay. However, they were included for statistical analysis. Light intensity was between 10 and 20 lumens with a day length increased step-wise to 16 h (Appendix A). Commercial management programs defined for Bovans and Hy-Line were followed. A commercial layer diet was fed *ad libitum.* Feed changed periodically, with pre-lay from 19 to 20 wk of age (15.5%, 1,331 kcal ME), and peak layer from 21 to 36 wk (18%, 1,325 kcal ME) (Appendix A).

Body weights and feed intake were measured at the end of each 4 wk period. Body weight gain and feed conversion were also calculated each period. Egg production and mortality were recorded daily. Egg production was recorded weekly, by period, and cumulatively. Egg weights were assessed from 20 to 36 wk of age, at the end of each 4 wk period. Shell strength was determined by specific gravities at 32 and 36 wk of age.

Statistical Analysis

The study was a 2 x 2 x 2 x 3 factorial design with strain, claw, density, and beak as main effects. Data were analyzed using the General Linear Models (GLM) procedure (SAS® Institute, 2000). For mortality and percent production, data were analyzed using an arc sine transformation. This is reflected in significance and standard error, but actual percentages are presented. Means found to be significantly different from each other were identified using Duncan's (1955) multiple range test.

RESULTS AND DISCUSSION

Heterophil to Lymphocyte Ratios

During the six sampling periods for heterophil to lymphocyte (H:L) ratios during the 3 wk time period, claw reduction caused a significant difference between treatments only once (Table 1). At 9 d of age, the reduced claw (RC) birds had significantly higher H: L ratios than intact claw (IC) birds. According to the standard scale reported by Gross and Siegel (1993), the ratio of the RC birds, about 0.5, was not out of normal range. The IC birds showed lower ratios throughout the trial, especially at 7 and 9 d of age. The higher H: L ratios for the RC birds early could possibly be the result of the reduced foot spread, which is described in more detail below. Overall, claw reduction did not significantly affect the stress levels of the young cockerels, as measured by H: L ratios. These results disagreed with Satterlee *et al*. (1985) and Donaldson *et al*. (1991) who reported less stress in the RC group. Perhaps this is because H: L ratios were only studied during the first 3 wk of age during this study as a preliminary trial for Experiment 2. It did appear that as the birds aged, the ratios increased, approaching the high end of normal for both claw treatment groups.

No significant differences were seen in the H: L ratios between each beak treatment group (Table 1). From the results, it appears that the age at which beaks are trimmed also does not affect stress levels early in life. The results agree with McFarlane and Curtis (1989) who reported a nonsignificant rise in H: L levels for beak trimmed birds when compared to the intact beak controls. However, McKee and Harrison (1995) found a significant increase in H: L ratios for the trimmed beak group.

Blood was drawn to analyze H: L ratios to determine stress levels during the first few weeks of life, shortly after initial handling, housing, and beak and claw treatments. It is beneficial from a welfare point of view for those who want to beak trim pullets that trimming does not cause the birds to initially be under increased stress compared to intact beak birds. Claw reduction may still create a question because of the significance shown at 9 d of age. However, like beak trimming, the H: L ratios seem to indicate that the treatment does not cause excess stress.

Growing Period

Claw Reduction. Immediately following the claw treatment with microwave energy, the claws and occasionally up to 1 mm of the tip of the toe flesh appeared white instead of pink in color. However, the immediate observation of the subsequent physical activity of the RC birds did not appear to be affected by the treatment. They moved around the brooder cage very actively and behaved in a similar manner as the IC birds. The claws atrophied within 7 to 10 d without any injured tissue appearing at the treatment site, which is contrary to that reported by those who claw trimmed with a hot blade debeaker (Ruszler, 1970; Coles *et al*., 1980, unpublished data). The difference must be the result of the different method of treatment. The computer controlled microwave claw processor was more accurate in removing the claws without being invasive like the hot blade technique. The only visible physical drawback seen with claw reduction involved the design of the cages. The space between each wire of the cage floor was 2.54 cm^2. With the claw not being present, the effective foot support was not as wide as with claws. It was observed that this sometimes allowed the toe to slip into the space between the wires, which may have caused extra pressure on the web between the toes creating a superficial split in the epidermal tissue of the web of some RC birds. This split was observed when weighing the birds at 12 wk of age and affected approximately 2% of the RC birds. This split appeared to be healed by 16 to 18 wk of age.

Body Weight. The body weight of both the RC and IC birds was equal to or greater than breeder standards throughout the trial. As can be seen in Table 2, the RC group had significantly lower body weight than the IC group for much of the growout period. During the period of accelerating body growth, from 3 to 8 wk, some birds grew rapidly while others grew slowly. During this time, from 3 to 6 wk, the body weights were not significantly different. The lighter body weights of the RC birds may have been the result of the treatment given at 1 d of age, requiring them to overcome the initial physical insult. The RC growth curve was similar to the IC curve but delayed a few days, starting at 6 wk (Figure 1). The reduction in early growth caused by the claw treatment was also in agreement with Compton *et al*. (1981a), who used a hot blade, removing a portion of the toe with the claw. These authors postulated that the shortened claw reduced the foot spread and made it more difficult for the very young chick to move about the cage until the toe grew long enough to spread across more than one of the floor wires.

Body Weight Gain. Weight gain (Table 2) showed similar results as body weights. During the first week, the IC birds gained significantly more than the RC birds. As the birds grew rapidly through 4 wk of age, while the space per bird remained at 95 cm^2/bird, the body mass increased 6.5 fold. This effectively reduced the amount of space per bird available for movement, which affected the rate of gain between the claw treatment groups. The RC birds gained more body weight than IC birds when effective cage space was the most limited. This may be due more to the lack of nervous activity in the RC birds, allowing for the feed consumed to be utilized for weight gain rather than for supplying energy for the extra activity of the IC birds, as suggested by Goodling *et al*. (1984). Perhaps there was not as much maneuvering space for escape and evasion of injury from cagemates' claws when their body size was larger but with the same space per bird. This difference showed significance only at 3 and 4 wk of age. From 4 to 6 wk of age, while the birds were still rapidly growing, the increased space per bird to about 200 cm^2 allowed the IC group to experience a similar rate of gain to the RC group. The birds were spread out to the bottom tier at 6 wk, allowing 310 cm^2/bird. With the increase in available space per bird allowing greater movement, the IC birds again gained significantly more from 8 to 16 wk. The RC birds were able to tolerate the more crowded conditions better than the IC birds, as shown by the significantly higher body weight gain during these times of more limited space per bird. It is also possible that when more space per bird was available, the IC birds may have been more able to evade the action of cagemates stepping on them and scratching them than when the cages were more crowded. The IC birds' learned response to the experience of being hurt by claws of cagemates during periods of more limited space may explain the change in the weight gain pattern from 3 to 6 wk of age. At 18 wk of age, when growth had essentially ceased, there was no significant difference in body weight gain between the two groups.

Feed Consumption. Feed consumption patterns (Table 3) throughout the growing period corresponded to body weights, with the IC birds consuming significantly more than the RC birds from 7 to 18 wk of age. However, because there was no significant difference between the groups in feed consumption during the first two weeks, it seems unlikely that the birds' ability to eat was affected by the RC treatment. Both treatments followed a typical feed consumption pattern, eating more feed each period until body weight gain slowed at 13 wk of age, when they ate less than or equal to the previous period. Overall, the IC birds consumed significantly more feed than the RC birds throughout the growing period. These results agreed with Goodling *et al*. (1984) who found lower feed consumption and body weight during the growing period following claw trimming at hatch. In that study, the authors found no difference in body weight gain and postulated that the higher feed intake by the IC group was probably not being deposited as fat, but was needed to support their higher level of activity. By being less active, the RC birds may not have needed to eat as much as the more active and possibly more easily frightened IC birds. Perhaps the IC birds were reminded of the presence of feed as they moved about the cage, causing them to over-consume. This idea of over-consumption could also be called "impulse feeding."

Feed Conversion. Feed conversion (Table 3) was not different between the two treatment groups from 5 to 18 wk of age. Significant differences occurred only from 0 to 4 wk, when the RC birds were more efficient than the IC birds. This was also when the RC birds had the higher rate of body weight gain during the period when the lowest amount of space per bird was allowed, also supporting the conjecture that RC birds could tolerate crowded conditions more easily. The RC group did eat less feed and was lower in body weight, but after 4 wk of age it was no more efficient in converting feed to body weight. Since the body weight and feed intake were depressed for the RC birds, the suggestion could be made that the RC birds experienced discomfort after 4 wk of age, which caused them to perform at a different level. However, there was no way to tell from this study if the birds experienced any discomfort from the claw reduction. A study focusing on the pain that might be caused by the RC treatment would be beneficial to examine levels of stress by measuring heterophil to lymphocyte ratios or blood corticosterone levels.

Mortality. Mortality for all treatments was very low (Table 4). Throughout the growing period the mortality of the claw treatments was not different. These results agree with the findings of Compton *et al.* (1981a) and Goodling *et al*. (1984). Despite not being significantly different, the RC birds' mortality tended to occur toward the beginning, which also includes poor quality chicks and starve-outs, while the mortality for the IC birds was more dispersed. Although the findings were not statistically significant, they were similar to results by Owings *et al*. (1972), Newberry (1992), and Proudfoot *et al*. (1979), with mortality more closely following trimming for the RC birds. All the figures were very low and below commercial standards.

Beak Trimming. When the beaks were treated with infrared energy at 1 d of age, the part of the beak tip exposed to the energy appeared white in color. Over the next 7 to 10 d, the tip fell off and the beak was blunted and was similar in appearance to beaks trimmed with a hot blade at 7 d of age. However, no apparent wound appeared as when trimmed with a hot blade debeaker. A few birds, less than 2%, developed soft tissue that resembled a scab on the end of the upper beak that did not appear to harden over for several weeks. However, this condition did not appear to inhibit feeding or other activities. From daily observations, it appeared that as the birds matured, there seemed to be no mechanical difference between the 1 d (1-day) and 7 d (7-day) beak trimmed (BT) groups with no hindrance in eating and drinking.

Body Weight. The results of the beak treatments were similar to the results of the claw treatments in that the trimmed birds grew at a slower rate than the intact beak (IB) birds. From 2 to 18 wk, the IB birds were the heaviest, followed by the 7-day, and then 1-day treatments (Table 5). By 2 wk of age, the IB group was significantly heavier in this study than the two beak trimmed (BT) groups. Except at 2, 3, and 12 wk of age, all treatment groups were significantly different from each other. This further supports that the younger the birds were when their beaks were trimmed, the more their body weight was reduced during the growing period. This agrees with Glatz (1990) who reported birds trimmed at hatch had lower body weight than 10 d BT birds. Andrade and Carson (1975) also found similar results, that the 1-day BT birds were significantly lighter than later trimmed birds and the control. Again, the growth curves were similar but separated by a few days after the third week (Figure 2).

Body Weight Gain. From 0 to 2 and after 12 wk of age, there were no significant differences in rate of gain between any of the three treatments (Table 5). The later weeks not showing significance showed that any effect of beak trimming diminished with maturity and that the BT treatments did not have long-term detrimental effects on rate of growth. The results also showed that the trimmed birds were able to overcome any initial setbacks. The differences in weight gain not appearing until 3 wk of age would suggest that the trimming did not immediately affect either of the BT groups' ability to eat and put on weight. From wk 4 to 12, the IB birds gained significantly more weight per period than the 1-day BT birds. The 7-day BT birds gained more than the other two groups at 3 wk of age, but after that, their weight gain fell between the IB and 1-day BT groups. It appears from the results that the younger a bird is when treated, the more its ability to gain body weight is affected. Although there was some individual variation, all of the treatments did follow the normal pattern of weight gain. Further studies are needed to determine if the effect is related to age of treatment or the trimming technique used.

Feed Consumption. Feed consumption (Table 6) followed the body weight pattern with the IB birds consuming more feed than the other two treatment groups. The 1-day treatment consumed significantly less feed than the other treatments throughout the growing period, while all three groups differed from 0 to 4 and 13 to 18 wk of age. Obviously, the lower body weight of the BT birds did not demand extra feed intake to maintain growth. This was evidenced by their body weight being equal to or above the commercial management guide body weight curves. The difference between the 1-day and the other treatment groups during the period of rapid growth (4 to 14 wk) indicates that there may be different nutritional requirements to attain acceptable body weight. The feed intake difference between treatment groups would not seem to be related to the configuration of the beak, at least between the two BT groups in that there was no visual difference in shape or length between the 1-day and 7-day BT groups. However, there is still the difference and suspicion of the differences between age and trim technique.

Feed Conversion. No significant differences for feed conversion (Table 6) were found except from 7 to 8 wk of age, when the 1-day BT was statistically more efficient than the other two groups. As they grew older, the IB birds tended toward poorer feed conversion. Their significantly higher feed consumption and feed conversion later in the growout period may have been due to wastage by flipping feed out of the trough with their beak. Wasted feed was visible on the floor under the IB birds' cages and not under the others. The amount was not measured. However, by 16 wk of age, many of the IB birds were also flipping the 60 cm long feeder chain out onto the floor each day. Lee and Craig (1990) and Craig (1992) reported significantly higher feed consumption by the IB birds due to wastage by flipping feed out of the trough with their beak. The lower feed usage by both

BT groups tended to support the observation that IB birds were using more feed due to wastage.

Neuromas. Breward and Gentle (1985) have reported that neuromas may develop, creating discomfort for the trimmed birds, subsequently causing them to eat less and have significantly lower body weight than IB birds. It was postulated that if not due to prolonged discomfort, the decreased feed intake could have been a learned behavior that stemmed from the initial physical insult or pain of the treatment. However, their findings may not be valid for this study because Breward and Gentle studied beak trimming on adult birds, and as Andrade and Carson (1975) pointed out, the later the beak trimming was performed, the more negative was the effect of the treatment on the bird. The beak tissue in a newly hatched pullet is not fully developed or mature and may be able to recover from treatment more easily and possibly with no or fewer neuromas than mature beak tissue as in adult birds. In a later study by Gentle *et al*. (1997), it was found that beak trimming did not have as dramatic an effect on birds trimmed at 1 or 10 d of age as on birds trimmed as adults. Their study also concluded that neuromas did not form in birds beak trimmed at 1 or 10 d of age. In fact, it was reported that the sensory receptors did not ever regenerate. This lends support to the observation that the initial setback was the main effect and did not continue throughout the growing period. The possibility of a connection between this initial setback and neuromas needs further study.

Mortality. The 1-day BT group had significantly higher mortality than the 7-day BT and IB groups during the first week (Table 7). The 1-day BT group was the only one treated, affecting those birds more while the others were affected only by natural events. However, the difference may be due to age at which the treatment was given, as suggested by Andrade and Carson (1975). They reported that mortality was highest shortly after trimming, which agrees with the results of this study. Despite some significant differences in mortality, all the figures were very low and below commercial standards and the differences in mortality from 2 wk of age until the end of the growout were not significantly different between the three beak treatment groups.

Laying Period

Claw Reduction. Body Weight and Gain. As can be seen in Table 8, the body weight trend that appeared in the growing period continued into the laying period, from 18 to 36 wk of age. This agrees with Ruszler and Quisenberry (1979) and Compton *et al.* (1981b). However, this difference in body weight was within management standards. Therefore, the lower body weight could have an advantage economically and physiologically by not having to support the extra weight while being productive. It does not seem that any physical insult from claw reduction could have persisted after attaining mature body weights, which would continue expression into the lay period. The difference in body weight could also have been affected by the increased activity of the IC birds due to fearful behavior, which again leads to the idea of impulse feeding. This excess feed intake would then have been converted into higher body weights. Body weight gains (Table 8) were not significantly different throughout the laying period. This agrees with Compton *et al.* (1981a) who found body weight gains to not be significantly different after 20 wk of age.

Feed Consumption and Conversion. Laying period feed consumption and feed conversion (Table 9) differences were significant only from 25 to 28 wk of age, favoring the RC birds. This is an indication that the RC birds were able to carry on daily functions such as eating just as well as the IC birds. Martin *et al*. (1976) found decreased feed consumption, but better conversion by RC birds. Throughout lay, the RC birds tended toward lower feed consumption and better feed conversion than IC birds. Most past studies agreed with these results and reported no differences in feed conversion despite lower feed consumption (Compton *et al*., 1981b; Goodling *et al*., 1984). Both groups were laying at a high rate of production throughout the laying period, resulting in enhanced feed conversion making it difficult to find measurable differences. When all energy was focused on egg production, less activity may have resulted in less intake and wasted energy.

Egg Production. Claw reduction did not have an effect on sexual maturation, in that there was no significant effect on average age at first egg between claw treatments (Table 10). Both the RC and IC groups peaked close to commercial guidelines, just above 94% hen-day production (Figure 3). From 18 to 36 wk of age, egg production did not differ between the claw treatment groups for hen-housed, hen-day, or cumulative egg production (Tables 11 and 12). Martin *et al*. (1976), Ruszler and Quisenberry (1979), Compton *et al.* (1981a; b), and Satterlee *et al*. (1985) reported that RC birds laid more eggs. However, the high rate of lay in this study by both treatment groups did not allow for much improvement. Strains of layers used in previous studies were not expected to peak above 91 to 92% while the present strains expect to attain 95%. Figure 4 shows the hen-day production for each strain, which differ from each other by about 5% post-peak. This was not unexpected because the commercial management guides for each strain show a 1 to 2% difference in hen-day production post-peak.

Overall, no difference was seen between claw treatments for egg weights (Table 13) except at 28 wk when the RC birds laid significantly lighter eggs. The overall result of nonsignificant differences in egg weights agrees with the findings of Compton *et al.* (1981b). Mean shell strength, as measured by specific gravities (Table 14), was not affected by claw reduction. Compton *et al*. (1981b) reported similar findings after 22 wk, no difference in specific gravities between RC and IC birds.

Mortality. Table 15 shows the mortality percentages for each claw treatment group. No differences were found during the laying period from 18 to 36 wk of age. From 33 to 36 wk of age, the RC group had lower mortality than the previous period, while the IC group stayed steady around 1%. Ruszler and Quisenberry (1979) reported higher mortality for RC birds, but this was probably only due to the late age (23 wk) at which they were trimmed. Compton *et al*. (1981b) and Satterlee *et al*. (1985) found results that more closely agreed with this study with no significant differences between claw treatment groups.

Beak Trimming. Body Weight and Gain. From 18 to 32 wk of age, the body weight changes followed the same pattern as the growing period, with the IB group weighing significantly more than the 1-day BT group. The 7-day BT group fell in the middle of the other two groups, not showing consistent differences from either the 1-day BT or IB groups (Table 16). This agrees with many past studies, which reported that BT birds had reduced body weight compared to control birds (Lee and Reid, 1977; Blokhuis et al., 1987; Craig and Lee, 1990; Hughes and Gentle, 1995). At 36 wk of age no differences were found in body weight between any of the three groups. Duncan *et al*. (1989), Carey (1990), Maizama and Adams (1994), and Cunningham and Mauldin (1996) reported that body weights of BT birds rebounded after an initial depression. The body weights in this study did not fully recover until the period ending at 36 wk of age.

Body weight gains were significantly different only until 24 wk of age (Table 16). This shows that the 1-day BT birds eventually recovered the body weight they lacked throughout the growing period and gained more so they were not different once they reached peak production at 36 wk of age. The idea that the treatment did not affect the ability of the BT or IB birds to gain weight during lay agrees with Andrade and Carson (1975) and Craig and Lee (1990).

Feed Consumption and Conversion. Feed consumption results (Table 17) were similar to the growing period where the IB birds consumed significantly more feed than either BT group. However, the 1-day BT birds as well as the 7-day BT group had significantly less feed usage than the IB birds, which may have partially been due to feed wastage by flipping it out with their intact beaks. Andrade and Carson (1975), Lee and Reid (1977), Blokhuis *et al*. (1987), Lee and Craig (1990), and Hughes and Gentle (1995), and McKee and Harrison (1995) found higher feed usage by the IB birds over the BT birds. Craig (1992) measured the amount of wasted feed and found that the IB birds wasted more feed than the BT birds. Some of the higher feed intake by the IB birds could have also been deposited as fat, supporting the results of higher body weights up to 36 wk of age.

No consistent differences in feed conversion were found (Table 17). From 20 to 24 wk of age, the IB birds were the least efficient in converting feed to eggs, followed by the 1-day BT birds, with the 7-day BT birds being the most efficient. This agrees with Glatz (1990). From 29 to 32 wk of age, the 1-day and 7-day BT groups had better feed conversion than the IB group. This supports other reports that the extra feed being used by the IB birds was only being wasted. This disagrees with most other authors, including McKee and

Harrison (1995), who found beak trimming to significantly improve feed conversion over control birds.

Egg Production. The 1-day BT and IB groups started laying significantly later than the 7-day BT group (Table 10). Andrade and Carson (1975) also found delayed sexual maturity in 1-day hot blade BT birds. The shifting in statistical significance values between treatments during the first 10 wk of lay defies logical explanation (Table 18 and Figure 7). It probably is due more to variations in hormonal changes affecting sexual maturity of individual birds than any other factor. Despite hen-housed and hen-day production shifting statistical significance from 20 to 28 wk of age, the cumulative figures (Table 19) remained fairly constant in significance. The 7-day BT birds laid more eggs than the 1-day BT birds while the IB birds, until 27 wk of age, also usually laid fewer. This was initiated by the 7-day BT group starting to lay the earliest. Throughout the later part of the laying period, from 29 to 36 wk of age, there were no significant differences between any of the beak treatments in hen-day or hen-housed percent production (Table 18), nor were differences found between beak treatment groups in cumulative eggs. Morgan (1957) found an improvement in egg production by BT birds. However, other studies have not found any differences (Lee and Reid, 1977; Struwe *et al*., 1992b; Maizama and Adams, 1994).

No significant differences were found between beak treatment groups for mean egg weights for most of the laying period that was studied (Table 20). At 32 wk of age, the 1-day BT birds did show significantly heavier eggs than the 7-day BT birds, but this subsequently disappeared. Other studies have found smaller eggs produced by BT birds (Glatz, 1990; Craig *et al*., 1992). Specific gravities (Table 21) were not different between beak treatment groups. Lee and Reid (1977), Carey (1990) and Struwe *et al*. (1992b) also found no differences in egg shell quality between BT groups. Egg weights for all of the treatments increased from 20 to 36 wk of age, as eggshell strength held steady. Beak trimming, whether infrared at 1 d of age or hot blade at 7 d of age, had no real effect on rate of lay or egg quality characteristics.

Mortality. Percent mortality for the beak treatments is shown in Table 22. No significant differences existed between the three groups. Other studies that did not find differences in mortality agree with these results (Lee and Reid, 1977; Carey, 1990; Lee and Craig, 1990, Maizama and Adams, 1994). However, Cunningham and Mauldin (1996) showed decreased mortality for BT birds. This study may not have shown any improvement in mortality because it was so low each period.

The results were confounded for beak treatments because of the trimming procedures being compared. Beak trimming at 1 d of age with the infrared energy and at 7 d of age with a hot blade debeaker was chosen because these are the two types of beak treatments currently performed in the industry. Despite being practical, it is not possible to determine whether the differences in results were due to the age difference or the type of trimming.

Fearfulness

Between 6 and 8 wk of age (Figure 6) IC birds expressed the highest level of fear, scoring fearfulness levels mostly between 8 and 10, while 70% of the RC birds scored in the range of 3 to 5. The same pattern occurred from 16 to 18 wk of age (Figure 7) with the IC birds still showing elevated fearful activity up to a level of 10 while the RC did not receive a fearfulness score above 7. The RC birds did not express as much fearfulness as the IC birds when disturbed, which agrees with the findings of Hansen (1969), Ruszler (1970), Ruszler and Kiker (1975), and Ruszler and Quisenberry (1979). The scores for each observer contained slight variations between the four activities but were consistently lower for the RC pullets compared to the IC birds. The scores for both claw treatment groups were consistently higher or lower for each observer when compared to the other observers. This indicates that they were consistent in their fearfulness scoring, but the conception of the intensity of expression of fearfulness differed slightly between observers. Because of their reduced level of fear, the RC birds may not have spent as much energy as the IC birds. Needing to replenish spent energy, the more excitable IC birds may have had the motivation to move around the cage and peck at the feed and water more often than the RC birds. This may be additional support for the higher feed usage and body weight of the IC birds. It is possible that the level of fearfulness may not have changed once the birds reached 16 to 18 wk of age, but due to their adult body size, there was less room in the cage for the birds to express that fearfulness. Another possible explanation for the lower fearfulness responses from 16 to 18 wk of age is the observation that the expression of fearfulness diminished as the birds approached sexual maturity. This is in agreement with Hansen (1976) and Krueger and Ruszler (1999, lecture notes). Despite the apparent drop in fearfulness between the two time periods, the RC birds consistently exhibited less fear each time at a highly significant level ($P<0.0001$).

A weighted total (number of observations x fearfulness score) of the observations for the fearfulness level of each activity shows an interesting phenomenon. Table 23 shows that the feeding activity (activity 1) scored the lowest level of fearfulness expressed which was followed by arm waving over the front of the cages (activity 3). Walking past the birds (activity 2) scored third highest, with the broom waving over their heads (activity 4) being the highest. It is important to note that this order of increasing fearfulness was not in the same order that the activities were performed. This shows that the birds did not become accustomed to the activities, nor did the fearful level rise steadily upon each successive activity. The activity of feeding probably scored the lowest because that is a daily activity to which they are more or less accustomed. The waving of the arms may have alerted the birds that a large object was approaching, allowing them to expect a change, whereas just walking past them did not give the needed advanced warning. The broom overhead was probably interpreted as a danger from nature such as a flying predator.

Interactions

Claw treatment showed significant interactions for body weight and body weight gain with beak treatment and strain at 3 wk of age. The beak and claw treatment interaction (Table 24) could be due to initial setbacks by both BT and RC treatments when done together up to about 3 wk of age. The combination of RC and IB treatments at 3 wk of age shows an interesting idea. Although the interaction was only significant at this age, it seems that the impulse feeding was triggered with this combination. Intact beak birds seemed to cause more aggression while claw reduction may have lead to less worry about being stepped on and scratched by cagemates. This increased activity because of more aggression from pecking may have led to impulse feeding while higher body weight and gain resulted from reduced body movement. There appears to be no explainable reason for the claw treatment x strain interaction (Table 25), because it did not occur at any other time period. However, it appears that during this period, the Bovans strain was affected by the claw treatment, whereas the RC Hy-Line strain actually had higher body weights than IC. The body weight and gain of the two strains responded to the treatment equally thereafter. At 18 wk of age (Table 25), there was an interaction for feed consumption between the claw treatment and strain. Again, the feed consumption, like body weight and gain at 3 wk, shows that the Bovans strain may have been set back by the treatment, but the reason is not clear.

Interactions between beak trimming and strain are shown in Tables 26 and 27. It is expected that normal weights of two different strains would differ due to genetic variation. However, interactions were still present at various times during the growout. There were significant interactions between beak treatment and strain at 2, 3, 12, and 16 wk of age for body weight and body weight gain (Table 26). These interactions suggest that beak trimming had a greater effect on the performance of the Bovans strain. At each week, the 1-day BT Bovans seemed most affected, followed by the 7-day BT, and then the IB group. The performance of the Hy-Line strain did not show as much nor consistent variation between beak treatment groups. At 1 wk of age there was a significant interaction for mortality between strain and beak treatment (Table 27). It suggests that Bovans were more affected by the 1-day BT shortly after the treatment, but that the Hy-Line strain was not bothered by beak trimming at the young age. The lower grade of day old chick quality in the Bovans was probably the prime reason.

Although all of the interactions were not consistent throughout the growing period, they may suggest that strains react differently to claw and beak trimming. Some strains may be adversely affected while others may benefit from these treatments. However, any differences disappear by 20 wk of age, in that no interactions were present in this study during lay, from 20 to 36 wk of age.

Economics

Lighter body weight and less feed consumption by the reduced claw birds may actually be a benefit for producers, in that the pullets required less feed, and developed less body weight to be maintained during egg production than the IC birds. The feed costs were as follows: 0 to 6 wk of age, \$206/ton; 7 to 12 wk, \$180/ton; 13 to 20 wk, \$188/ton; 21 to 36 wk, \$198/ton. Table 28 shows that the RC birds ate \$.03 worth of feed per bird less than the IC birds throughout the growing period and \$.03 less during the first 18 wk of lay. From 7 to 18 and 25 to 28 wk of age, the IC birds had significantly higher feed costs per period than RC birds (Table 29). Despite individual weeks being significantly different, cumulative feed costs did not show significance because of the higher standard error when costs were added together from week to week. Claw reduction did not significantly delay sexual maturity. Therefore, less cost for feed while maintaining normal egg production can only result in an economic benefit.

The slightly lower body weight of the 1-day BT group is also an economic advantage due to less total initial body weight to maintain during lay. Except from 18 to 24 wk of age, the IB birds consistently and significantly cost the most to feed (Table 29). The 1-day BT birds were always significantly less than the IB birds, and the 7-day BT birds fell between the two groups varying in significant difference levels between the other groups. Intact beak birds required feed in the amounts of \$.03/bird and \$.06/bird more than the 7-day and 1-day birds, respectively, throughout the growing period (Table 28). Additionally, they required \$.04 and \$.06 more than the 7-day and 1-day BT birds, respectively, during the first 18 wk of lay.

Being able to bring RC and BT pullets to sexual maturity on less feed agreed with past studies (Martin et al., 1976; Ruszler, 1994). This difference could be another indication that the age at which the treatment was given or the type of trimming that was performed may have some residual effect at a later time in the life of the hen. Also aiding in economics, production was not significantly different between the two BT groups from 18 to 20 wk of age. Andrade and Carson (1975) concluded that beak trimming at 6 d of age is most desirable followed by 1 d of age because of decreased feed consumption and body weight. They also found no negative effects on egg production. Another positive aspect of both claw and beak trimming was that they did not negatively affect feed conversion. This is particularly important to producers, since feed is the greatest expense (60 to 70% of total cost) when producing ready-to-lay pullets.

In addition, the cost of labor needed to handle the birds is reduced when beak trimming is done at 1 d of age instead of after housing. The cost of labor to beak trim birds using a precision debeaker at 7 d of age is between 5 and 10 cents per bird. Using the new technology to vaccinate for Marek's disease, beak trim with infrared energy, and claw trim with microwave energy, all in the hatchery, presently costs between two and three cents per bird. Trimming at hatch also eliminates the additional stress of handling the birds at 7 to 10 d of age.

Looking at a hypothetical situation using the egg production and feed consumption values of the birds in this study, a cost and returns analysis was set up, assuming commercial conditions for a flock of 120,000 laying hens comparing claw treatments. Table 30 shows that the IC birds gained more profit from egg production because they laid more eggs that were larger. The IC birds laid more extra large and large eggs than the RC birds, who laid more medium sized eggs (Table 32). The IC birds also ate more feed, resulting in the generation of more manure by the birds, which in turn generated more income from manure sales. However, the higher feed consumption resulted in $4,214 more for IC birds' feed costs during the first 18 wk of lay, not including the operating capital interest for that feed. The

$415.38 cost of trimming for the RC group had a minimal effect on net returns when the differences of egg income plus pullet and feed costs are included in the final net return difference of $891.

The same cost and returns analyses were compared for beak trimming (Table 31). The 7-day BT birds gained the most profit. Some of this may be due to their earlier sexual maturity. They also laid more large and medium eggs, which have a greater market value than small eggs (Table 32). Even though the IB birds laid the most extra large eggs, that was not enough to overcome the large and medium eggs laid by the 7-day BT birds. The 1-day birds, with their lower body weight, laid the highest percentage of small eggs. The IB birds, as can be expected, gained the most profit from manure sales, followed by the 7-day and 1-day BT groups. However, this higher feed usage was a disadvantage economically. Not including operating capital interest, from 18 to 26 wk of age, the IB group ate $7,512 and $7,555 more than the 7-day and 1-day BT birds, respectively. At 36 wk of age, the IB birds had $11,215 and $8,048 less net returns to land and management than the 7-day and 1-day BT birds, respectively.

From the cost and returns analyses, it appears that beak trimming, particularly at 1-day of age could be more economical than leaving beaks intact. This new infrared and microwave technology, which is continually being improved, may offer another production and husbandry tool to improve economics for the producer as well as the overall welfare of the bird in the cage. The procedure could be a partial answer to some of the concerns being expressed by those poultry customers who may not be properly informed about present husbandry practices. However, the questions concerning the entire laying period remain to be answered. Since some may consider it to be a mutilation, other studies measuring stress levels and certain physiological morphology need to be carried out to determine if this technology will become a useful husbandry tool to improve the well-being of the bird.

CONCLUSIONS

Heterophil to lymphocyte ratios during the first 3 wk of life did not indicate differences in stress. Therefore, claw and beak trimming did not appear to cause more or less trauma to cockerel chicks, at least during the first few weeks following treatment, handling, and housing. Heterophil to lymphocyte ratios throughout the growing and laying periods need to be determined to assess stress levels during growth, sexual development, and production.

Claw reduction statistically reduced body weights throughout the study. However, the effects were no longer significant past the growing period, as shown by nonsignificant differences after 16 wk of age for body weight gain, feed consumption, and feed conversion. The lower body weight of RC birds may actually have been beneficial. Claw reduction did not seem to be detrimental to pullets beginning to lay, in that there were no differences in mortality or egg production. One benefit of claw reduction was that the RC birds were significantly less fearful than intact claw birds during the growing period and to a lesser extent during the laying period. Under standard commercial conditions, claw reduction also was shown to be an economical practice.

Beak trimming at 1-day of age with infrared energy significantly decreased body weight and feed consumption. With the 7-day BT group most often falling between the 1-day BT and IB groups, it seems the age at trimming does make a difference, the younger the bird when trimmed, the more it is affected. Especially with less feed usage, beak trimming was shown to be beneficial. Feed conversion, body weight gain, and mortality did not show consistent significant differences. The 7-day trimming may allow earlier sexual maturity, but no differences existed for either BT group in egg production once in full lay. Beak trimming was economical, especially at 7 d of age.

Overall, claw reduction would be useful to the laying hen industry from a welfare point of view. Through 36 wk of age, there would be no economic gain or loss. However, differences may show up later in lay. The cost to reduce the claws of a laying hen in the hatchery is just a fraction of the profit from just one egg produced. So, to reduce welfare pressures, claw reduction would be a wise practice, with only benefits to gain.

Whether at 1 or 7 d of age, beak trimming would be a good practice both from an economic and welfare point of view. However, the cost (1¢/bird) of beak trimming in the hatchery with infrared energy is much less than the labor cost (7-10¢/bird) to trim at 7 or 10 d of age. Beak trimming at 1 d of age, due to ease and economics of the procedure being done in the hatchery, with no deleterious effects on stress, growth, or production, could also be recommended to the poultry industry.

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TABLE 1. Heterophil to lymphocyte ratios for claw and beak treatments of cockerels[1]

Age	Claw Treatment		Beak Treatment		
(d)	Reduced Claw	Intact Claw	1-day Trim[2]	7-day Trim[3]	Intact Beak
7	0.45 ± 0.07	0.33 ± 0.04	0.41 ± 0.07	0.41 ± 0.08	0.33 ± 0.04
9	0.51 ± 0.33 [a]	0.33 ± 0.03 [b]	0.46 ± 0.08	0.24 ± 0.03	0.43 ± 0.06
11	0.41 ± 0.05	0.35 ± 0.05	0.43 ± 0.06	0.36 ± 0.09	0.32 ± 0.04
14	0.51 ± 0.09	0.49 ± 0.18	0.42 ± 0.06	0.41 ± 0.51	0.62 ± 0.11
17	0.59 ± 0.22	0.42 ± 0.05	0.57 ± 0.22	0.52 ± 0.11	0.39 ± 0.07
21	0.63 ± 0.08	0.56 ± 0.10	0.73 ± 0.16	0.50 ± 0.14	0.53 ± 0.09

[a, b] Means within rows with different superscripts are significantly different ($P<0.05$)
[1] means ± SE
[2] beak trimmed with infrared energy at 1 d
[3] beak trimmed with hot blade debeaker at 7 d

TABLE 2. Body weight (g) and body weight gain (g/bird) for claw treatments during the growing period[1]

Age	Body Weight (g)		Body Weight Gain (g/bird)	
(wk)	Reduced Claw	Intact Claw	Reduced Claw	Intact Claw
0	40 ± 0.61	41 ± 0.55		
1	65 ± 0.55 [b]	67 ± 0.44 [a]	24 ± 0.54 [b]	26 ± 0.54 [a]
2	115 ± 1.20 [b]	118 ± 0.85 [a]	51 ± 1.01	51 ± 0.85
3	182 ± 1.71	183 ± 1.47	66 ± 0.65 [a]	64 ± 1.06 [b]
4	265 ± 2.39	262 ± 1.83	83 ± 1.16 [a]	79 ± 1.12 [b]
6	469 ± 2.56	472 ± 2.45	205 ± 1.11	207 ± 1.38
8	660 ± 2.99 [b]	665 ± 2.73 [a]	190 ± 1.48 [b]	194 ± 1.43 [a]
12	1,037 ± 5.76 [b]	1,056 ± 5.47 [a]	375 ± 3.58 [b]	389 ± 3.40 [a]
16	1,236 ± 7.13 [b]	1,263 ± 6.64 [a]	199 ± 3.17 [b]	208 ± 2.11 [a]
18	1,304 ± 8.13 [b]	1,333 ± 7.19 [a]	67 ± 2.87	69 ± 1.18

[a, b] Means within rows within body weight and body weight gain with different superscripts are significantly different ($P<0.05$)
[1] means ± SE

TABLE 3. Feed consumption (g/bird/d) and feed conversion (g feed/g gain) for claw treatments during the growing period[1]

Age	Feed Consumption (g/bird/d)		Feed Conversion (g feed/g gain)	
(wk)	Reduced Claw	Intact Claw	Reduced Claw	Intact Claw
0-4	17.9 ± 0.20	18.1 ± 0.13	6.08 ± 0.06 ^{b}	6.44 ± 0.08 ^{a}
5-6	39.9 ± 0.27	40.1 ± 0.26	2.73 ± 0.01	2.71 ± 0.02
7-8	44.1 ± 0.17 ^{b}	50.0 ± 0.16 ^{a}	3.69 ± 0.03	3.68 ± 0.03
9-12	63.6 ± 0.35 ^{b}	65.1 ± 0.42 ^{a}	4.77 ± 0.03	4.70 ± 0.04
13-16	64.3 ± 0.33 ^{b}	66.1 ± 0.34 ^{a}	9.99 ± 0.92	8.98 ± 0.08
17-18	55.2 ± 0.37 ^{b}	56.5 ± 0.33 ^{a}	11.80 ± 0.48	11.72 ± 0.20

$^{a, b}$ Means within rows within feed consumption and feed conversion with different superscripts are significantly different ($P<0.05$)
[1] means ± SE

TABLE 4. Mortality (%) for claw treatments during the growing period[1]

Age	Mortality (%)		Cumulative Mortality	
(wk)	Reduced Claw	Intact Claw	Reduced Claw	Intact Claw
1	0.24 ± 0.85	0.08 ± 0.51	4	1
2	1.06 ± 1.56	0.49 ± 1.16	16	7
3	0.16 ± 0.70	0.00	18	7
4	0.08 ± 0.51	0.00	19	7
5-6	0.00	0.23 ± 0.60	19	10
7-8	0.00	0.09 ± 0.30	19	11
9-12	0.32 ± 0.58	0.08 ± 0.29	23	12
13-16	0.00	0.00	23	12
17-18	0.00	0.00	23	12

[1] means ± SE

TABLE 5. Body weight (g) and body weight gain (g/bird) for beak treatments during the growing period[1]

Age	Body Weight (g)			Body Weight Gain (g/bird)		
(wk)	Intact Beak	7-day Trim[2]	1-day Trim[3]	Intact Trim	7-day Trim	1-day Trim
0	41 ± 0.85	41 ± 0.68	41 ± 0.67			
1	66 ± 0.73	65 ± 0.61	66 ± 0.60	26 ± 0.82	25 ± 0.51	25 ± 1.07
2	119 ± 1.03 [a]	116 ± 1.05 [b]	116 ± 1.51 [b]	52 ± 1.83	51 ± 0.69	52 ± 1.91
3	185 ± 2.26 [a]	184 ± 1.53 [a]	179 ± 1.99 [b]	64 ± 2.00 [b]	67 ± 0.65 [a]	63 ± 0.63 [b]
4	269 ± 3.33 [a]	265 ± 1.84 [b]	258 ± 2.42 [c]	84 ± 1.84 [a]	81 ± 1.25 [ab]	78 ± 1.16 [b]
6	483 ± 3.47 [a]	474 ± 2.37 [b]	459 ± 2.55 [c]	209 ± 1.69 [a]	208 ± 1.42 [a]	202 ± 1.33 [b]
8	677 ± 3.47 [a]	667 ± 3.00 [b]	650 ± 3.33 [c]	194 ± 1.72 [a]	193 ± 2.10 [ab]	189 ± 1.36 [b]
12	1,063 ± 7.28 [a]	1,054 ± 5.97 [a]	1,028 ± 6.94 [b]	386 ± 4.71 [a]	387 ± 3.56 [a]	375 ± 4.66 [b]
16	1,271 ± 8.65 [a]	1,256 ± 7.43 [b]	1,229 ± 8.80 [c]	208 ± 4.98	202 ± 2.86	202 ± 2.68
18	1,339 ± 9.54 [a]	1,323 ± 8.48 [b]	1,299 ± 9.81 [c]	68 ± 1.63	67 ± 2.15	69 ± 3.37

[a, b, c] Means within rows within body weight and body weight gain with different superscripts are significantly different ($P<0.05$)

[1] means ± SE

[2] beak trimmed with hot blade debeaker at 7 d

[3] beak trimmed with infrared energy at 1 d

TABLE 6. Treatment means and standard deviations of feed consumption (g/bird/d) and feed conversion (g feed/g gain) for beak treatments during the growing period[1]

Age	Feed Consumption (g/bird/d)			Feed Conversion (g feed/g gain)		
(wk)	Intact Beak	7-day Trim[2]	1-day Trim[3]	Intact Beak	7-day Trim	1-day Trim
0-4	18.7 ± 0.27 [a]	18.1 ± 0.13 [b]	17.4 ± 0.17 [c]	6.25 ± 0.11	6.27 ± 0.08	6.25 ± 0.09
5-6	41.0 ± 0.38 [a]	40.3 ± 0.29 [a]	39.0 ± 0.26 [b]	2.75 ± 0.02	2.71 ± 0.02	2.71 ± 0.02
7-8	51.8 ± 0.41 [a]	50.9 ± 0.38 [a]	49.0 ± 0.36 [b]	3.74 ± 0.03 [a]	3.72 ± 0.05 [a]	3.61 ± 0.03 [b]
9-12	65.1 ± 0.47 [a]	65.2 ± 0.38 [a]	63.0 ± 0.52 [b]	4.75 ± 0.05	4.74 ± 0.04	4.73 ± 0.05
13-16	67.3 ± 0.50 [a]	65.3 ± 0.32 [b]	63.7 ± 0.38 [c]	10.80 ± 1.84	9.18 ± 0.13	8.92 ± 0.10
17-18	58.5 ± 0.46 [a]	55.8 ± 0.35 [b]	54.0 ± 0.34 [c]	12.30 ± 0.27	11.34 ± 0.58	11.81 ± 0.33

[a, b, c] Means within rows within feed consumption and feed conversion with different superscripts are significantly different ($P<0.05$)
[1] means ± SE
[2] beak trimmed with hot blade debeaker at 7 d
[3] beak trimmed with infrared energy at 1 d

TABLE 7. Mortality (%) for beak treatments during the growing period[1]

Age	Mortality (%)			Cumulative Mortality		
(wk)	Intact Beak	7-day Trim[2]	1-day Trim[3]	Intact Beak	7-day Trim	1-day Trim
1	0.00 [b]	0.00 [b]	0.43 ± 1.36 [a]	0	0	4
2	0.98 ± 2.15	0.43 ± 1.25	0.98 ± 1.82	7	4	12
3	0.16 ± 1.01	0.00	0.10 ± 0.66	8	4	13
4	0.00	0.11 ± 0.68	0.00	8	5	13
5-6	0.00	0.21 ± 0.66	0.10 ± 0.47	8	7	14
7-8	0.00	0.00	0.12 ± 0.41	8	7	15
9-12	0.16 ± 0.59	0.00	0.43 ± 0.76	9	7	19
13-16	0.00	0.00	0.00	9	7	19
17-18	0.00	0.00	0.00	9	7	19

[1] means ± SE
[2] beak trimmed with hot blade debeaker at 7 d
[3] beak trimmed with infrared energy at 1 d

TABLE 8. Body weight (g) and body weight gain (g/bird) between claw treatments during the laying period[1]

Age	Body Weight (g)		Body Weight Gain (g/bird)	
(wk)	Reduced Claw	Intact Claw	Reduced Claw	Intact Claw
18	1,306 ± 5.72 [b]	1,334 ± 5.53 [a]		
20	1,479 ± 8.92 [b]	1,508 ± 8.54 [a]	173 ± 6.57	174 ± 7.09
24	1,632 ± 7.84 [b]	1,658 ± 7.84 [a]	154 ± 6.16	150 ± 4.96
28	1,651 ± 7.90 [b]	1,691 ± 8.17 [a]	19 ± 9.63	34 ± 9.22
32	1,745 ± 9.18 [b]	1,778 ± 9.47 [a]	94 ± 9.20	87 ± 6.86
36	1,771 ± 9.40 [b]	1,806 ± 10.21 [a]	26 ± 7.35	27 ± 9.62

[a, b] Means within rows within body weight and body weight gain with different superscripts are significantly different ($P<0.05$)

[1] means ± SE

TABLE 9. Feed consumption (g/bird/d) and feed conversion (g feed/dozen eggs) for claw treatments during the laying period[1]

Age	Feed Consumption (g/bird/d)		Feed Conversion (g feed/dozen eggs)	
(wk)	Reduced Claw	Intact Claw	Reduced Claw	Intact Claw
19-20	76 ± 0.57	76 ± 0.55	19,572 ± 1,522.43	18,416 ± 1,401.33
21-24	95 ± 0.59	96 ± 0.57	1,870 ± 29.67	1,862 ± 31.87
25-28	102 ± 0.64 [b]	104 ± 0.67 [a]	1,325 ± 9.77 [b]	1,352 ± 11.12 [a]
29-32	115 ± 0.89	116 ± 0.90	1,489 ± 15.22	1,503 ± 15.21
33-36	113 ± 1.15	114 ± 1.01	1,475 ± 16.17	1,510 ± 15.86

[a, b] Means within rows within feed consumption and feed conversion with different superscripts are significantly different ($P<0.05$)

[1] means ± SE

TABLE 10. Age (d) at first egg[1]

Treatment	Age (d)
Reduced Claw	141.5 ± 0.40
Intact Claw	140.6 ± 0.40
Intact Beak	141.7 ± 0.52 [a]
7-day Beak Trim[2]	139.7 ± 0.46 [b]
1-day Beak Trim[3]	141.7 ± 0.46 [a]

[a, b] Means within columns within beak and claw treatments with different superscripts are significantly different ($P<0.05$)

[1] means ± SE

[2] beak trimmed with hot blade debeaker at 7 d

[3] beak trimmed with infrared energy at 1 d

TABLE 11. Hen-housed and hen-day production (%) for claw treatments[1]

Age (wk)	Hen-housed Production (%)		Hen-day Production (%)	
	Reduced Claw	Intact Claw	Reduced Claw	Intact Claw
19	1.0	1.2	1.0	1.2
20	6.5	7.7	6.5	7.7
21	24.4	27.6	24.4	28.6
22	54.8	57.2	54.8	57.2
23	81.6	81.9	81.6	81.9
24	92.2	91.1	92.3	91.3
25	92.4	92.8	92.9	93.3
26	92.4	91.5	93.2	92.1
27	93.2	93.2	94.4	94.1
28	92.5	92.7	93.6	93.7
29	92.3	92.6	93.4	93.6
30	91.5	93.3	93.3	93.9
31	91.8	91.2	94.0	92.5
32	91.8	92.1	93.8	93.9
33	90.6	89.8	92.9	91.9
34	90.2	90.0	92.8	92.2
35	89.4	92.0	92.0	91.3
36	90.0	89.3	92.6	91.5

TABLE 12. Cumulative eggs for claw treatments

Age (wk)	Cumulative Production (hen-housed eggs)	
	Reduced Claw	Intact Claw
19	0.1	0.1
20	0.5	0.6
21	2.2	2.6
22	6.1	6.6
23	11.8	12.3
24	18.2	18.7
25	24.7	25.2
26	31.2	31.6
27	37.7	38.1
28	44.2	44.6
29	50.6	51.1
30	57.0	57.5
31	63.5	63.9
32	69.9	70.4
33	76.2	76.7
34	82.5	83.0
35	88.8	89.2
36	95.1	95.4

TABLE 13. Egg weights (g) for claw treatments[1]

Age (wk)	Egg Weight (g)	
	Reduced Claw	Intact Claw
20	50.1 ± 0.25	50.3 ± 0.30
24	52.9 ± 0.23	53.2 ± 0.23
28	58.8 ± 0.17 [b]	59.7 ± 0.11 [a]
32	60.9 ± 0.19	61.3 ± 0.20
36	61.8 ± 0.22	62.2 ± 0.22

[a,b] Means within rows with different superscripts are significantly different (P<0.05)

[1] means ± SE

TABLE 14. Specific gravities for claw treatments[1]

Age (wk)	Specific Gravity	
	Reduced Claw	Intact Claw
32	1.084 ± 0.0003	1.084 ± 0.0002
36	1.083 ± 0.0003	1.083 ± 0.0003

[1] means ± SE

TABLE 15. Mortality (%) for claw treatments during the laying period[1]

Age (wk)	Mortality (%)	
	Reduced Claw	Intact Claw
18-20	0.00	0.00
20-24	0.00	0.00
25-28	1.02 ± 0.75	1.00 ± 0.75
29-32	1.17 ± 0.81	0.87 ± 0.70
33-36	0.35 ± 0.45	1.04 ± 0.77

[1] means ± SE

TABLE 16. Body weight (g) and body weight gain (g/bird) for beak treatments during the laying period[1]

Age (wk)	Body Weight (g)		
	Intact Beak	7-day Trim[2]	1-day Trim[3]
18	1,336 ± 5.89 [a]	1,328 ± 7.72 [b]	1,295 ± 6.78 [c]
20	1,495 ± 9.78 [a]	1,513 ± 10.24 [a]	1,472 ± 11.93 [b]
24	1,655 ± 9.47 [a]	1,650 ± 9.34 [ab]	1,630 ± 10.09 [b]
28	1,692 ± 10.04 [a]	1,665 ± 9.35 [b]	1,658 ± 10.37 [b]
32	1,779 ± 11.63 [a]	1,759 ± 10.99 [ab]	1,747 ± 11.78 [b]
36	1,797 ± 12.05	1,786 ± 11.88	1,783 ± 12.44
	Body Weight Gain (g/bird)		
20	158 ± 6.95 [b]	185 ± 8.65 [a]	177 ± 9.21 [ab]
24	160 ± 5.64 [a]	137 ± 6.69 [b]	158 ± 7.87 [a]
28	37 ± 11.13	15 ± 11.96	27 ± 11.60
32	89 ± 8.06	94 ± 12.75	89 ± 8.28
36	17 ± 5.89	27 ± 11.95	36 ± 12.73

[a, b, c] Means within rows within body weight and body weight gain with different superscripts are significantly different ($P<0.05$)
[1] means ± SE
[2] beak trimmed with hot blade debeaker at 7 d
[3] beak trimmed with infrared energy at 1 d

TABLE 17. Feed consumption (g/bird/d) and feed conversion (g feed/dozen eggs) for beak treatments during the laying period[1]

Age (wk)	Feed Consumption (g/bird/d)		
	Intact Beak	7-day Trim[2]	1-day Trim[3]
18-20	76 ± 0.65 [b]	77 ± 0.72 [a]	75 ± 0.68 [b]
20-24	95 ± 0.74	96 ± 0.74	95 ± 0.71
25-28	106 ± 0.79 [a]	102 ± 0.79 [b]	101 ± 0.77 [b]
29-32	118 ± 1.10 [a]	113 ± 1.10 [b]	115 ± 1.12 [b]
33-36	116 ± 1.40 [a]	112 ± 1.40 [b]	113 ± 1.50 [b]
	Feed Conversion (g feed/dozen eggs)		
18-20	16,981 ± 1,860.24	18,412 ± 1,457.99	21,552 ± 2,105.75
20-24	1,909 ± 37.01 [a]	1,796 ± 33.07 [b]	1,892 ± 41.91 [ab]
25-28	1,353 ± 13.34	1,341 ± 13.06	1,323 ± 12.11
29-32	1,538 ± 22.31 [a]	1,471 ± 15.59 [b]	1,479 ± 16.85 [b]
33-36	1,521 ± 21.79	1,472 ± 16.70	1,484 ± 20.01

[a,b] Means within rows within feed consumption and feed conversion with different superscripts are significantly different ($P<0.05$)

[1] means ± SE

[2] beak trimmed with hot blade debeaker at 7 d

[3] beak trimmed with infrared energy at 1 d

TABLE 18. Hen-housed and hen-day production (%) for beak treatments

Age	Hen-housed Production (%)			Hen-day Production (%)		
(wk)	Intact Beak	7-day Trim[1]	1-day Trim[2]	Intact Beak	7-day Trim	1-day Trim
19	1.0	1.6	0.7	1.0	1.6	0.7
20	6.4 [ab]	8.6 [a]	5.9 [b]	6.4 [ab]	8.6 [a]	5.9 [b]
21	23.6 [b]	30.8 [a]	23.5 [b]	23.6 [b]	30.8 [a]	23.5 [b]
22	52.3 [b]	60.4 [a]	55.2 [ab]	52.3 [b]	60.4 [a]	55.2 [ab]
23	81.8	82.3	81.0	81.8	82.3	81.0
24	92.1	91.7	91.3	92.3	91.7	91.3
25	93.8 [a]	91.9 [b]	92.1 [b]	94.2	92.6	92.5
26	93.0	91.4	91.3	96.3	92.4	91.9
27	94.4	92.7	92.6	95.6 [a]	93.6 [ab]	93.6 [b]
28	93.3	91.7	92.8	94.5	92.8	93.6
29	92.2	92.4	92.7	93.3	93.5	93.6
30	92.0	91.8	92.7	93.6	93.3	93.9
31	90.0	91.4	93.1	91.9	93.4	94.4
32	91.9	91.7	92.2	93.8	93.7	94.0
33	90.8	89.4	90.4	92.8	92.0	92.5
34	90.8	89.7	89.8	93.0	92.7	91.9
35	89.2	89.0	89.5	91.3	91.9	91.7
36	90.0	89.0	89.3	92.0	91.9	92.2

[a, b] Means within rows within hen-housed and hen-day productions with different superscripts are significantly different ($P<0.05$)
[1] beak trimmed with hot blade debeaker at 7 d
[2] beak trimmed with infrared energy at 1 d

TABLE 19. Cumulative eggs for beak treatments

Age (wk)	Cumulative Production (hen-housed eggs)		
	Intact Beak	7-day Trim[1]	1-day Trim[2]
19	0.1	0.1	0.1
20	0.5 ^{ab}	0.7 ^{a}	0.5 ^{b}
21	2.2 ^{b}	2.9 ^{a}	2.1 ^{b}
22	5.8 ^{b}	7.1 ^{a}	6.0 ^{b}
23	11.6 ^{b}	12.9 ^{a}	11.7 ^{b}
24	18.0 ^{b}	19.3 ^{a}	18.0 ^{b}
25	24.6 ^{b}	25.7 ^{a}	24.5 ^{b}
26	31.1 ^{b}	32.1 ^{a}	30.9 ^{b}
27	37.7 ^{ab}	38.6 ^{a}	37.4 ^{b}
28	44.2 ^{ab}	45.0 ^{a}	43.9 ^{b}
29	50.7	51.5	50.3
30	57.1	57.9	57.8
31	63.4	64.3	63.3
32	69.8	70.7	69.8
33	76.2	77.0	76.1
34	82.6	83.3	82.4
35	88.8	89.5	88.7
36	95.1	95.7	95.0

$^{a, b}$ Means within rows with different superscripts are significantly different ($P<0.05$)
[1] beak trimmed with hot blade debeaker at 7 d
[2] beak trimmed with infrared energy at 1 d

TABLE 20. Egg weights (g) for beak treatments[1]

Age (wk)	Egg Weight (g) Intact Beak	7-day Trim[2]	1-day Trim[3]
20	50.2 ± 0.37	50.5 ± 0.33	49.9 ± 0.32
24	52.8 ± 0.24	53.4 ± 0.24	52.9 ± 0.30
28	59.3 ± 0.23	59.2 ± 0.24	59.3 ± 0.22
32	61.1 ± 0.23 [ab]	60.8 ± 0.24 [b]	61.5 ± 0.25 [a]
36	62.1 ± 0.29	61.9 ± 0.25	62.0 ± 0.27

[a,b] Means within rows with different superscripts are significantly different ($P<0.05$ Duncan's multiple range test)
[1] means ± SE
[2] beak trimmed with hot blade debeaker at 7 d
[3] beak trimmed with infrared energy at 1 d

TABLE 21. Specific gravities for beak treatments[1]

Age (wk)	Specific Gravity Intact Beak	7-day Trim[2]	1-day Trim[3]
32	1.085 ± 0.0003	1.084 ± 0.0003	1.084 ± 0.0003
36	1.083 ± 0.0004	1.084 ± 0.0003	1.083 ± 0.0003

[1] means ± SE
[2] beak trimmed with hot blade debeaker at 7 d
[3] beak trimmed with infrared energy at 1 d

TABLE 22. Mortality (%) for beak treatments during the laying period[1]

Age (wk)	Mortality (%) Intact Beak	7-day Trim[2]	1-day Trim[3]
18-20	0.00	0.00	0.00
21-24	0.00	0.00	0.00
25-28	1.24 ± 1.01	0.87 ± 0.86	0.91 ± 0.88
29-32	0.91 ± 0.88	1.50 ± 1.11	0.65 ± 0.75
33-36	0.46 ± 0.63	0.72 ± 0.79	0.91 ± 0.88

[1] means ± SE
[2] beak trimmed with hot blade debeaker at 7 d
[3] beak trimmed with infrared energy at 1 d

TABLE 23. Fearfulness scores at 6 to 8 and 16 to 18 wk for claw treatments

6 to 8 weeks

	Reduced Claw										
Activity	1	2	3	4	5	6	7	8	9	10	Total
1	1	8	7	3	1	0	0	0	0	0	55
2	0	0	4	5	8	2	1	0	0	0	91
3	1	2	11	4	2	0	0	0	0	0	62
4	0	1	0	6	5	3	2	2	1	0	108
	Intact Claw										
1	0	0	0	1	3	0	1	10	2	3	114
2	0	0	0	0	0	1	3	4	9	3	170
3	0	0	0	1	1	1	3	5	5	4	161
4	0	0	0	0	0	0	0	3	7	10	188

16 to 18 weeks

	Reduced Claw										
Activity	1	2	3	4	5	6	7	8	9	10	Total
1	6	6	3	1	4	0	0	0	0	0	51
2	2	4	5	6	1	1	1	0	0	0	67
3	0	10	7	2	1	0	0	0	0	0	54
4	1	3	7	4	2	3	0	0	0	0	72
	Intact Claw										
1	0	0	2	2	1	6	2	5	2	0	127
2	0	0	0	1	2	2	4	10	1	0	143
3	0	0	0	0	2	5	9	4	0	0	135
4	0	0	0	0	1	6	5	4	3	1	145

Activity key: 1 = Feeding; 2 = Walking by; 3 = Waving arm; 4 = Waving broom

TABLE 24. Body weight and body weight gain interactions of claw x beak treatments

	Body Weight	
	Wk 3	
	Reduced Claw	Intact Claw
1-day[1]	178	181
7-day[2]	182	186
Intact Beak	188	181
	Body Weight Gain	
	Reduced Claw	Intact Claw
1-day	64	63
7-day	67	68
Intact Beak	69	61

Interactions were significant at $P<0.05$

[1] beak trimmed with infrared energy at 1 d

[2] beak trimmed with hot blade debeaker at 7 d

TABLE 25. Body weight, body weight gain, and feed consumption interactions of strain x claw treatments

	Body Weight		Feed Consumption	
	Wk 3		Wk 18	
	Hy-Line	Bovans	Hy-Line	Bovans
Reduced Claw	189	175	57.1	53.2
Intact Claw	187	179	57.4	55.5
	Body Weight Gain			
	Hy-Line	Bovans		
Reduced Claw	68	64		
Intact Claw	63	65		

Interactions were significant at $P<0.05$

TABLE 26. Body weight and body weight gain interactions of strain x beak treatments

	Body Weight							
	Wk 2		Wk 3		Wk 12		Wk 16	
	Bovans	Hy-Line	Bovans	Hy-Line	Bovans	Hy-Line	Bovans	Hy-Line
1-day[1]	110	121	171	187	979	1,076	1,164	1,295
7-day[2]	112	120	178	190	1,015	1,094	1,203	1,309
Intact Beak	115	123	183	186	1,034	1,093	1,223	1,320

	Body Weight Gain					
	Wk 2		Wk 3		Wk 12	
	Bovans	Hy-Line	Bovans	Hy-Line	Bovans	Hy-Line
1-day	71	78	61	65	344	406
7-day	74	77	66	69	363	411
Intact Beak	77	79	67	61	368	404

Interactions were significant at $P<0.05$
[1] beak trimmed with infrared energy at 1 d
[2] beak trimmed with hot blade debeaker at 7 d

TABLE 27. Mortality interactions of strain x beak treatments

	Mortality (%)	
	Wk 1	
	Bovans	Hy-Line
1-day[1]	0.38	0
7-day[2]	0	0
Intact Beak	0	0

Interactions were significant at $P<0.05$
[1] beak trimmed with infrared energy at 1 d
[2] beak trimmed with hot blade debeaker at 7 d

TABLE 28. Cumulative feed costs for beak and claw treatments from 0 to 18 and 19 to 36 wk of age[1]

Age	Claw Treatment Feed Cost ($/bird)		Beak Treatment Feed Cost ($/bird)		
(wk)	Reduced Claw	Intact Claw	Intact Beak	7-day Trim[2]	1-day Trim[3]
0-4	0.11 ± 0.00	0.12 ± 0.00	0.12 ± 0.00 [a]	0.12 ± 0.00 [b]	0.11 ± 0.00 [c]
5-6	0.25 ± 0.02	0.25 ± 0.01	0.25 ± 0.02	0.25 ± 0.02	0.24 ± 0.02
7-8	0.39 ± 0.02	0.40 ± 0.02	0.41 ± 0.03	0.40 ± 0.03	0.39 ± 0.03
9-12	0.74 ± 0.02	0.77 ± 0.02	0.78 ± 0.03	0.77 ± 0.02	0.75 ± 0.02
13-16	1.13 ± 0.02	1.16 ± 0.02	1.18 ± 0.03	1.16 ± 0.02	1.12 ± 0.02
17-18	1.29 ± 0.02	1.32 ± 0.01	1.31 ± 0.03	1.28 ± 0.02	1.25 ± 0.02
19-20	0.22 ± 0.00	0.22 ± 0.00	0.22 ± 0.00 [b]	0.22 ± 0.00 [a]	0.22 ± 0.00 [b]
21-24	0.80 ± 0.01	0.81 ± 0.01	0.80 ± 0.01	0.81 ± 0.01	0.80 ± 0.01
25-28	1.42 ± 0.01 [b]	1.44 ± 0.01 [a]	1.45 ± 0.01 [a]	1.43 ± 0.01 [ab]	1.42 ± 0.01 [b]
29-32	2.14 ± 0.01	2.16 ± 0.01	2.18 ± 0.02 [a]	2.14 ± 0.02 [ab]	2.13 ± 0.02 [b]
33-36	2.86 ± 0.03	2.89 ± 0.02	2.91 ± 0.03	2.87 ± 0.03	2.85 ± 0.03

[a, b, c] Means within rows, within claw and beak treatments with different superscripts are significantly different ($P<0.05$)
[1] means ± SE
[2] beak trimmed with hot blade debeaker at 7 d
[3] beak trimmed with infrared energy at 1 d

TABLE 29. Feed costs for beak and claw treatments during the growing and laying periods[1]

Age	Claw Treatment Feed Cost ($/bird)		Beak Treatment Feed Cost ($/bird)		
(wk)	Reduced Claw	Intact Claw	Intact Beak	7-day Trim[2]	1-day Trim[3]
0-4	0.11 ± 0.001	0.12 ± 0.001	0.12 ± 0.002 [a]	0.12 ± 0.001 [b]	0.11 ± 0.001 [c]
5-6	0.13 ± 0.001	0.13 ± 0.001	0.13 ± 0.001 [a]	0.13 ± 0.001 [a]	0.12 ± 0.001 [b]
7-8	0.14 ± 0.001 [b]	0.14 ± 0.001 [a]	0.14 ± 0.001 [a]	0.14 ± 0.001 [a]	0.14 ± 0.001 [b]
9-12	0.35 ± 0.002 [b]	0.36 ± 0.002 [a]	0.36 ± 0.003 [a]	0.36 ± 0.002 [a]	0.35 ± 0.003 [b]
13-16	0.37 ± 0.002 [b]	0.39 ± 0.002 [a]	0.39 ± 0.003 [a]	0.38 ± 0.002 [b]	0.37 ± 0.002 [c]
17-18	0.16 ± 0.001 [b]	0.16 ± 0.001 [a]	0.17 ± 0.001 [a]	0.16 ± 0.001 [b]	0.16 ± 0.001 [c]
19-20	0.22 ± 0.002	0.22 ± 0.002	0.22 ± 0.002 [b]	0.22 ± 0.002 [a]	0.22 ± 0.002 [b]
21-24	0.58 ± 0.003	0.59 ± 0.003	0.58 ± 0.005	0.59 ± 0.004	0.58 ± 0.004
25-28	0.63 ± 0.004 [b]	0.64 ± 0.004 [a]	0.65 ± 0.005 [a]	0.63 ± 0.005 [b]	0.62 ± 0.005 [b]
29-32	0.70 ± 0.005	0.71 ± 0.006	0.72 ± 0.007 [a]	0.69 ± 0.006 [b]	0.70 ± 0.007 [b]
33-36	0.69 ± 0.007	0.70 ± 0.006	0.71 ± 0.009 [a]	0.68 ± 0.006 [b]	0.70 ± 0.009 [ab]

[a, b, c] Means within rows, within claw and beak treatments with different superscripts are significantly different ($P<0.05$)
[1] means ± SE
[2] beak trimmed with hot blade debeaker at 7 d
[3] beak trimmed with infrared energy at 1 d

TABLE 30. Comparison of claw treatment cost and returns for commercial flocks of 120,000 caged layers

	Reduced Claw		Intact Claw	
Income Item	Quantity	Value	Quantity	Value
Eggs [#/HH; RC[1] $.5351/doz; IC[2] $.5396/doz(Table 32)]	951,000 doz	508,880.10	954,300 doz	514,940.28
Manure (25% moisture; $15/ton) *	297 tons	4,450.71	300 tons	4,507.20
Total		$ 513,330.81		$ 519,447.48
Operating Expenses	Quantity	Value	Quantity	Value
ITEM				
Pullets w/Marek's ($2.25 ea.)**	120,000 birds	92,215.38	120,000 birds	93,461.54
Claw Reduction (1¢/bird)	120,000 birds	415.38	120,000 birds	0.00
Feed (18-36 wk; $194/ton)	1,712 tons	332,092.07	1,734 tons	336,306.19
Medicine & Vaccination ($40/k)	120,000 birds	1,661.54	120,000 birds	1,661.54
Electricity ($215/k)	120,000 birds	8,930.77	120,000 birds	8,930.77
REPAIRS				
Building (1%)	$150,968.08	1,509.68	$150,968.08	1,509.68
Equipment (3%)	$214,425.00	6,432.75	$214,425.00	6,432.75
INTEREST ON OPERATING CAPITAL				
Pullets (12%)	$92,215.38	3,830.49	$93,461.54	3,882.25
Feed (12%; 60 d)	$49,551.60	991.03	$56,066.00	1,121.32
Labor (12%; 60 d)	$2,910.00	58.20	$2,910.00	58.20
Miscellaneous (supplies, phone, disinfectant; $20/k)	120,000 birds	830.77	120,000 birds	830.77
Total		$ (448,968.07)		$ (454,195.00)
Net returns to capital, labor, land, and management		64,362.74		65,252.48
Annual Fixed Cost (Table 33)		(55,136.00)		(55,136.00)
Net returns to labor, land, and management		9,226.74		10,116.48
Labor cost or value ($7/h, 8 h/d for 1 man + manager @ 30,000)		(17,460.00)		(17,460.00)
Net returns to land and management		$ (8,233.26)		$ (7,343.52)

* Fresh manure @ 87% moisture.

** Reduced claw pullet cost = $2.22

Note: Feed, eggs, & manure are actual figures. Other costs prorated to 18 of 52 wk.

[1] claw reduced with microwave energy at 1 d; [2] intact claw

TABLE 31. Comparison of beak treatment cost and returns for commercial flocks of 120,000 caged layers

	1-day	7-day	Intact Beak
Income Item	Value	Value	Value
Eggs [#/HH; 1-d[1] \$.5359/doz; 7-d[2] \$.5391/doz; IB[3] \$.5370(Table 32)]	508,944.23	516,080.43	510,687.00
Manure (25% moisture; \$15/ton) *	4,445.04	4,445.61	4,546.29
Total	\$ 513,389.27	\$ 520,526.04	\$ 515,233.29
Operating Expenses	Value	Value	Value
ITEM			
Pullets w/Marek's (\$2.25 ea.)**	90,969.23	92,215.38	93,461.54
Claw Reduction (1¢/bird)	415.38	2,907.69	0.00
Feed (18-36 wk; \$194/ton)	331,668.15	331,711.26	339,223.37
Medicine & Vaccination (\$40/k)	1,661.54	1,661.54	1,661.54
Electricity (\$215/k)	8,930.77	8,930.77	8,930.77
REPAIRS			
Building (1%)	1,509.68	1,509.68	1,509.68
Equipment (3%)	6,432.75	6,432.75	6,432.75
INTEREST ON OPERATING CAPITAL			
Pullets (12%)	3,778.72	3,830.49	3,882.25
Feed (12%; 60 d)	912.65	1,049.54	1,069.15
Labor (12%; 60 d)	150.82	150.82	150.82
Miscellaneous (supplies, phone, disinfectant; \$20/k)	830.77	830.77	830.77
Total	\$ (447,260.47)	\$ (451,230.69)	\$ (457,152.63)
Net returns to capital, labor, land, and management	66,128.80	69,295.35	58,080.66
Annual Fixed Cost (Table 33)	(55,136.07)	(55,136.07)	(55,136.07)
Net returns to labor, land, and management	10,992.73	14,159.28	2,944.59
Labor cost or value (\$7/h, 8 h/d for 1 man + manager @ 30,000)	(17,460.00)	(17,460.00)	(17,460.00)
Net returns to land and management	\$ (6,467.20)	\$ (3,300.65)	\$ (14,515.34)

* Fresh manure @ 87% moisture.
** 1-day beak trim pullet cost = \$2.19; 7-day beak trim pullet cost = \$2.22
Note: Feed, eggs, & manure are actual figures. Other costs are prorated to 18 of 52 wk.
[1] beak trimmed with infrared energy at 1 d; [2] beak trimmed with hot blade at 7 d; [3] intact beak

TABLE 32. Blend price calculations for claw and beak treatments

Egg size	price/doz (cents)	Reduced Claw eggs (%)	Reduced Claw Total (cents)	Intact Claw eggs (%)	Intact Claw Total (cents)		
Extra large and jumbo	60	0.0693	4.16	0.1007	6.04		
Large	58	0.4816	27.93	0.4932	28.61		
Medium	50	0.3190	15.95	0.2823	14.12		
Small	42	0.1301	5.46	0.1238	5.20		
Total	210	1	53.51	1	53.96		
		1-day Trim[1] eggs (%)	1-day Trim[1] Total (cents)	7-day Trim[2] eggs (%)	7-day Trim[2] Total (cents)	Intact Beak Eggs (%)	Intact Beak Total (cents)
Extra large and jumbo	60	0.0800	4.80	0.0770	4.62	0.0980	5.88
Large	58	0.4898	28.41	0.5031	29.18	0.4692	27.21
Medium	50	0.2898	14.49	0.3088	15.44	0.3033	15.17
Small	42	0.1402	5.89	0.1113	4.67	0.1295	5.44
Total	210	1	53.59	1	53.91	1	53.70

[1] beak trimmed with infrared energy at 1 d
[2] beak trimmed with hot blade debeaker at 7 d

TABLE 33. Investments and fixed costs for claw and beak treatments

	Investment			Average Annual Fixed Cost			
	New	Average	Years of life	Depreciation	Interest (12%)	Taxes & Insurance (6%)	Total
Buildings	150,968	75,484	20	7,548	9,058	4,529	21,136
Equipment	214,425	107,213	15	14,295	12,866	6,433	33,593
Well	1,731	865	20	87	104	52	242
Pump	865	433	10	87	52	26	164
Totals	367,989	183,995		22,016	22,079	11,040	$55,136

* Building costs does not include pad preparation or other external hook-ups. Equipment includes manure removal equipment and egg cooler. No land values are included.

FIGURE 1. Growth curve for claw treatments

FIGURE 2. Growth curve for beak treatments

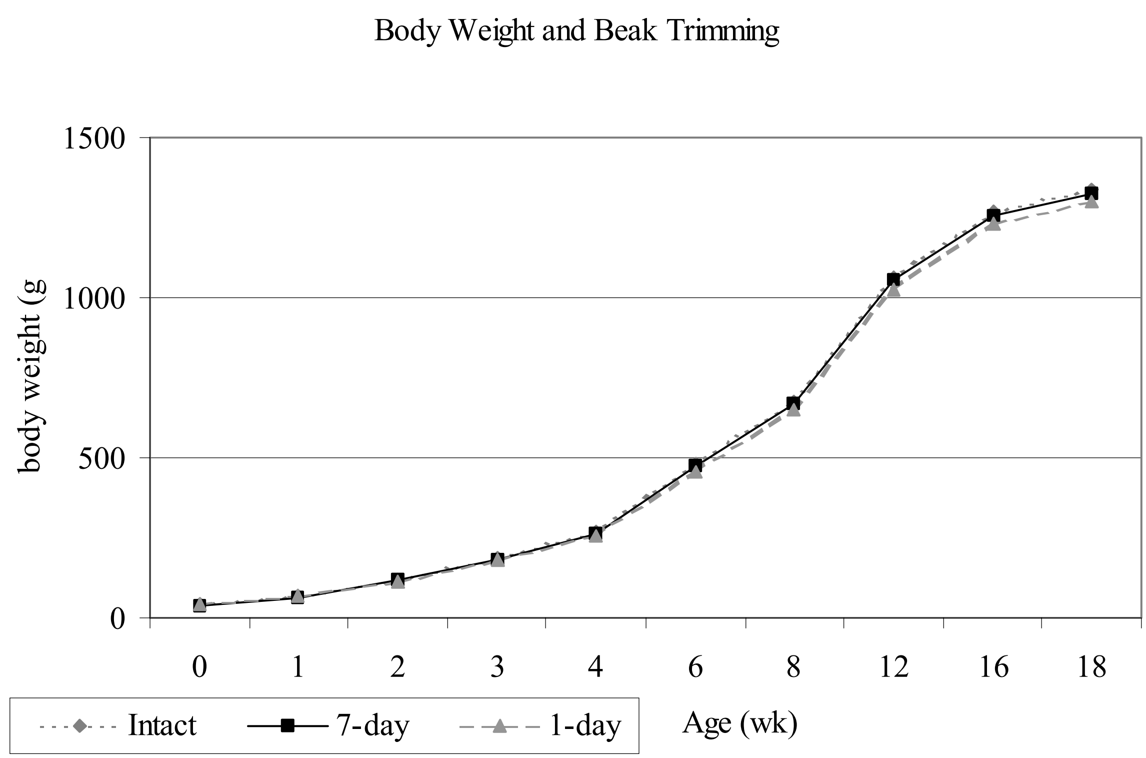


FIGURE 3. Hen-day production (%) per week for claw treatments

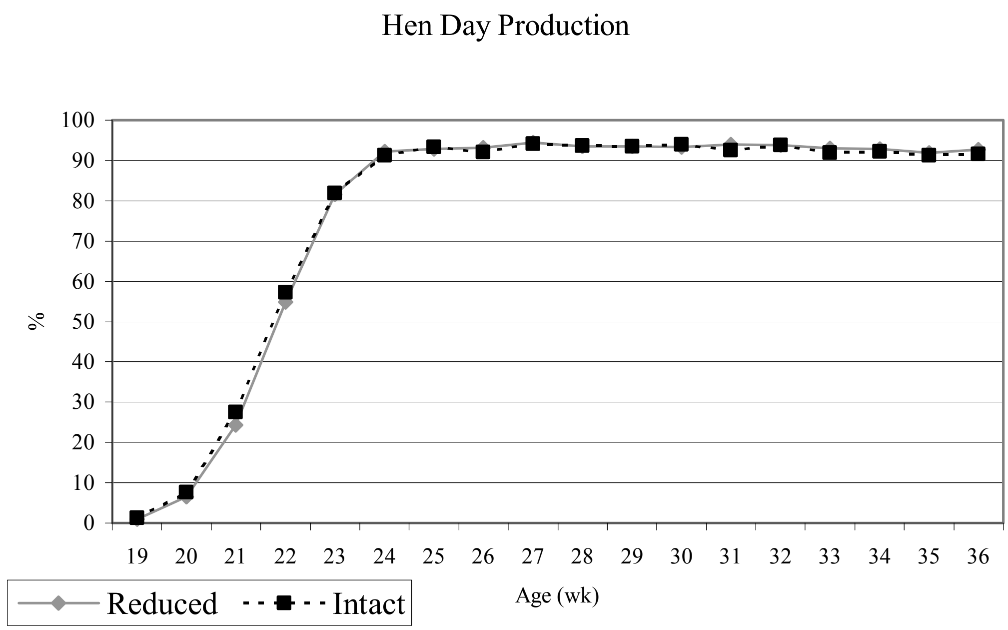


FIGURE 4. Hen-day production (%) per week for strains

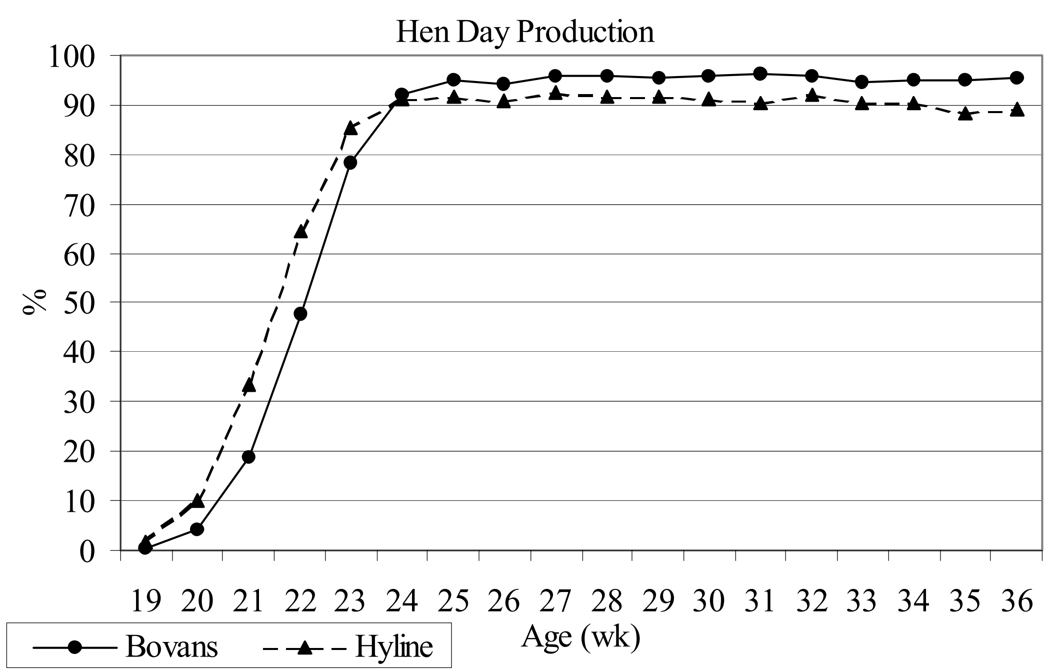


FIGURE 5. Hen-day production (%) per week for beak treatments

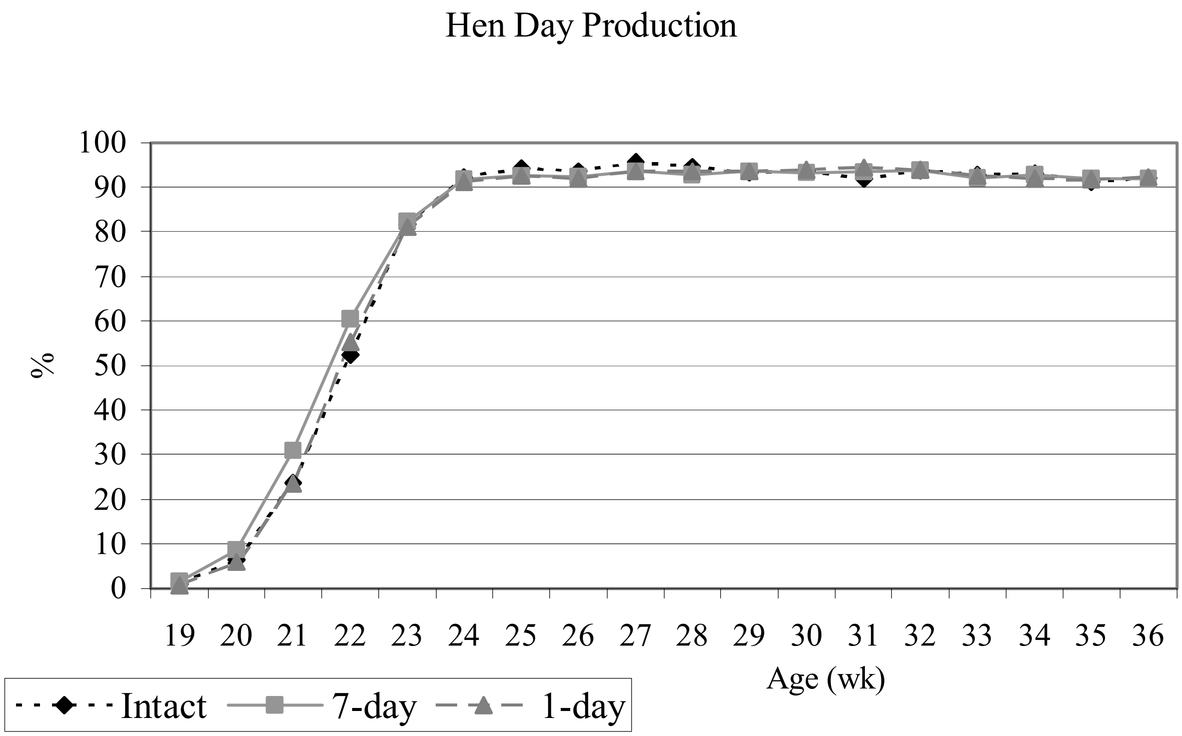
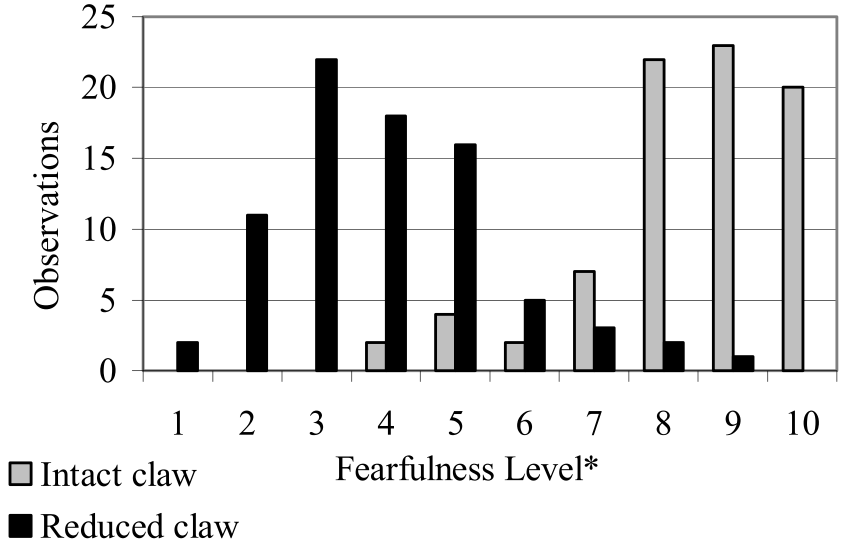
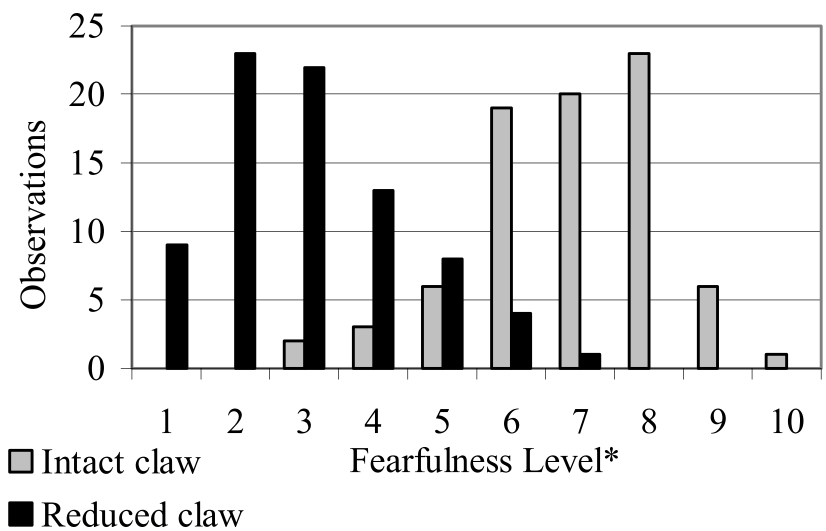


FIGURE 6. Total observations of fearfulness levels for four fear inducing activities between claw treatments from 6 to 8 wk of age



*Fearfulness Score: 1 = calm 10 = total fear

FIGURE 7. Total observations of fearfulness levels for four fear inducing activities between claw treatments from 16 to 18 wk of age



*Fearfulness Score: 1 = calm 10 = total fear

APPENDIX A

Growing and laying period ration formulation, including starter, grower, developer, pre-lay, and peak layer

Nutrient	Units	Starter	Grower	Developer	Pre-lay	Peak layer
Crude Protein	%	20.000	17.500	15.000	15.482	18.012
Crude Fat	%	3.925	4.226	3.832	5.278	6.3867
Crude Fiber	%	3.396	3.994	4.219	3.358	2.779
ME Poultry	kcal/lb	1330	1300	1300	1331	1325
Lysine	%	1.074	0.830	0.580	0.845	1.054
Methionine	%	0.349	0.320	0.256	0.367	0.459
TSAA	%	0.690	0.620	0.528	0.631	0.751
Arginine	%	1.324	1.094	0.859	1.017	1.229
Tryptophan	%	0.273	0.224	0.178	0.189	0.226
Histidine	%	0.513	0.437	0.359	0.401	0.471
Threonine	%	0.771	0.651	0.541	0.591	0.707
Isoleucine	%	0.873	0.727	0.602	0.632	0.772
Phenylalanine	%	0.984	0.814	0.661	0.756	0.905
Phe + Tyr	%	1.796	1.477	1.193	1.457	1.714
Dry Matter	%	3.914	3.998	3.526	89.328	90.054
Calcium	%	1.028	0.950	0.900	9.592	13.769
Tot. Phosphorus	%	0.686	0.643	0.602	2.485	4.102
Avail. Phosphorus	%	0.450	0.400	0.380	0.673	0.672
Sodium	%	0.200	0.200	0.200	0.449	0.461
Chloride	%	0.168	0.190	0.201	0.183	0.182
Potassium	%	0.804	0.689	0.512	0.263	0.278
Magnesium	%	0.183	0.190	0.179	0.721	0.807
Sulphur	%	0.230	0.208	0.181	0.174	0.182
Copper	ppm	22.272	21.410	16.123	0.176	0.207
Zinc	10ppm	15.561	16.040	11.717	17.276	17.726
Manganese	10ppm	8.990	9.424	6.863	13.282	12.873
Cobalt	ppm	0.082	0.085	0.074	7.388	7.007
Iodine	ppm	4.133	4.109	3.749	0.071	0.066
Iron	%	0.020	0.016	0.013	3.909	3.677
Selenium	ppm	0.316	0.319	0.430	0.010	0.011
Stab. Vit. A	KIU/lb	3.402	3.402	2.552	0.367	0.363
Vitamin D	KIU/lb	1.400	1.400	1.050	2.551	2.552
Vitamin E	mg/lb	13.510	15.211	14.652	1.050	1.050
Vitamin K	mg/lb	1.094	1.093	0.838	12.255	10.322
Biotin	mg/lb	0.078	0.068	0.064	0.836	0.830
Choline	g/lb	0.750	0.500	0.500	0.061	0.068
Folic Acid	mg/lb	0.187	0.182	0.166	0.748	0.748
Niacin	g/lb	0.022	0.024	0.022	0.447	0.474
Pantothenic Acid	mg/lb	7.596	7.540	6.310	0.021	0.020

Photoperiod Schedule

Age (wk)	Photoperiod (hr)	Age (wk)	Photoperiod (hr)
0-1	22.00		
1-2	20.00	18-19	13.00
2-3	18.00	19-20	14.00
3-4	16.00	20-28	Increased each wk in 15 min increments to 16 h
4-17	10.00		
17-18	12.00		

Fearfulness Evaluation Sheet

Room	Activity	Score: Reduced Claw	Score: Intact Claw
A	Feeding	____	____
	Walking	____	____
	Arm waving	____	____
	Broom	____	____
B	Feeding	____	____
	Walking	____	____
	Arm waving	____	____
	Broom	____	____
C	Feeding	____	____
	Walking	____	____
	Arm waving	____	____
	Broom	____	____
D	Feeding	____	____
	Walking	____	____
	Arm waving	____	____
	Broom	____	____

Ranking -- 1 = very calm; 2 = mild chirp; 3 = normal mvmnt; 4 = loud chirp; 5 = excited mvmnt; 6 = fearful chirp; 7 = flighty; 8 = squawk; 9 = wild mvmnt; 10 = panic

Experience

__ None
__ Have seen live chickens
__ Have cared for small home flock
__ Own a personal flock
__ Professional skills
__ Worked for commercial operation
__ Family farm operation
__ Laboratory experience

Giemsa-May-Gruenwald Staining Procedure

1. Allow the spun blood to dry. Stain no later than 1 day following spinning.
2. Place slides on staining rack. Cover slides with May-Gruenwald staining solution (undiluted) for 5 minutes.
3. Rinse with buffer (stored in refrigerator and titrated at each use to pH of 7.2). Stir by blowing air through pipette for 5 minutes. Pour off buffer.
4. Cover slides with giemsa blood stain (diluted 50:50 with dH_2O). Only dilute what is needed for each staining session, about 1 ml per slide. Stir by blowing air through pipette every few minutes. After 15 minutes, pour off stain.
5. Rinse slides by swishing them in dH_2O. Place in bibulous paper booklet and allow to dry.

Buffer Recipe:

5.6 g NaH_2PO_4
21.4 g Na_2HPO_4
bring up to 1 L and pH of 7.2

CHRISTA F. HONAKER

Christa F. Honaker, daughter of Mr. and Mrs. Charles W. Ferst, was born on March 21, 1978, in Atlanta, Georgia. Elementary, middle, and high school education were completed in Maryville, Tennessee. Following graduation from Maryville High School in 1996, she attended Virginia Polytechnic Institute and State University in Blacksburg, Virginia. A Bachelor of Science degree in Animal and Poultry Science was conferred in 2000. In the fall of 2000, Christa continued to graduate studies at Virginia Tech. Her major area of specialization was husbandry and management of egg-type chickens under the direction of Dr. P. L. Ruszler in the Department of Animal and Poultry Science.

Christa is a member of the Poultry Science Association, and received the Award of Excellence in 2001. In 2002, she was granted the Maurice Stein Fellowship Award. She is also a member of Sigma Xi.