Comparative Effects of Infrared and One-Third Hot-Blade Trimming on Beak Topography, Behavior, and Growth

R. M. Marchant-Forde,*[1] A. G. Fahey,*† and H. W. Cheng*

*USDA-Agricultural Research Service, Livestock Behavior Research Unit, 125 S. Russell St., West Lafayette, IN 47907; and †Purdue University, West Lafayette, IN 47907

ABSTRACT This research examined the effects of infrared beak treatment on layer chicks. Seventy-two layer chicks were assigned to hot-blade trimming (HB), infrared treatment (IR), or a control treatment. Day-old chicks were pair-housed by treatment. Beak photographs, behavior, and production indices were obtained at intervals for 9 wk posttreatment. All beaks were normally shaped at the onset of the study, and no perceptible treatment-related differences in shape occurred over time ($P > 0.05$). Posttreatment, HB birds had shorter beaks relative to the other 2 groups ($P < 0.05$). Control and IR beaks remained comparable in length until tissue eroded in IR beaks at 1 to 2 wk posttreatment. Thereafter, beak length increased in all treatments over time ($P < 0.01$). Two weeks posttreatment, beaks were longest in control birds, intermediate in HB birds ($P < 0.001$), and shortest in IR birds ($P < 0.001$). The HB birds had abnormal deviations from a normal upper-to-lower mandible length ratio than the IR or control birds ($P < 0.05$). Notable effects of treatment on production emerged by +2 d and persisted for 5 wk. Growth and feed intake were lower in HB and IR birds compared with control birds ($P < 0.05$), with IR birds performing least well until the fourth week of the study ($P < 0.05$). Thereafter, they performed similarly to the HB group. Feed waste was lowest in the IR group and was generally greatest in the control group ($P < 0.05$). There was an overall effect of trimming, irrespective of method, on behavior, particularly eating and drinking behaviors ($P < 0.05$). Specifically, IR birds were less active ($P < 0.01$) and spent less time eating ($P < 0.01$) and drinking ($P < 0.05$) than did control birds. Behavior in HB birds often ranked intermediate in duration and incidence, but was not significantly different compared with behavior measured in the control and IR groups. Effects of treatment on behavior were not present after 1 wk posttrimming. Results indicate that acute pain occurred with both trimming methods. Although the impact of trimming appeared to be greatest in the IR birds initially, these differences disappeared relatively quickly, and subsequent performance was similar in both trimmed groups.

Key words: beak trimming, well-being, layers, infrared, hot blade

2008 Poultry Science 87:1474–1483
doi:10.3382/ps.2006-00360

INTRODUCTION

Beak trimming of poultry functions to reduce or inhibit undesirable behaviors, such as interbird pecking, aggression, and cannibalism. As with most invasive husbandry procedures, beak trimming has elicited a great deal of debate and research concerning the relative advantages and disadvantages of the practice from an animal well-being perspective. Although the resulting benefits of lowered aggression, feather pecking, and cannibalism may indeed favor improved well-being during the laying cycle, there is a considerable body of morphological, neurophysiological, behavioral, and production research demonstrating the emergence of several markers of acute and chronic pain (e.g., persistent lethargy and guarding behaviors, reduced feed intake, and development of neuromas) as a result of trimming (Eskeland, 1981; Gentle, 1986; Gentle et al., 1990, 1991). Nevertheless, the reported effects of beak trimming on behavior, physiology, and production are at times paradoxical. This may be due in part to inconsistency in the type and degree of beak trimming performed (e.g., hot blade vs. cold blade; one-half vs. one-third), together with differences in bird strain or breed, as well as variations in both the age at which the procedure is performed and what parameters are observed. The degree and type of behavioral modifications that occur following beak trimming are somewhat determined by age at trimming and the severity of trimming performed. Generally, although not exclusively, there is a positive correlation between the age of the bird at trimming and the impact of the procedure on measures of well-being. A similar relationship seems to exist between the severity of trimming (e.g., one-fourth vs. one-third

Received October 20, 2006.
Accepted November 13, 2007.
[1]Corresponding author: rforde@purdue.edu

vs. one-half) and other measurable outcomes, and these have been addressed at length in a recent comprehensive review (Hester and Shea-Moore, 2003). Different strains of chickens may also respond differently to beak trimming. For instance, although white and brown egg-laying strains have not been used simultaneously in any single study, between-study comparisons suggest that brown egg-laying hens are more negatively affected by trimming. They appear to develop more pain-related behaviors and form neuromas more readily following trimming at 4 to 5 wk of age (Breward and Gentle, 1985; Gentle, 1986; Lee and Craig, 1990; Kuo et al., 1991).

The benefits of beak trimming to both bird and producer promote its continued use in the United States. Even so, it is anticipated that increasing pressure for improved well-being will require the poultry industry to seek and instigate alternatives to conventional hot-blade trimming (**HB**). One such substitute is infrared treatment (**IR**), which is purported to be the most promising new method of trimming, in terms of efficacy and well-being outcomes (Glatz, 2005). Nevertheless, because research into IR is still in its infancy, sufficient data have yet to emerge to either support or negate its postulated benefits.

Infrared beak trimming is a completely automated process in which day-old chicks are immobilized by using a head restraint and infrared energy is focused on the area of the beak requiring trimming. High-intensity heat penetrates down through the beak's corneum layer to the basal tissue and prevents further germ layer growth. Following treatment, the corneum-generating layer remains intact until 7 to 10 d posttrimming, after which the tip of the beak begins to slough off and is subsequently eroded away with use. One of the perceived advantages of this method of trimming, relative to HB, is the elimination of open wounds and potential bleeding sites that may lead to inflammation, infection, and associated pain. Furthermore, in earlier studies, trimming has resulted in a reduction in feed intake that has, in part, been attributed to trimming-induced changes in a bird's ability to grasp and manipulate feed (Gentle et al., 1982, 1997). With IR, reduction in beak length occurs much more gradually, which may facilitate better adaptation of beak-related functions (e.g., feeding behavior) posttrimming.

The present work is the first in a series of studies designed to evaluate the effectiveness and effects of IR beak trimming on layer well-being. The specific objective of this work was to compare the temporal effects of IR and HB at 1 d of age on the subsequent behavior and growth of layer chicks from 0 to 9 wk of age.

MATERIALS AND METHODS

Housing and Husbandry

All research described herein was approved by the Purdue University Animal Care and Use Committee. Seventy-two day-old White Leghorn chicks (Hy-Line W-36) were randomly assigned to 1 of 3 treatment groups: IR, HB, and sham trimming (control). Chicks within treatments were randomly paired and housed in identical cages (182 cm^2/bird) within the same environmentally controlled room. They had ad libitum access to water and a mash diet appropriate for the stage of development (0 to 6 wk: CP 20%, ME 2,984; 6 to 9 wk: CP 18%, ME 3,027), and lighting was standardized at 14L:8D so that temporal behavior was not influenced by a changing photoperiod. The temperature was initially maintained at 30 to 33°C from 0 to 1 wk of age, and then lowered by 2 to 3°C weekly until an ambient temperature of 21°C was reached at 5 wk of age.

Treatments

All treatments were applied at the hatchery by the same trained operator just prior to the chicks being transported for 2 h to the Purdue University animal housing facilities. Twenty-four (12 pairs, n = 12) of the chicks were trimmed by using a hot-blade trimmer (200 F, Lyon Electric Co. Inc., San Diego, CA) with a guide plate (3.5 mm) attached to attain a one-third reduction in length of both the upper and lower mandibles. Prior to trimming, beaks were visually assessed and marked with permanent ink to indicate the point of amputation. Blade temperature was preset to 950°F (500°C) and remained in contact with the beak for 2 s during trimming to sufficiently cauterize adjacent tissue and reduce the incidence of hemorrhaging. A second batch of 24 chicks was trimmed by using an automated infrared beak treatment system (Nova-Tech Engineering Inc., Willmar, MN) preset to trim both mandibles at 60 Hz to produce a one-third to one-half reduction in total beak length. The remaining chicks were picked up and handled to somewhat simulate the handling stress being experienced by the chicks in the other 2 treatment group, but their beaks remained untrimmed.

Beak Data

To evaluate treatment-related differences in beak lengths and regrowth rates, photographs of every chick's beak were taken immediately posttreatment and then at d 2 and 4 posttreatment. Thereafter, beaks were photographed on a weekly basis until the chicks reached 10 wk of age. Representative images from the individual treatment groups are presented in Figure 1, panels a to c. Changes in beak length were evaluated at the abovementioned time periods by using MCID imaging research software (version 4.0, Imaging Research Inc., Ontario, Canada). Beaks were imported into MCID in .tiff format before being individually calibrated (number of pixels per horizontal and vertical centimeter) by using a background reference scale incorporated into each image. An initial reference line (1) was inserted between standardized reference points on the upper and lower mandibles while also passing through the tip of the nares (Figure 1, panel d). Curvilinear lines (2 and 3) were then inserted from the points of intersection of the vertical reference line along the dorsal medial culmen of the upper mandible and along the anterior interramal and gonys regions of

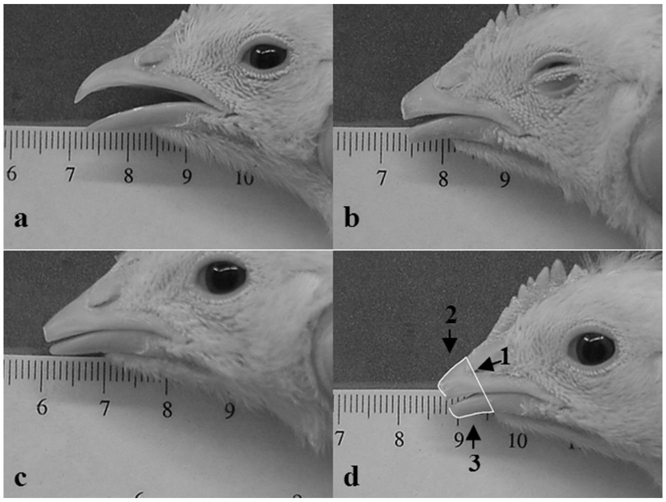

Figure 1. Representative images of an a) untrimmed control chick; b) an infrared-treated chick; and c) a hot-blade trimmed chick. Picture d) outlines the approach used to measure beak lengths.

the lower mandible to the tip of the upper and lower mandibles, respectively. The lengths of the upper (2) and lower mandibles (3) were then automatically generated by the software based on the earlier calibration scale. Beaks were further classified according to shape (normal or abnormal, e.g., split, presence of swellings, absence of keratinized epidermis at the beak tip) and the upper-to-lower mandible ratio to evaluate the emergence of any abnormalities during regrowth caused by the individual trimming methods.

Behavior

Chick behavior was recorded between 0800 and 1000 h by direct live focal observations (Martin and Bateson, 1993) on d 0, 1, 2, 3, and 4 and during wk 2, 3, 4, 5, 7, 8, and 9 post procedures. Two trained observers entered the room 10 min before the onset of behavior recording and sat motionless 1 m from the cages, enabling the chicks to habituate to the presence of the observers and return to normal behaviors before behavior recording was initiated. The same 2 observers were used throughout the experiment and were always balanced across treatments. The posture and behavior of one randomly preselected (using Microsoft Excel's "randbetween" function, Microsoft Corporation, Redmond, WA) individual per cage were continuously recorded by the observers for a 5-min period by using the ethogram outlined in Table 1. The time spent in different postures (e.g., sitting and standing) and behaviors (e.g., walking, eating, drinking), and the incidence of other behaviors (e.g., environmental pecking, beak wiping, interbird pecking) were recorded. In general, behaviors of very short duration, such as environmental pecking or interbird pecking, were documented by incidence. Behaviors of longer duration, such as eating and preening, were evaluated in terms of both the number of occurrences (bouts) of the behavior and the duration of each of these bouts. These data were then processed to determine the proportion of time spent engaged in individual behaviors or postures, along with the number of bouts and the average bout length of that particular behavior or posture.

Production and Physical Parameters: Feed Intake, Waste, BW, and Organ Weight

Feed intake, waste, and feed conversion efficiency (**FCE**) were determined on a weekly basis for each pair of birds from 2 wk of age onward. To evaluate feed waste, paper-lined trays were placed beneath cages to collect dispersed feed. The contents of the tray were passed through a sieve to separate feed from fecal matter prior to weighing. Body weight was measured on d 0, 2, and 5, and then once per week thereafter. These data were used to calculate average daily feed intake and feed wastage, average daily gain, and FCE. Those data collected from individual birds within cages were averaged to give cage means. At 10 wk of age, one randomly chosen bird per cage was anesthetized (3-mL intraperitoneal injection of sodium pentobarbital) and humanely euthanized by cervical dislocation, and the organs (heart, liver, spleen, and right adrenal) were harvested and weighed. All organ weights were then expressed as a function of BW to account for any differences in gross size attributable to variations in BW.

Statistical Analysis

All data were checked for normality and homogeneity of variance. Nonnormal data were transformed by using λ values generated by Box-Cox transformations. Repeated-measures GLM option of ANOVA (GLM, Minitab version 12.1, State College, PA) was then used to evaluate the effects of the different treatments over time. Where significant F-values were noted, Tukey's honestly significant difference tests (Minitab version 12.1) were used to determine where these differences existed. Where the outcomes of transformations were unsatisfactory, Kruskal-Wallis and Mann-Whitney U-tests (Minitab version 12.1) were used in place of parametric approaches. Associations between behavior and production parameters were assessed by using Pearson correlation coefficients (Minitab version 12.1). Results were considered significant when $P < 0.05$ and are expressed, where appropriate, as the mean ± SEM.

RESULTS AND DISCUSSION

Beak Data

Beak length data were analyzed to determine the effects of treatment on the amount of beak tissue trimmed, beak regrowth rates, and any changes in the upper-to-lower mandible length ratio that may have come about as the beak grew. To support efficient and normal beak function posttrimming, the respective lengths of the upper and lower mandibles should continue to resemble those of

Table 1. Behavior ethogram[1]

Item	Description
Posture	
Stand	Standing with no apparent movement of legs
Sitting/crouching	Sitting or crouching with body in contact with the ground
Behavior	
Inactive/rest/sleep	Performing no perceptible behavior or with eyes closed or slowly opening and closing
Walk	Taking one or more steps
Eat	Head extended toward the feeder and appears to be manipulating or ingesting feed
Drink	Beak in contact with drinker and appears to be ingesting water
Preen	Self-manipulation of own feathers with beak
Head flick	Body immobile apart from rapid head movements in any direction or rotations of the head around its vertical or horizontal axis
Beak wiping	Beak-related behavior that consists of rapid stroking of alternate sides of the beak on the floor or sides of the cage
Wing flapping	Extension and flapping of wings
Body shake	Raise feathers and shake body
Peck floor	Pecks delivered at cage floor
Peck wall	Peck delivered at cage walls
Peck feeder	Pecks delivered around the outside of the feeder
Peck bird	Peck delivered at cage mate
Scratch floor	Scratch floor with feet, usually associated with eating behavior

[1]Adapted from Hurnik et al. (1995).

untrimmed beaks, in which the lower mandible is slightly shorter than the upper one. Any deviations from this normal length ratio may contribute to impairment of beak-related activities, such as eating, drinking, and preening, resulting in a reduction in productivity and well-being.

All beaks were considered normally shaped at the onset of the study and remained so for the duration of the study ($P > 0.05$). Wounds and necrotic beak tissue were still present 2 to 3 wk after HB, and upper mandibles healed more rapidly than lower ones. Consistent with earlier reports (Honaker and Ruszler, 2004), there was no occurrence of open wounds in the IR birds. The different trimming methods, however, did result in 1) varying proportions of trimming across treatments ($P < 0.01$), 2) different regrowth rates ($P < 0.01$), and 3) changes in normal upper-to-lower mandible length ratios ($P < 0.01$).

Temporal assessment of beak length highlighted an overall effect of treatment, time, and their interaction on upper and lower mandible lengths ($P < 0.001$; Table 2). For the most part, both the absolute length and the relative growth rate of beaks increased over time in all 3 groups ($P < 0.001$). This is a predictable trend in growing birds and is in line with beak-trimming data published elsewhere (Kuo et al., 1991; Gentle et al., 1997). The ability of the beak to regrow after trimming has been associated with the severity of trimming together with the age at which trimming was performed. Generally speaking, when less than 50% of the beak is trimmed at a young age, considerable regrowth is likely to occur. The beak regrowth rate in HB birds may even exceed that of untrimmed birds, possible because of compensatory growth (Gentle et al., 1997). There was no evidence of any such compensatory growth in the present study. Immediately following HB trimming or IR treatment, birds in the HB group has shorter upper and lower mandible lengths relative to the other 2 treatment groups ($P < 0.05$; Table 2). Upper mandible lengths were similar in the control and IR birds until the onset of treatment-related tissue degeneration and erosion in the IR beaks. This was first

Table 2. Treatment-related differences in beak length and upper-to-lower mandible ratios from 0 to 9 wk of age

	Upper[1] (cm)			Lower[2] (cm)			Abnormal ratios[3] (proportion)		
Item	Control	Hot blade	Infrared	Control	Hot blade	Infrared	Control	Hot blade	Infrared
Day 0	0.70 ± 0.01^{a}	0.53 ± 0.01^{b}	0.65 ± 0.01^{a}	0.55 ± 0.01^{a}	0.43 ± 0.01^{b}	0.56 ± 0.01^{a}	0 ± 0	0 ± 0	0 ± 0
Day 2	0.82 ± 0.01^{a}	0.63 ± 0.03^{b}	0.79 ± 0.04^{a}	0.64 ± 0.02	0.47 ± 0.01	0.63 ± 0.01	0 ± 0	0 ± 0	0 ± 0
Day +4	0.84 ± 0.01^{a}	0.66 ± 0.01^{b}	0.78 ± 0.01^{a}	0.68 ± 0.01	0.57 ± 0.01	0.67 ± 0.01	0 ± 0	0 ± 0	0 ± 0
Week +1	0.93 ± 0.01^{a}	0.73 ± 0.01^{b}	0.76 ± 0.02^{b}	0.72 ± 0.01	0.66 ± 0.01	0.72 ± 0.01	0 ± 0	0 ± 0	0.04 ± 0.04
Week +2	1.08 ± 0.01^{a}	0.77 ± 0.01^{b}	0.73 ± 0.03^{b}	0.83 ± 0.01	0.79 ± 0.02	0.83 ± 0.02	0 ± 0^{a}	0 ± 0^{a}	0.42 ± 0.06^{b}
Week +3	1.29 ± 0.02^{a}	0.95 ± 0.02^{b}	0.85 ± 0.02^{b}	1.01 ± 0.01^{a}	0.86 ± 0.01^{b}	0.83 ± 0.02^{b}	0 ± 0	0.08 ± 0.05	0.11 ± 0.06
Week +4	1.44 ± 0.02^{a}	1.08 ± 0.02^{b}	0.95 ± 0.03^{b}	1.13 ± 0.02^{a}	0.95 ± 0.02^{b}	0.93 ± 0.02^{b}	0 ± 0	0.04 ± 0.04	0.04 ± 0.04
Week +5	1.62 ± 0.02^{a}	1.24 ± 0.03^{b}	1.09 ± 0.02^{c}	1.35 ± 0.02^{a}	1.15 ± 0.02^{b}	0.97 ± 0.02^{b}	0 ± 0^{a}	0.19 ± 0.08^{b}	0.04 ± 0.04^{ab}
Week +6	1.62 ± 0.03^{a}	1.27 ± 0.03^{b}	1.09 ± 0.02^{c}	1.36 ± 0.03^{a}	1.18 ± 0.03^{b}	1.05 ± 0.03^{b}	0 ± 0^{a}	0.23 ± 0.08^{b}	0.04 ± 0.04^{a}
Week +7	1.68 ± 0.02^{a}	1.37 ± 0.04^{b}	1.12 ± 0.02^{c}	1.43 ± 0.02^{a}	1.37 ± 0.03^{a}	1.09 ± 0.03^{b}	0 ± 0^{a}	0.23 ± 0.08^{b}	0.08 ± 0.05
Week +8	1.98 ± 0.02^{a}	1.47 ± 0.04^{b}	1.28 ± 0.02^{c}	1.66 ± 0.02^{a}	1.54 ± 0.03^{b}	1.12 ± 0.02^{c}	0 ± 0^{a}	0.31 ± 0.09^{b}	0.08 ± 0.05^{a}
Week +9	2.07 ± 0.05^{a}	1.56 ± 0.04^{b}	1.30 ± 0.03^{c}	1.72 ± 0.04^{a}	1.65 ± 0.03^{a}	1.22 ± 0.03^{b}	0 ± 0^{a}	0.35 ± 0.09^{b}	0.11 ± 0.06^{a}

[a–c]Means with different superscripts differ ($P < 0.05$).

[1]Upper mandible length.

[2]Lower mandible length.

[3]Proportion of birds exhibiting an abnormal upper-to-lower mandible ratio.

noticeable between the second and fourth day following treatment and became increasingly prominent until the second week after treatment. Similar effects of IR treatment were reported earlier by Honaker and Ruszler (2004). Thereafter, there was an increase in upper mandible length in all 3 treatment groups ($P < 0.01$; Table 2). Upper mandible length was consistently greater in control birds, intermediate in HB birds, and shorter in IR birds ($P < 0.001$). Immediately posttrimming, HB birds exhibited a 33% reduction in upper mandible length relative to the control birds and a 19% reduction compared with the IR birds. There were no initial differences in beak length in IR and control birds. By the end of the study, beak lengths in the control birds were almost 60% longer than the beaks of IR birds (1.30 ± 0.03 vs. 2.07 ± 0.05, $P = 0.0001$). Honaker and Ruszler (2004) also reported no immediate alterations in beak length following IR at 1 d of age, but they do not present any data reporting on regrowth rates. By wk +9, upper mandibles in the HB birds were approximately 20% longer than those measured in the IR treatment group during this same time period ($P = 0.005$). Net growths between 0 d and +9 wk were 1.37, 1.03, and 0.65 cm in the control, HB, and IR birds, respectively, indicating that IR also resulted in a reduction in the regrowth rate relative to rates in the other 2 treatment groups ($P < 0.001$). The persistent reduction in beak length in the HB birds differed from published data (Gentle et al. 1997), in which there were no differences in beak length in intact and HB birds within 5 wk posttrimming. The cause of these conflicting findings is not readily apparent because little has been published on the sequential regrowth of beaks when trimmed at 1 d of age. Speculatively, however, they may relate to bird genetics, trimming severity, or other differences in experimental approaches between these 2 studies.

Analogous effects of trimming methods were evident, although less apparent, in the length of the lower mandibles (Table 2). Overall, control birds had longer lower mandibles, the mandibles of HB birds were intermediate in length, and those of IR birds were generally shorter. Hot-blade trimming resulting in an initial reduction in mandible length compared with the other 2 treatment groups ($P < 0.05$). There were no significant differences between IR and control birds until the onset of tissue degeneration in the IR birds 2 to 3 wk following treatment. The difference in timing of tissue erosion in the upper and lower mandibles of IR individuals likely relates to variations in the relative amount of use, and therefore abrasion, that individual mandibles undergo on a day-to-day basis. From the third week posttreatment, lower mandible lengths were considerably longer in trimmed birds ($P < 0.001$), but there were no noticeable effects of the method of trimming until the seventh week after treatment. From this point onward, regrowth rates in the HB group were such that the lower mandibles no longer differed in length from those of the control birds ($P > 0.05$). Mandible lengths of the IR birds, however, remained approximately 20 to 30% shorter than the mandibles of the control and HB birds during all remaining time points ($P < 0.001$).

The beak data indicate that regrowth rates were more suppressed by IR than HB, as indicated by the larger increase in beak length in the HB group. From the literature, beak regrowth seems to be of concern when chicks are HB-trimmed earlier than 7 to 10 d of age (see Hester, 2005, for a review). Hot blade-trimmed birds at this stage are often exposed to a second, more permanent trim in later life. The long-term efficacy of IR at inhibiting regrowth is unknown. Neither of the trimmed groups in this study exhibited much in the way of compensatory beak growth in their upper mandibles that would have warranted a second trimming. The HB birds, however, did show some compensatory regrowth in their lower mandibles and it is, of course, feasible that further regrowth may occur beyond the 9-wk period examined in this work.

Trimmed beaks may develop a range of anatomical abnormalities as the remaining tissue heals and grows (Lunam et al., 1996). This was certainly true in this study, in which trimming, regardless of the method used, induced changes in upper-to-lower mandible ratios that were not evident in the control birds. At the onset of the study, mandible ratios were considered to be normal (the lower mandible shorter than the upper one) across all treatment groups (Table 2). Within several weeks, however, the proportion of birds with overextending lower mandibles was significantly greater (40%) in the IR treatment group than in the other 2 groups ($P < 0.001$). This difference was due almost exclusively to differences in erosion rates between the upper and lower mandibles following IR treatment. Treated tissues of upper mandibles eroded away more rapidly than those of the lower beak, so this was not a persistent difference. By the fourth week posttreatment, only 4% of the IR birds exhibited overextending lower mandibles, akin to the 4% in the HB treatment and 0% in the control birds during this same period. More treatment differences emerged over time, with the HB treatment accounting for statistically more deviation from a normal ratio from the fifth week through to the end of the study (35% of birds by wk +9, $P < 0.05$). This high proportion of abnormal ratios in HB-trimmed birds at 1 d of age has been reported elsewhere, where it was also noted to persist well into the laying cycle (Lunam et al., 1996). Similar measures have not been investigated in IR-treated birds before now, so no data are available for direct comparison. The impact of beak deformities on bird production and welfare has not been rigorously researched, although beak deformities likely impair normal beak-related functions, including eating, imbibing, preening, and so forth, with potential secondary effects on welfare.

Production Parameters: Feed Intake, Feed Waste, BW, and Organ Weight

The effects of beak trimming on feed intake and growth are key indices presented in the beak-trimming literature

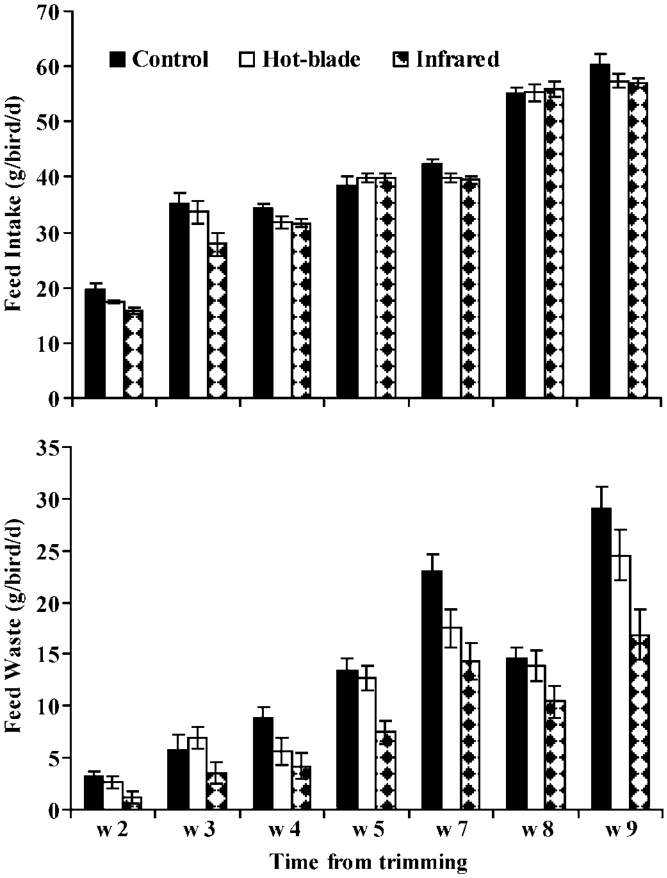

Figure 2. Effects of hot-blade and infrared trimming on feed intake (top) and feed waste (bottom) for 9 wk posttrimming.

as a gauge of the impact and efficacy of different types and timings of beak-trimming treatments. The predominant, although not irrevocable, finding is that moderate trimming, particularly at earlier ages, reduces feed use and subsequent growth (Glatz and Lunam, 1994; Gentle et al., 1997; Davis et al., 2004), with minimal residual effects on time to reach sexual maturity and subsequent egg production (Andrade and Carson, 1975; Craig and Lee, 1989, 1990; Kuo et al., 1991; Struwe et al., 1992). Both feed intake and waste were somewhat predictably influenced by trimming and trimming method in this study (Figure 2). Average daily feed intake was highest in the control group and lowest in the IR group for 3 wk after trimming. During wk +2, both HB and IR birds consumed (g/bird per d) less on a daily basis than control birds (19.5 ± 0.3 vs. 17.4 ± 0.2 vs. 15.8 ± 0.4, in control vs. HB vs. IR, respectively, P = 0.02). The IR birds had lower intake during wk +3 relative to control birds (35.2 ± 1.9 vs. 27.8 ± 1.2, P = 0.038). Apart from a tendency for intake to be lower in the IR birds compared with control birds during wk +4, there were no further discernible differences in feed intake. Reductions in feed intake following HB at 1 d of age have been reported to persist for several weeks to several months (Andrade and Carson, 1975; Glatz, 1990; Lee and Craig, 1990; Craig, 1992; Cunningham, 1992). Depressed intake in this study continued to exist for 2 to 3 wk in the HB birds and for 3 to 4 wk in the IR group. Honaker and Ruszler (2004) also reported a depression in intake in IR-treated birds compared with HB-trimmed birds at 7 d and with intact control birds that was apparent for 18 wk following the procedure. Because feed wastage was not accounted for by these authors, it was not possible to discern precisely how much of this difference was related to variation in intake or actual feed wastage between the 2 groups. However, because they also reported higher BW in the intact birds, it is reasonable to suggest that at least a portion of these differences was attributable to higher intake in intact birds also.

There are no published data evaluating the comparable effects of HB and IR at 1 d of age, which inhibits any further comparison of our results with other research at this stage. In general, however, changes in feed intake after beak trimming in poultry, irrespective of the trimming method or age, may indicate a decrease in motivation to feed that had been attributed to an increase in the presence of pain and discomfort caused by tissue, nerve, or receptor damage (Breward and Gentle, 1985; Gentle, 1986). Lowered intake may also result from greater mechanical difficulties in feeding caused by anatomical changes in beak shape, loss of beak sensitivity, or both that may arise after trimming, particularly in hens trimmed as adults (Gentle et al., 1982; Workman and Rogers, 1990). Reports on the effects of HB generally agree that trimming reduces intake, but by how much and for how long depends somewhat on the age at trimming, the severity of trimming, properties of the physical diet (mash vs. pellets), and individual study characteristics. Intake in the HB-trimmed chicks in this study had resumed to normal levels by the third week posttrimming. Lee (1980), on the other hand, found continued suppression of intake between 8 and 20 wk of age following HB (removal of two-thirds of the upper mandible) at 1 d of age. The shorter response duration in this study may be due to the relatively small amount of beak tissue removed at trimming and is consistent with previously published data on the effects of trimming severity on feed intake (Gentle et al., 1982; Glatz, 1987). Honaker and Ruszler (2004) reported a more persistent (up to 18 wk) suppression of intake in IR birds that did not exist in this work. It is difficult to determine the underlying reasons for these divergent results, but they may be due in part to variations in bird genetics, housing environments, or other differences in experimental conditions that existed between these 2 studies. In the study by Honaker and Ruszler (2004), birds of different genetic origins were housed in a much more competitive environment (larger group size and higher stocking density), and any or all of these factors may have contributed to the more pronounced reduction in intake exhibited by these birds. We did continue to see a numerical suppression in intake in the trimmed birds until the end of the study, which, with a larger sample size, may have been significantly different. Overall, the absence of any notable differences in intake in HB and IR birds in our study suggests that the impact of these 2 procedures was similar, at least in terms of

Table 3. Effects of hot-blade and infrared trimming on BW

Time	Control[1]	Hot blade[1]	Infrared[1]	*P*-value
Day 0	36.86 ± 0.77	35.88 ± 0.56	35.975 ± 0.47	0.473
Day 2	41.97 ± 0.37[a]	40.22 ± 0.45[b]	37.946 ± 0.59[c]	0.000
Day 5	50.50 ± 0.52[a]	47.17 ± 0.8[b]	42.87 ± 1.03[c]	0.000
Week 1	65.97 ± 1.23[a]	61.16 ± 1.23[b]	54.45 ± 1.56[c]	0.000
Week 2	108.21 ± 2.07[a]	102.44 ± 1.94[b]	95.72 ± 1.25[c]	0.000
Week 3	167.43 ± 2.78[a]	158.45 ± 2.06[b]	155.81 ± 2.44[b]	0.005
Week 4	241.10 ± 3.34[a]	232.59 ± 3.68[ab]	231.27 ± 3.2[b]	0.076
Week 5	322.31 ± 4.54	310.73 ± 4.64	315.13 ± 3.85	0.179
Week 6	383.88 ± 7.16	385.67 ± 7.88	388.01 ± 6.15	0.921
Week 7	462.49 ± 5.18	457.16 ± 7.69	462.64 ± 5.3	0.776
Week 8	569.99 ± 7.73	562.56 ± 9.23	565.73 ± 7.73	0.814
Week 9	663.42 ± 7.68	654 ± 11.1	655.41 ± 7.48	0.725

[a–c]Means with different superscripts differ ($P < 0.05$).

[1]All values expressed are means in grams ± SEM.

feed intake data, in spite of more severe trimming in the IR birds.

Feed wastage was numerically lower in the IR birds for the entirety of the study, and statistically so during wk +2, +5, +7, +8, and +9 compared with the other 2 treatment groups ($P < 0.05$; Figure 2). It did not differ between control and HB birds from wk +8 onward ($P > 0.05$). Lower feed wastage in trimmed birds has been observed in a number of earlier studies and is a likely consequence of a trimming-related suppression in feeding as well as alterations in feed-directed beak behaviors that contribute to a reduction in feed spillage (Gentle et al., 1982; Blokhuis et al., 1987; Lee and Craig, 1990; Craig et al., 1992). The differences seen in both feed intake and waste data across treatments were supported by the feeding behaviors exhibited by the birds in this study, in which a reduction in general feeding was evident in the trimmed birds compared with the control birds. Reduced feed wastage may be an important factor from the producers' perspective because feed represents a large proportion of the costs associated with egg production.

Although the trimmed birds in this study had lower overall feed use (intake + waste), there were no apparent effects of trimming or trimming method on FCE ($P > 0.05$). Beak-trimmed birds, particularly when trimmed at older ages, often exhibit improved FCE (Eskeland, 1981; Blokhuis et al., 1987; Craig et al., 1992). However, Honaker and Ruszler (2004) failed to demonstrate any consistent improvements in FCE in IR-trimmed birds, and Gentle et al. (1997) found improved FCE in chicks trimmed at 10 d of age, but not at 1 d of age. In general, however, the consensus among the producer and scientific communities is that beak-trimmed birds do habitually exhibit favorable FCE compared with intact conspecifics. Several factors may contribute to this improved FCE, including lower feed wastage, suppressed feeding behavior, and alterations in nutritional and energy requirements caused by delayed sexual maturity. Failure to demonstrate similar results in this study may relate to the timing of the data collection. Previously, the beneficial effects of HB at 1 d on FCE were more apparent later on in the growing period or during the laying cycle (Lee and Reid, 1977; Lee, 1980).

There were no differences in BW at the onset of the study. By d 2, however, there was an overall effect of trimming on BW ($P < 0.05$; Table 3), irrespective of the method used. Trimmed birds also exhibited a depression in BW at d +5 and at weekly weighing until the sixth week of the study ($P < 0.05$). Thereafter, BW was comparable in the trimmed and control birds. Analysis of treatment × time interactions highlighted a depression in BW in HB and IR birds between day +2 and wk +4, inclusive ($P < 0.05$), with IR birds performing least well during this time period. From wk 5 through the end of the study, BW was numerically higher in the IR treatment relative to the HB birds, although this difference never reached significant levels. A number of earlier studies have provided evidence of reduced BW subsequent to trimming, particularly when HB was performed on young chicks (Blokhuis et al., 1987; Glatz and Lunam, 1994; Gentle et al., 1997). This depression in BW can persist for anywhere from several weeks to several months, again depending on the timing and severity of the trimming performed (Glatz, 1987; Craig and Lee, 1990; Lee and Craig, 1990, 1991). Nevertheless, many of these studies found that reductions in growth rate, BW, or both were transient effects that disappeared either before or during the laying period. Similarly, Honaker and Ruszler (2004) documented a reduction in BW following IR from 2 to 18 wk of age,

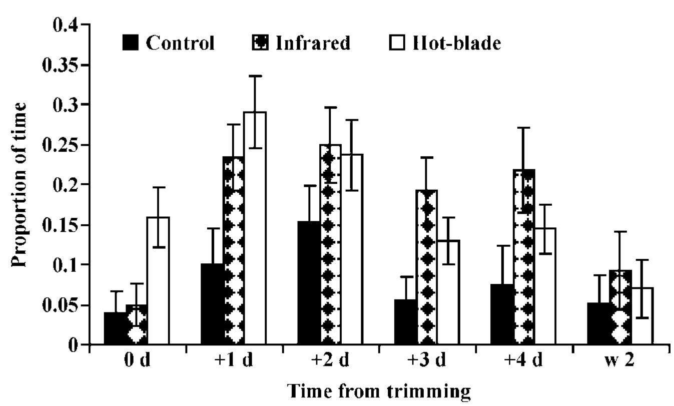

Figure 3. Effect of trimming and trimming method on the proportion of time birds spent standing inactive

Table 4. Impact of different methods of beak trimming (control vs. infrared vs. hot blade) on the performance of eating, drinking, and preening behaviors

Behavior	Control	Infrared	Hot blade	P-value
Stand rest				
Total time (s)	11.39 ± 2.51^{a}	27.82 ± 5.05^{b}	21.68 ± 4.13^{ab}	0.012
Bouts (n)	0.46 ± 0.14^{a}	0.807 ± 0.14^{b}	0.73 ± 0.12^{ab}	0.009
Mean bout length (s)	5.17 ± 1.11^{a}	11.53 ± 2.33^{b}	8.46 ± 1.76^{ab}	0.020
Eat				
Total time (s)	74.59 ± 6.89^{a}	46.01 ± 5.77^{b}	57.22 ± 6.2^{ab}	0.004
Bouts (n)	2.39 ± 0.23^{a}	1.67 ± 0.22^{b}	1.77 ± 0.18^{ab}	0.006
Mean bout length (s)	26.40 ± 2.92^{a}	18.58 ± 3.08^{b}	22.62 ± 2.48^{ab}	0.005
Drink				
Total time (s)	10.18 ± 1.97^{a}	3.36 ± 1.09^{b}	6.41 ± 1.53^{ab}	0.019
Bouts (n)	0.55 ± 0.09^{a}	0.20 ± 0.07^{b}	0.36 ± 0.07^{ab}	0.012
Mean bout length (s)	5.68 ± 0.97^{a}	1.72 ± 0.55^{b}	3.84 ± 0.98^{ab}	0.010
Pecks (n)	5.79 ± 0.99^{a}	1.76 ± 0.60^{b}	3.84 ± 0.90^{ab}	0.008
Preen				
Total time (s)	20.05 ± 2.40^{a}	23.27 ± 2.11^{ab}	25.18 ± 2.14^{b}	0.033
Bouts (n)	1.11 ± 0.15^{a}	1.22 ± 0.14^{ab}	1.44 ± 0.14^{b}	0.036
Mean bout length (s)	9.70 ± 1.74^{a}	11.09 ± 1.52^{ab}	10.77 ± 1.34^{b}	0.068

[a,b]Means with different superscripts differ ($P < 0.05$).

although relative gain did not differ after 12 wk, and in an earlier report they found BW to be numerically, although not statistically, higher in IR birds during the laying period (Honaker et al., 2002). Finally, there were significant treatment-related differences in posthumous liver weights (control > HB > IR, $P < 0.001$), but all other organs were comparable across all treatment groups.

Behavior

Evaluation of the effects of trimming on behavior (HB + IR vs. control) highlighted an overall effect of trimming, irrespective of the method used. The predominant effects appeared on feeding-related behaviors, with trimmed birds spending less time eating (seconds; 51.86 ± 4.29 vs. 74.59 ± 6.89, $P = 0.007$) and carrying out fewer (1.72 ± 0.14 vs. 2.39 ± 0.23, $P = 0.009$) and shorter bouts of eating (20.69 ± 1.96 vs. 26.40 ± 2.92, $P < 0.05$) than intact controls. Similarly, they also spent less time drinking (4.947 ± 0.95 vs. 10.18 ± 1.97, $P = 0.01$), exhibited fewer (0.28 ± 0.05 vs. 0.55 ± 0.09, $P = 0.007$) and shorter (2.83 ± 0.58 vs. 5.68 ± 0.97, $P = 0.006$) drinking bouts, and in doing so, delivered fewer pecks at the drinker (2.84 ± 0.55 vs. 5.79 ± 0.99, $P = 0.009$). Opposing trends were seen in preening behavior, with trimmed birds actually demonstrating more preening (total time, number of bouts, and average bout length) relative to control birds ($P < 0.05$). Furthermore, the overall frequency of beak wiping was higher and interbird pecking was lower in trimmed birds (both, $P < 0.05$). Finally, trimmed birds exhibited fewer bouts of standing alert (1.84 ± 0.09 vs. 1.53 ± 0.12, $P = 0.01$) relative to untrimmed controls, but all other behaviors were statistically similar in frequency and duration.

There was an overall effect of individual treatment (HB vs. IR vs. control birds) on the frequency and duration of standing resting, eating, drinking, and other behaviors (Table 4). Specifically, control birds spent considerably less time standing resting ($P < 0.01$) and more time eating ($P < 0.01$) and drinking ($P < 0.05$) than IR-trimmed birds. Control birds also engaged in fewer bouts of standing resting ($P < 0.01$) and more bouts of eating ($P < 0.01$) that were, on average, of greater duration ($P < 0.01$) than those performed by IR birds. Analogous trends were seen in both the incidence of drinking bouts ($P < 0.01$) and mean bout length ($P < 0.01$). Furthermore, the number of pecks delivered at the drinker during imbibing was also suppressed by IR ($P < 0.01$). Aside from a tendency for HB birds to have shorter mean eating bouts than control birds ($P = 0.09$), all other feeding-related parameters in HB birds were intermediate in duration and incidence, but not significantly different from those measured in the control and IR groups. Analysis of preening behavior, however, disclosed a difference in the time spent preening ($P < 0.05$) and in the number of preening bouts ($P < 0.05$) between HB and control birds. Mean preening bout length also tended to be of longer duration in the HB group, perhaps indicating a reduction in the effectiveness of preening stemming from altered beak shape, the presence of pain, or both ($P = 0.06$; Table 4). A reduction in preening behavior has been demonstrated in 16-wk-old birds for up to 5 wk after trimming (Duncan et al., 1989), as well as in HB-trimmed chicks at 1 and 10 d of age (Gentle et al., 1997).

There was an overall tendency for IR birds to peck more at the feeder (0.78 ± 0.28 vs. 0.13 ± 0.05, $P = 0.070$), and they may have participated in less interbird pecking (0.29 ± 0.05 vs. 0.95 ± 0.31, $P = 0.076$) relative to control birds. Beak trimming is believed to alter pecking behavior by changing the beak shape, reducing sensory feedback, and perhaps also by inducing acute or chronic pain in the beak stump. Increased pecking at the feeder may also be indicative of reduced feeding ability (Gentle et al., 1982). This could certainly be the case in this study, in which there was a transient emergence of abnormal upper-to-lower mandible ratios in the IR group that would likely have affected their ability to pick up and manipulate feed. Pecking in the HB birds was numerically intermediate to levels in IR-treated and control birds, with no perceptible statistical differences.

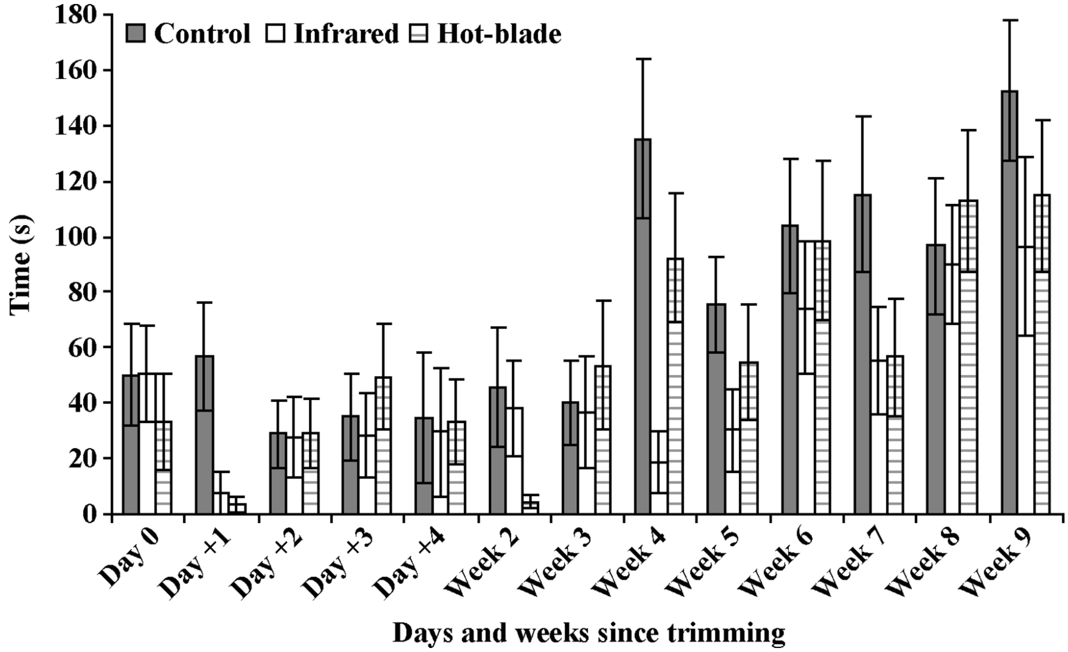

Figure 4. Beak trimming-related changes in feeding behavior following infrared or hot-blade trimming in day-old chicks.

For most behaviors, any treatment-related differences were no longer present within 1 wk posttrimming. Inactivity (proportion of time and number of bouts) was higher in both trimmed groups for up to 4 d after trimming relative to the control group, with a few differences between the HB and IR birds (Figure 3). For instance, inactivity was higher in the HB group for the initial 24-h period after trimming but tended to be greater in the IR birds on d 3 and 4 after treatment ($P < 0.1$). There were no further treatment-related differences at later time periods. Suppressed activity has commonly been observed to occur in association with beak trimming. Gentle et al. (1997) also found that removal of one-third of the beak with a heated blade at 1 d of age caused a reduction in activity in ISA Brown chicks that was evident for 1 wk afterward. Several other studies have reported similar decreases in activity levels in birds trimmed at older ages (Eskeland, 1981; Duncan et al., 1989; Craig and Lee, 1990; Kuo et al., 1991; Lee and Craig, 1991). There are no published data describing the effects of IR on behavior.

Time spent feeding, number of feeding bouts, and mean bout duration were all higher in control birds during the first several days after trimming ($P < 0.05$). Time spent eating was less in HB birds relative to control birds during wk +2 ($P < 0.05$) and was lower in IR birds during wk +4, +5, +7, and +9 (either, $P < 0.05$ or $P < 0.1$; Figure 4). Comparable trends were also apparent in the number of bouts of eating, with treatment differences occurring during wk +2 through wk +7, inclusive ($P < 0.05$). The effects of trimming methods on preening were most apparent during the initial 48 h following trimming. Immediately after trimming, control birds preened less than HB or IR birds ($P < 0.05$), and by d +1 preening (total time, number of bouts, and bout duration) was lowest in the IR group ($P < 0.05$). Preening (total time, number of bouts, and bout duration) in HB birds did not differ from that of control birds after the initial observation period, but was higher than that seen in IR birds during d 0, +1, and +2 ($P < 0.05$). No further statistical differences were present from then onward.

The findings in this study demonstrate that the IR beak treatment was more effective at reducing beak regrowth and, overall, resulted in fewer upper-to-lower mandible length abnormalities than HB. Both trimming methods affected production parameters. Feed intake was numerically lowest in the IR birds for 3 to 4 wk posttreatment, which likely reflects the increased feeding difficulty that these birds experienced because of the differences in tissue erosion rate in the upper and lower mandibles. Body weight was also initially lower in the IR birds, but later on it was numerically higher than that of the HB group. Infrared trimming also resulted in less feed wastage, which is a favorable outcome for producers, because feed represents a major portion of egg production costs. There was a temporary effect of both trimming methods on behavior but relatively few differences between IR and HB birds. On the whole, both trimming methods appear to have similar longer term impacts on production and well-being parameters. This is somewhat surprising, given that trimming was more severe in the IR treatment. More severe trimming is often associated with poorer outcomes in terms of production and bird welfare (Lunam et al., 1996; Gentle et al., 1997). From this perspective, IR may potentially offer an improvement over HB procedures when an equal amount of beak tissue is removed by using these 2 trimming methods.

REFERENCES

Andrade, A. M., and J. R. Carson. 1975. The effects of age and methods of debeaking on future performance of White Leghorn pullets. Poult. Sci. 45:666–674.

Blokhuis, H. J., J. W. van der Haar, and P. G. Koole. 1987. Effects of beak trimming and floor type of feed consumption and body weight of pullets during rearing. Poult. Sci. 66:623–625.

Breward, J., and M. J. Gentle. 1985. Neuroma formation and abnormal afferent nerve discharges after partial beak amputation (beak trimming) in poultry. Experientia 41:1132–1135.

Craig, J. V. 1992. Beak trimming benefits vary among egg-strain pullets of different genetic stocks. Poult. Sci. 71:2007–2013.

Craig, J. V., J. A. Craig, and G. A. Milliken. 1992. Beak trimming effects on beak length and feed usage for growth and egg production. Poult. Sci. 71:1830–1841.

Craig, J. V., and H. Y. Lee. 1989. Research note: Genetic stocks of White Leghorn type differ in relative productivity when beaks are intact versus trimmed. Poult. Sci. 68:1720–1723.

Craig, J. V., and H. Y. Lee. 1990. Beak-trimming and genetic stocks effects on behavior and mortality from cannibalism in White Leghorn-type pullets. Appl. Anim. Behav. Sci. 25:107–123.

Cunningham, D. L. 1992. Beak trimming effects on performance, behavior and welfare of chickens: A review. J. Appl. Poult. Res. 1:129–134.

Davis, G. S., K. E. Anderson, and D. R. Jones. 2004. The effects of different beak trimming techniques on plasma corticosterone and performance criteria in Single Comb White Leghorn hens. Poult. Sci. 83:1624–1628.

Duncan, I. J. H., G. S. Slee, E. Seawright, and J. Breward. 1989. Behavioural consequences of partial beak amputation (beak-trimming) in poultry. Br. Poult. Sci. 30:479–488.

Eskeland, B. 1981. Effects of beak trimming. Pages 193–200 in First Eur. Symp. Poult. Welf. Danish Branch, World's Poult. Sci. Assoc., Copenhagen, Denmark.

Gentle, M. J. 1986. Neuroma formation following partial beak amputation (beak trimming) in the chicken. Res. Vet. Sci. 41:383–385.

Gentle, M. J., B. O. Hughes, and R. C. Hubrecht. 1982. The effect of beak trimming on food intake, feeding behaviour and body weight in adult hens. Appl. Anim. Ethol. 8:147–159.

Gentle, M. J., B. O. Hughes, A. Fox, and D. Waddington. 1997. Behavioural and anatomical consequences of two beak trimming methods in 1- and 10-day-old chicks. Br. Poult. Sci. 38:453–463.

Gentle, M. J., L. N. Hunter, and D. Waddington. 1991. The onset of pain related behaviours following partial beak amputation in chickens. Neurosci. Lett. 128:113–116.

Gentle, M. J., D. Waddington, L. N. Hunter, and R. B. Jones. 1990. Behavioural evidence for persistent pain following partial beak amputation in chickens. Appl. Anim. Behav. Sci. 27:149–157.

Glatz, P. C. 1987. Effects of beak trimming and restraint on heart rate, food intake, body weight and egg production in hens. Br. Poult. Sci. 28:601–611.

Glatz, P. C. 1990. Effects of beak trimming on the production performance of hens. Aust. J. Exp. Agric. 30:349–355.

Glatz, P. C. 2005. What is beak-trimming and why are birds trimmed? Pages 1–17 in Poultry Welfare Issues: Beak Trimming. P. C. Glatz, ed. Nottingham University Press, Nottingham, UK.

Glatz, P. C., and C. A. Lunam. 1994. Production and heart rate responses of chickens beak-trimmed at hatch at 10 or 42 days-of-age. Aust. J. Exp. Agric. 34:443–447.

Hester, P. Y. 2005. Production responses of beak trimmed birds. Pages 79–86 in Poultry Welfare Issues: Beak Trimming. P. C. Glatz, ed. Nottingham University Press, Nottingham, UK.

Hester, P. Y., and M. Shea-Moore. 2003. Beak trimming egg-laying strains of chickens. World's Poult. Sci. J. 59:458–474.

Honaker, C. F., and P. L. Ruszler. 2004. The effects of claw and beak reduction on growth parameters and fearfulness of two Leghorn strains. Poult. Sci. 83:873–881.

Honaker, C. F., P. L. Ruszler, and C. L. Novak. 2002, Production parameters and fearfulness levels affected by beak and claw reduction in two strains of Leghorn hens. Page 14 in Proc. Concurrent Mtg. 23rd Annu. Southern Poult. Sci. Soc. Mtg. and the 43rd Southern Conf. Avian Dis. (Abstr.)

Hurnick, J. F., A. B. Webster, and P. B. Siegel. 1995. Dictionary of Farm Animal Behavior. Iowa State Press, Ames.

Kuo, F.-L., J. V. Craig, and W. M. Muir. 1991. Selection and beak-trimming effects on behavior, cannibalism, and short-term production traits in White Leghorn pullets. Poult. Sci. 70:1057–1068.

Lee, H.-Y., and H. Y. Craig. 1990. Beak-trimming effects on the behavior and weight gain of floor-reared, egg strain pullets from three genetic stocks during the rearing period. Poult. Sci. 69:568–575.

Lee, H.-Y., and J. V. Craig. 1991. Beak-trimming effects on behavior patterns, fearfulness, feathering, and mortality among three stocks of White Leghorn pullets in cages or floor pens. Poult. Sci. 70:211–221.

Lee, K., and I. S. Reid. 1977. The effects of Marek's disease vaccination and day-old debeaking on the performance of growing pullets and laying hens. Poult. Sci. 56:736–740.

Lee, K. 1980. Long term effects of Marek's disease vaccination with cell-free Herpesvirus of turkey and age at debeaking on performance and mortality of White Leghorns. Poult. Sci. 59:2002–2007.

Lunam, C. A., P. C. Glatz, and Y.-J. Hsu. 1996. The absence of neuromas in beaks of adult hens after conservative trimming at hatch. Aust. Vet. J. 74:46–49.

Martin, P., and P. Bateson. 1993. Measuring Behaviour: An Introductory Guide. Cambridge University Press, Cambridge, UK.

Struwe, F. J., E. W. Gleaves, and J. H. Douglas. 1992. Stress measurements on beak-trimming and untrimmed pullets. Poult. Sci. 71:1154–1162.

Workman, L., and L. J. Rogers. 1990. Pecking preferences in young chickens: Effects of nutritive reward and beak trimming. Appl. Anim. Behav. Sci. 6:115–126.