Effects of the Degree of Beak Trimming on the Performance of White Leghorns

A Thesis Submitted to the College of

Graduate Studies and Research

in Partial Fulfillment of the Requirements

for the Degree of Master of Science

in the Department of Animal and Poultry Science,

University of Saskatchewan,

Saskatoon, SK,

Canada.

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ABSTRACT

Three experiments utilizing pullets from hatcheries using different beak trimming techniques were conducted to determine the effects of degree of beak trimming on the performance and welfare of White Leghorns. The methods used to modify beak length were: Exp. 1- infrared (IF) varying guide-plate hole sizes (H, Strain 1); Exp. 2 – IF varying IF intensity (I, Strain 2); and Exp. 3 – hot-blade (HB) varying guide-plate hole sizes (H, Strain 3). Beak treatments included control (C), and an attempt to remove 20, 40 and 60% of the beak of day-old chicks. Pullets were housed on litter floor pens for the brooding and rearing period (0-17 wks) and commercial cages for the laying period (17-59 wks). Performance records were initiated at 19 wks and continued until 59 wks of age. Altering beak length was successful for Exp. 3 only, achieving 14, 31 and 39% reduction in length for the respective treatments. IF methods achieved 30 to 36% reduction regardless of the severity goal. A reduction in growth during part of the brooding and rearing period which continued throughout the duration of the trial for the 60% severity of Exp. 3. Feed intake was reduced in treated birds of Exp. 1 and 3, but not Exp. 2. Hen-day egg production, egg weight and specific gravity were unaffected. However, hen-housed egg production was reduced for the controls of all experiments due to an increase in mortalities. Behaviour observations via scan sampling indicated pain 1-d post-treatment in Exp. 3 by a decrease in running and litter pecking and a non-significant increase in resting. Minor effects of IF treatment were seen 1-d post-treatment, suggesting reduced or a lack of pain. An apparent but inconsistent effect of both HB and IF treatment was showed increase in object pecking throughout the trial. A general decrease in aggressive behaviour in treated birds of all experiments was noted. Feather condition improved for all treated birds. In conclusion, beak trimming regardless of technique or severity caused minor effects on hen performance while improving welfare conditions relating to decreased aggression and mortalities and an improvement in feather condition.

ACKNOWLEDGMENTS

I would like to express my profound gratitude to my supervisor, Dr. H. Classen for his extensive knowledge, mentorship and friendship throughout the duration and long distance nature of this project. I would also like to thank my committee members, Dr. S. Gomis, Dr. H. Gonyou, and graduate chairs Dr. T. Mutsvanga and Sheila Schmutz for their guidance and critique. I would like to thank Joe Stookey for his useful comments and suggestions and serving as an external examiner.

I would like to acknowledge the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Canadian Poultry Research Council (CPRC) for their financial support of this project. Thank you to the staff of the supporting hatcheries: Steinbach, Brandon, and Abbotsford hatcheries for their assistance and support at the initiation of this project in 2007.

Heartfelt thanks to Karen Schwean-Lardner who mentored me from start to the bitter end in completing this thesis. She took me under her wing and guided me in every aspect of my graduate career. Through endless e-mails and many phone calls that went into the early hours of the morning from coast to coast, continent to continent throughout my travels abroad she was always happy to double check information, run stats, send files, or lend advice and for that I am so thankful. Thank you to Karen and Tennille Knezacek for the countless hours of standing on cold cement floors for hours on end, measuring 300+ beaks in the dead of winter.

A big thank-you to Dawn Abbot, Tennille Knezachuk, Robert Gonda, Mark Meier, Brad Wiens, Dorian Brosnihan, Centaine Raginski, Misaki Cho and the rest of the poultry team at the University of Saskatchewan Poultry Centre. Without this amazing team, I would still be collecting data! Thank you all for your help and devoted support on the long data collection days. A special thanks to Melissa Johnson and Carlyle Bennett for their help on the initiation of this project at their respective local hatcheries.

A special thanks to the clients and staff at Stonehenge Stables and Beacon Hill Show Stables (Colts Neck, NJ) for their endless support, encouragement and friendship. An extra pair of eyes, an ear to listen, a shoulder to cry on and a sense of humour almost as good as any Canadian's is what I appreciated the most of this special group of people during the completion of this thesis. A special thanks to Max Amaya for being so patient, flexible and understanding with my work schedule which facilitated the completion of this project during a busy competition season.

Last but not least, a heartfelt thank you to my parents Dennis and Zenia, brother Stephen, and the rest of my extended family and friends for their never ending support and encouragement throughout my entire scholastic and professional career. You have been my leaning post, and always encouraged me to strive for excellence and for that I am eternally grateful.

DEDICATION

"This thesis is dedicated to my parents who have always supported me in dreaming big and instilling the confidence to live dangerously"

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1.0 INTRODUCTION

The process of beak trimming was first introduced in the 1900's as a management tool to control injurious pecking that can lead to significant feather and skin damage and cannibalism, which results in pain and often leads to death. When beak trimming was first initiated, beak tips of varying ages of birds were blunted with a sharp knife as this area was thought to lack innervation. It has since been determined that the beak is well innervated and pain is possible when beak trimming takes place. In Canada, beak trimming is most commonly performed on day-old pullets at their respective hatcheries by means of either the traditional hot-blade (HB) or more recently by infrared (IF) technique. These automated IF techniques are far more sophisticated than the earlier methods practiced and they are designed to reduce pullet stress levels and handling by performing automated vaccinations during the same period.

Despite the improvements in technique, beak trimming laying hen pullets is a controversial issue with considerable debate regarding its advantages and disadvantages. Since beak trimming is one of the primary management tools used to control feather and vent pecking that can escalate into cannibalism, it improves the long-term welfare of the bird. As soon as a feather pecking outbreak occurs, it is often difficult to control and resolve, potentially leading to death loss upwards of 30% within the flock (Gentle et al., 1997). In contrast, beak treatment may cause pain that is both acute and chronic in nature, which may negatively affect bird behaviour. The occurrence and nature of these effects are altered by a number of factors including age, severity, and method of treatment (Hester and Shea-Moore, 2003; Dennis et al., 2009; Pizzolante et al., 2007). Recent research has indicated that chronic pain does not occur if birds are treated moderately (30 to 50% removal; Gentle et al., 1982; Marchant-Forde et al., 2008) and at a young age (less than 10 days of age; Gentle, 1997; Gentle et al., 1997). Further, the extent of short-term pain and behavioural effects for hot-blade treatment is limited if the same practices are used. The extent of the latter effects on infrared treated birds has been shown to be limited or possibly non-existent; however, more evidence is required in this area.

Discovering that moderate beak treatment minimizes negative effects is reassuring from a bird welfare perspective, but it also raises the question of consistency of treatment under commercial conditions. Does chick size or equipment setting affect the degree of beak shortening? If so, does this impact bird productivity or welfare? Research regarding severity of treatment on the production and welfare effects of both HB and IF techniques on White Leghorn pullets and hens is limited and therefore is the ultimate objective of this research. In addition, it is of interest to supplement the research literature on the impact of IF treatment on laying hens.

2.0 LITERATURE REVIEW

2.1 Background

Treating beaks of laying hens, broiler breeder chickens and turkeys by means of trimming and creating a blunted beak tip as a preventative measure to reduce cannibalism has been practiced in poultry production since its development by the Ohio Experiment Station in the 1930's (Kennard, 1937). Originally, beak trimming involved removing a quarter inch of the beak tip with a knife by hand. The beak tip was thought to have no nerve supply, thus the procedure was believed not to be painful. Because cannibalism has been an ongoing issue in poultry production, beak-trimming techniques have become more sophisticated over the years. Although there are obvious benefits, beak trimming has been frowned upon and believed to be an animal welfare concern in some countries as the practice is seen as an amputation or mutilation that may not completely abolish cannibalism in the flock (Potzsch et al., 2001).

Often in commercial poultry production, birds are housed within close proximity of each other to maximize profit and production. Such housing conditions have the potential to facilitate behaviours such as feather pecking and pulling, which can escalate to cannibalism. The initiation of cannibalism can be due to various reasons and is a behaviour exhibited by poultry, pigs, hyenas, hamsters, mice and various other invertebrate omnivores (Glatz, 2005b). Cannibalism is defined as the act of consuming tissue of other members of the same species, living or dead, during any period of the life cycle (Newberry, 2004). Aggressive and cannibalistic pecking is more prevalent, easily spread, and more difficult to control in free-range housing systems, which are largely practiced in Europe (Tauson et al.,1992; Blokhuis and Metz, 1996; Kathle and Kolstad, 1996; Glatz, 2005a, Rodenburg and Koene, 2004). In these free-range systems cannibalism can occur in up to 50% of a flock leading to extreme mortalities, a welfare concern, and loss of production (Bestman, 2000; Glatz, 2005b).

2.2 Factors Affecting Feather Pecking and Cannibalism

There are many variables than can contribute to feather pecking and pulling including housing conditions and environmental factors. These include group size, stocking density, feed form, light intensity and color, and rearing conditions (Rodenburg and Koene, 2004). When poultry are housed in small groups such as in battery cages, a hierarchy is developed within the first few days of housing. Aggressive pecking is often seen during this period while birds develop a dominance hierarchy (Savory, 1995). When developing this hierarchy, a great deal of bullying, vent and feather pecking and pulling, and brushing against the cage may occur, which can affect plumage condition. Much of the feather loss in the neck, wings, and tail are attributed to abrasion due to housing conditions (Bilcik and Keeling, 1999). This feather loss or exposure of tissue or blood can lead to further pecking, resulting in cannibalism and eventually mortality. McAdie and Keeling (2000) found that other birds pecked those with damaged or missing feathers more often than those with good feathering.

Aerni and his colleagues (2000) found that feed form affects feather pecking; birds fed a pelleted diet showed a higher frequency of this behaviour than those fed a mash diet. When feed is presented in a pelleted form, it is consumed faster and birds spend less time eating and more time engaging in other behaviours such as feather pecking.

Light intensity and color have also been shown to have an effect on feather pecking in laying hens. Low light intensity results in gentle feather pecking whereas higher light intensity contributes to a higher instance of severe feather pecking (Kjaer and Vestergaard, 1999) as birds are more active (Prayitno et al., 1997) and likely have improved visual ability under higher light intensity compared to low light intensity. Changing light colour from white to red light has also been practiced in hopes of reducing the birds' ability to differentiate between normal and discoloured plumage and skin condition (Rodenburg and Koene, 2007). D'Eath and Stone (1999) found that light color affected the bird's ability to recognize neighbouring birds and navigate its environment.

Fear may also play a role in feather pecking severity within a flock. A bird with an intact, un-treated beak may be viewed as dangerous by other birds as it possesses a "weapon" (intact beak) and is ready to attack at any moment. It has been found that those birds enduring the greatest amount of feather pecking were the most fearful in a cage setting (Hughes and Duncan, 1972) when their fear response to a stimulus was recorded. However, this requires confirmation as Vestergaard and Lisborg (1993) found that those birds performing the feather pecking were most fearful when assessed by tonic immobility.

2.2.1 Group Size and Stocking Density

Group size and housing density can impact animal behaviour and welfare. Animals in the wild, such as the ancestor of the domestic chicken the Red Jungle Fowl, live in small groups and can move through an extensive area (very low housing density) (Rodenburg and Koene, 2007). This is inherently different than commercial poultry production where many thousands of birds are housed in the same barn either in one large group or in small groups within a cage. Regardless, when birds are housed within close proximity of another as practiced in North American commercial poultry industry, gentle feather pecking can escalate to intentionally harmful behaviour.

Aggressive and harmful behaviour is more prevalent in flocks housed outside of cages and this has been suggested to be a function of group size. Mortalities in settings such as aviaries (Hill, 1986) and free-range systems (Keeling et al, 1988) can be upwards of 15%. Because laying hens can be housed in caged-systems in smaller group sizes, a reduction in cannibalism (Appleby and Hughes, 1991; Abrahamsson and Tauson, 1995) and therefore mortalities (Tauson et al., 2006) is an obvious welfare benefit. Establishment of a stable peck order has been suggested to be one of the reasons for the behavioural differences observed in caged and more extensively housed floor systems. Colony cage housing with more birds per cage (30 to 50) has also been shown to increase feather pecking leading to cannibalism (Schwean, 1995).

Housing density can also affect hen behaviour and aggression. Baxter (1994) found that housing hens on deep litter at less than 1425 cm^2/bird caused a decrease in the expression of static behaviours such as preening, wing stretching and flapping (Gregory, 2005). Gregory (2005) states that even at such a low stocking density, aggression may still be unavoidable. Recommended cage-housing densities are no less than 450cm^2 per bird in Canada. This density and the use of cages per se hinder the expression of some natural behaviours.

Aggression has been found to be highest in flocks with intermediate stocking densities (Hughes and Wood-Gush, 1977). At very low stocking densities birds are able to escape aggression, and at very high stocking densities the constant presence of a dominant hen may reduce conflict between subordinate birds (Gregory, 2005). However, it was found that increasing bird numbers within a cage leads to an increase in feather pecking when compared to increasing stocking densities (Allen and Perry, 1975). It has also been found that combining large bird numbers with a high stocking density lead to poor feather cover and condition in the flock (Nicol et al., 1999). A decline in plumage condition occurs when birds brush up against cage walls or other birds, which could eventually hinder thermoregulation (Hughes and Black, 1976). Welfare is also compromised when birds are densely housed due to the birds' reduced ability to access feed and water as dominant birds can guard feed and water from less subordinate birds (Hughes, 1983).

Because birds cannot escape one another in a cage setting, the stress may escalate into chronic stress. Often one bird may notice something unusual such as a fleck of dirt or spot of blood on another bird; other birds are attracted to this area, which will continue to peck or pull at the feathers in the area resulting in bare patches. These patches attract more attention and result in increased pecking of the area, which can eventually lead to death. Unlike other cannibalistic species that attack head-on, poultry attack their prey from the back or hind end, which can result in a longer and more painful death (Glatz, 2005b). Because of the potential for extreme pain with cannibalistic behaviour, one must consider if the short-term pain of beak trimming is counterbalanced by the long term-gain in preventing or reducing cannibalism.

2.3 Anatomy and Pain Perception

2.3.1 Beak Anatomy and the Healing Process

The beak is an anatomical structure containing an extensive sensory and nerve supply. It is an essential appendage of the bird, which not only allows it to eat and drink but also to display natural behaviours such as preening and pecking. The beak also allows the bird to choose between particles of food. The upper and lower mandibles of the chicken contain nociceptors with temperature thresholds of up to 48°C (Breward, 1984; Gentle, 1992; Lunam, 2005) that sense pain. When these nociceptors are activated, as they would be with the hot-blade treatment method (reaching upwards of 750°C), this triggers a considerable amount of acute pain (Gentle, 1986). Following beak trimming an abnormal neural discharge has been found, which is thought to trigger acute pain (Breward, 1984; Breward and Gentle, 1985; Gentle, 1986).

Laying hens have a trigeminal nerve that runs the length of the mandible, which when damaged, will regenerate nerve tissue three to four weeks post trimming. If nerves are injured from the trimming process due to beak trimming severely (greater than 50% of the beak removed) or after 5 weeks of age (Lunam et al., 1996), these damaged nerves send out un-myelinated sprouts. These tangled sprouts form neuromas and cause inflammation of the damaged tissue within 24 hours, which is part of the normal regeneration process. This inflamed tissue releases analgesic chemicals, which depolarize the nociceptors causing abnormal firing of the nerve fibers; this results in hypersensitization, chronic pain, and a persisting neuroma (Wall and Gutnick, 1974; Devor and Rappaport, 1990; Lunam, 2005). However, if birds are trimmed properly the axon sprouts ideally regress as the nerve fibers re-grow, and the neuroma will disappear. It was found that birds trimmed at 10 days or younger did not have persisting neuromas (Gentle et al., 1997). Formation of persistent neuromas is prevented and the keratinized tissue regenerated if less than 50% of the beak tissue is removed and if the trimming is performed at less than 10 days of age (Kuenzel, 2007).

If neuromas are found in the beak, their presence, formation and sensitization is believed to result in a lower degree of feather grooming and pecking preventing cannibalism (Gentle et al., 1982; Gentle 1986).

2.3.2 Phases of Pain

The pain sensation varies amongst birds and is related to the age that the bird was trimmed, the method of trimming, the severity of trim and species of bird. Pain is known to occur in three phases classified as painless, acute, and chronic (Cheng, 2005).

2.3.2.1 Painless Phase

The painless phase occurs immediately after tissue insult. This phase is most prevalent within the fight or flight mechanism when halting to tend to a wound can be life threatening (Schott, 2001). Behavioural evidence shows that birds decreased the number of pecks directed at objects only after 26 hours post-beak trimming (Gentle, 1991) suggesting that the pain free phase can last more than 24 hours. Even though there was significant discharge from the injury site, no abnormal triginominal nerve activity was recorded in the area up to 270 minutes post trimming (Gentle, 1991).

2.3.2.2 Acute Phase

The acute phase is essentially a transition period that exists following the painless phase and before preparation for recovery commences (Cheng, 2005). This phase can last from a few minutes to several days but does not persist beyond the healing process (Molony and Kent, 1997). If pain outlasts the healing process then it would be considered chronic pain, which will be discussed following the acute phase. The acute phase is initiated by hyperalgesia, which is an increased sensitivity to pain resulting from activated nociceptors caused by inflammation, as well as tissue and nerve damage (Cheng, 2005). Damaged cells at the site of insult release a substance onto nociceptor membranes, which leads to a pain message being delivered to the central nervous system (Cheng, 2005). Behaviours such as decreased movement, appetite and investigative pecking are seen post tissue damage indicating pain (Gentle et al., 1982). If these pain messages persist and are not relieved through analgesics, they can continue until healing is complete.

2.3.3 Chronic Phase

The chronic phase is defined as pain persisting for an extended period of time, weeks to months, outlasting the expected healing period (Molony and Kent, 1997; Cheng, 2005). A hypothesis as to why pain persists so long suggests that inflammation induces changes in myelinated afferents, leading to a reconstruction of membrane bound sodium channels, eventually resulting in peripheral and central sensitization (Cheng, 2005). Peripheral sensitization is linked to neuroma formation in the proximal stump at the lesion site. Neuromas are known to trigger pain and be a source of ectopic firing (Coderre et al., 1993; Devor, 1999). As noted above, chronic pain has been associated with severe hot-blade trimming later in life and not with moderate trimming at less than 10 days of age.

2.4 Methods of Beak Shortening

2.4.1 Hot-Blade

The most common method (Glatz, 2004) of beak shortening is trimming with an electrically heated hot-blade, which utilizes cauterization as part of the trimming treatment to prevent re-growth. The Lyon Electric Company developed the "debeaker" which was registered in 1943 as a hot-blade beak trimming machine (Glatz, 2004). Partial removal of both top and bottom beaks, reducing approximately 1/3- 1/2 of the beak's length, occurs in this treatment method (Glatz, 2005b). Once blades are heated to the appropriate temperature, approximately 650-750 degrees Celsius, the bird's beak is placed into a pre-determined guide-plate hole size. The technician (manually operated machine) or arms (robotic machine) place slight pressure on the cranium of the bird to ensure a perpendicular cut and under the bird's throat to draw back the tongue to prevent lingual damage during treatment. Downward pressure is applied by the blade to the beak tissue to cut and cauterize both top and bottom beaks. If done properly, beak trimming should not jeopardize the bird's ability to eat and drink or perform natural behaviours. The cauterisation process has the potential to cause damage to the tissue proximal to the incision decreasing the preciseness of the cut (Grigor et al., 1995; Gentle et al., 1997) and the severity of the treatment. Sub-dermal layers of the beak tissue are typically healed within 3-4 weeks of HB trimming (Gentle et al., 1997, Marchant-Forde et al., 2008).

2.4.2 Infrared Treatment

A technique that is growing in popularity is the infrared beak treatment patented by Nova-Tech Engineering. This method forces a strong beam of high intensity infrared energy source into the inner tissues of both upper and lower beaks in a non-contact, bloodless manner (Glatz, 2004). This process reduces the length of the beak following sloughing of the tissue, which occurs roughly one to two weeks post treatment (Glatz, 2004). The intense energy penetrates both the outer rhamhpotheca and inner tissue layers of the beak, which in turn treats the basal tissue and therefore depresses rhamphotheca re-growth (Glatz, 2004). Because the beak takes 7 to 14 days to begin sloughing off, the infrared treated beaks appear the same as non-treated beaks, and birds are capable of eating and drinking during the critical first few days of life. Post-treatment, the basal tissue takes on a white appearance and a white band appears on the top of the outer rhamphotheca visible to the naked eye, which indicates the damaged beak tissue (Glatz, 2004). After a period of seven to fourteen days, the treated beak tissue will first soften then slough off distal of the white band.

Occasionally, it was found that some chicks failed to slough their beaks or were missed during treatment, and these birds had to be re-trimmed using traditional beak-trimming techniques (T. Knezacek, personal communication).

2.4.2.1 Infrared Procedure

The infrared equipment, much like the automated hot-blade equipment, was devised to decrease chick handling throughout the beak treatment process as well as facilitate any additional treatments required at this early period of life such as vaccinations and any necessary medications. The infrared machine operates in a rotary manner where the birds are clasped by their cranium, which is used as a reference point (Glatz, 2004). Because the cranium is being used as a guideline, the severity of the treatment would be appropriate for the bird's cranium size assuming that birds with larger craniums posses' longer and larger beaks. Modification of the degree of beak treatment can be accomplished by at least two methods to accommodate varying chick sizes. The insert guide-plate hole size can be changed to accommodate the size of chick, or the amount of energy directed to the beak tissue can be altered. When guide-plate size is changed, the amount of beak tissue exposed to the infrared energy is affected, which either increases or decreases the treatment severity. When the intensity of the light is increased, it appears that a greater amount of basal tissue is being affected. This results in an increased treatment severity due to the increased amount of beak sloughing. Glatz (2004) indicated that this fully programmable procedure can accommodate a variety of species and breeds within a species to meet their specific needs.

2.4.3 Bio-Beak

The Bio-Beak trimming method was developed by Sterwin Laboratories (Millsboro, DE) and involves the use of a high voltage electrical current. The electrical current burns a hole in the upper beak of chicks at day of hatch (Glatz, 2004). This treatment method is quite rapid taking only 0.25 seconds to complete (Grigor et al, 1995). The Bio Beak treatment works similarly to the infrared process where the beak tissue from the hole to the tip of the beak sloughs completely by 14 days of age (Glatz, 2004). However, this process has not worked as effectively in chicks as it had in turkeys (Grigor et al., 1995) resulting in the need to re-trim the birds.

2.4.4 Laser

The laser trimming method operates by sending a stream of energy to the beak tissue. The energy dissipates as heat and is absorbed by the tissue. If the intensity of the energy is strong enough, the tissue is cut immediately where the laser is directed (Glatz, 2004). The process results in strong light emissions being produced with each pulse lasting only momentarily on the directed area. Laser machines often contain a cooling mechanism, which serves to dissipate the heat to the area. This cooling mechanism also works as a mild anaesthetic to decrease some of the painful sensations incurred during the treatment (Glatz, 2004). The laser treatment may have advantages over other methods due to its ability to reduce blood loss and pain because of its ability to cauterize the blood vessels and nerve endings during the treatment process (Poultry CRC, 2008).

Rooijen and Haar (1997) laser treated day old chicks and found that by 16 weeks of age, the beaks of laser- treated birds resembled those of intact birds. They also found that feather pecking and cannibalism were greatest amongst laser treated hens during the laying period. This research suggests that the laser treatment was not severe enough to have a significant effect on the underlying basal tissue, which is necessary to retard beak re-growth. The use of lasers has been suggested to increase treatment precision and thus reduce flock treatment variability. However, the results of earlier studies indicate significant re-growth and high levels of feather pecking and cannibalism in treated birds (Glatz, 2004).

2.4.4.1 Types of Lasers

There are numerous types of lasers available, which are used frequently in modern medicine. Neodymium-doped yttrium aluminum garnet Nd:$Y_3Al_5O_{12}$ (Nd: YAG Ophthalmic) and Coherent CO_2 lasers are two lasers that have been used to experiment in beak treatment effectiveness (Glatz, 2004). It is important to use the appropriate spot size and accompanying cutting (pulse) duration in order to cut and cauterize the tissue and prevent bleeding. The spot size is defined as the diameter of light intensity being exposed to the tissue; it is measured in microns. A 200 micron spot proved to be more effective than a 50 micron spot with a two second cutting duration as it allowed for adequate coagulation, which prevented bleeding (Glatz, 2004).

The Opthalmic laser set at 1.5W with a 200 micron spot size and 4 second pulse successfully cut through the outer keratin layer of the beak but failed to cut through the inner bony portion of the beak of day old chicks due to its low intensity (Glatz, 2004). It was noted that the laser treated chicks' beaks regardless of laser type, were straighter and cleaner cut than those treated by the hot-blade method (Glatz, 2004). Alternatively, a CO_2 laser with a 10W, 50 micron spot size and one second pulse proved to be effective in cutting through the inner bony tissue of the beak in one pass (Glatz, 2004). The type, spot size, and power of laser trimmer is imperative to the success of beak trimming, although protocols have yet to be devised to define the severity of beak trimming required for optimum production. Although interesting, this practice is not in widespread use as continued research is necessary to determine and devise protocols for a cost effective, consistent laser source for treating beaks.

2.5 Beak Re-Growth and Re-Treatment

The amount of beak re-growth following beak trimming depends on the age of the bird at trimming, the severity of trim and the method of trim. Birds mildly or moderately trimmed at day of hatch or at an early age have a greater chance of beak re-growth than those trimmed at an older age or trimmed more severely. The method of trim, hot-blade, infrared, or laser, must be adjusted to the correct temperature, energy, or spot size to ensure proper cauterization of the blood and nerve supply throughout the treatment process (Glatz, 2004). Without proper cauterization, the remaining beak runs the risk of severe haemorrhaging, which could lead to death loss. Beak re-trimming is sometimes used in industry after beak re-growth post trimming in order to decrease cannibalistic outbreaks in the flock; however, this practice seems to be less common in industry today (T, Knezacek, personal communication).

2.6 Trimming Age

In the commercial egg industry, chicks are treated by hatcheries on day of hatch or shortly thereafter by the producer. Research has shown that if birds are treated at a relatively young age (0 - 10 days of age), the prevalence of neuroma formation and chronic pain are reduced (Breward and Gentle, 1985; Gentle, 1997). Pain and neuroma formation are affected by the development of the nervous system. Research has also shown that trimming earlier in life results in a more rapid healing with little scar tissue development (Gentle et al., 1997). The authors noted that any re-growth that did occur did not contain afferent nerves or sensory corpuscles nor were neuromas present at the beak stumps three to six weeks post trimming. Trimming at an older age, greater than 21 days of age (Rooijen and Haar, 1997), can result in reduced growth rate and feed intake and increased behavioural changes that last for an extended period of time compared to early-age trimming (Schwean-Lardner et al., 2004). Beak trimming at a younger age has been shown to have less impact on bird welfare (Rooijen and Haar, 1997).

2.7 Bird Behaviour Post Treatment

Behavioural observation and measurement of physiological parameters are primary methods to detect pain in animals. Many behaviours that birds display are linked to physical and emotional pain, stress, and fearfulness. Table 2.1 lists and categorizes common laying hen behaviours. Some behaviours are characterized as stereotypies when they are repeated for long periods of time with no obvious reason. Other behaviours altered by traumatic events such as beak trimming, include an increase in lethargy, avoidance and guarding behaviours and a decline in eating, drinking and litter pecking (Eskeland, 1981; Gentle et al., 1990; Marchant-Ford et al., 2008). Each of these behaviours alone can indicate pain, distress or frustration in birds. However, when combined together these behaviours can illustrate the level of discomfort (mental or physical) that birds are experiencing, which serves as a useful tool for producers and researchers alike.

The behaviours listed below were selected and described in detail as they vary greatly when the hen's mental or physical state is challenged.

Table 2.1 Behaviour category and description

Behaviour category	Behaviour	Description[1]
Nutritive	Eating	Head extended into feeder, manipulating or ingesting feed
Nutritive	Drinking	Head extended to water line, manipulating water nipple
Exploratory	Litter pecking	Pecking at littler particles
Exploratory	Feather pecking	Pecking at plumage of a cage-mate
Exploratory	Object pecking	Pecking at anything other than feed, water, plumage, performed in a stereotypic manner
Maintenance	Preening	Self-manipulation of feathers on the body using the beak
Maintenance	Feather Ruffling	Fluffing up of the feathers
Maintenance	Wing flapping	Bird stands and flaps both wings in unison
Maintenance	Head scratching	Scratching head with either foot
Maintenance	Wing stretch	Extension of both wing and foot together on the same side of the body
Comfort	Resting	Sitting with both feet covered
Comfort/ Maintenance	Rest/Preen	Sitting, covering both feet while simultaneously manipulating own feathers
Comfort	Tail wag	Extension and ruffling of tail feathers
Pre-lay	Pacing	Pacing throughout the cage
Aggressive	Aggressive peck	Forceful pecking directed to another bird
Aggressive	Feather pull	Grasping and removing of another bird's plumage
Aggressive	Vent pecking	Forceful pecking at the vent region
Aggressive	Head pecking	Forceful pecking at the head or comb

[1] Descriptions were a modification of Hurnik et al., 1995; Schwean, 1995.

2.8 Behaviour

2.8.1 Eating and Drinking

Eating and drinking are two behaviours essential to the survival of the hen. Drinking behaviour can depend on the water source the bird is provided with. Typical intensive cage-housed systems provide a nipple-drinking system where the bird must manipulate the silver nipple end on the water line to access water. Birds typically consume water only when thirsty, however evidence of excessive drinking behaviour under stressful situations has been reported (Savory et al., 1989).

The decline of litter pecking, eating and drinking behaviour might indicate potential illness, pain, fear or frustration in the flock, which could all lead to a welfare concern. If birds are not eating and drinking, the nutrients they should be ingesting are therefore not being put into the products they are to be producing, which in this case are eggs.

2.8.2 Exploratory Behaviours

2.8.2.1 Object Pecking, Feather Pecking, Litter Pecking

Object and feather pecking is believed to be redirected pecking originating from pecking during dust-bathing (Kjaer and Vestergaard, 1999), litter pecking (Wenrich, 1975) or environmental exploration (Blokhuis, 1986; Rodenburg and Koene, 2007). Litter pecking can also be described as an exploratory behaviour because the bird tends to investigate each particle of feed or litter much like it investigates its environmental surroundings. A bird uses its beak to investigate, explore and manipulate its environment. A bird will gently or more aggressively peck at certain items in its immediate surroundings to better understand its environment. Such behaviour is typically harmless and is directed at non-living particles such as cage material, forage particles, debris, loose feathers or novel items within the cage (strings, perches, toys). Object pecking differs from feather pecking in that feather pecking is specifically directed to feathers of the bird committing the action or feathers of another bird.

Feather pecking behaviour can be categorized into two types: self-pecking and allo-pecking, each of which can also be categorized into self-preening and allo-preening, respectively (Glatz, 2005a). Self-pecking or self-mutilation is when pecking behaviour is directed to one-self, usually damaging one's toes, feathers or skin. When such pecking is not damaging, it is termed self-preening. Allo-pecking is a behaviour that is directed to other birds in an aggressive manner whereas non-aggressive pecking is termed allo-preening (Harrison, 1965). Gentle feather pecking is often directed at litter particles on the feathers of another bird without intentionally pulling or removing feathers and can develop into a stereotypic behaviour. The frequency of feather pecking is dependant among several factors, some of which include nutrition (Van Krimpen et al, 2005), lighting (Kjaer and Vestergaard, 1999), genetic background (Rodenburg et al., 2003) as well as group size and stocking density (Savory et al., 1999). Damage to the plumage due to cage design can also attract a bird's attention and in turn cause feather pecking (McAdie and Keeling, 2000; Rodenburg and Koene, 2004). This behaviour has the potential to cause damage to plumage, yet it is often ignored by the bird to which the behaviour is directed.

2.8.3 Aggressive Behaviours

2.8.3.1 Feather Pulling

Feather pulling is known as the intentional pecking or pulling of feathers of another bird (Rodenburg and Koene, 2004). Pulled feathers are sometimes eaten and it has been suggested that this behaviour may be a result of amino acid deficiency (Hughes and Duncan, 1972). Feather pulling may result in significant bare patches on the victim that encourages additional feather and tissue pecking possibly leading to cannibalism and even death. Feather cover is essential for the bird to maintain core body temperature as well as preventing abrasions to the skin's surface. Although feather pulling may not initially harm neighbouring birds, aggressive or cannibalistic behaviours have the potential to result.

2.8.3.2 Vent Picking

Vent picking is a severe form of aggressive behaviour and cannibalism (Savory, 1995). Laying of abnormally large eggs or commencement of the laying cycle in a young hen can occasionally lead to a prolapsed oviduct (Rodenburg and Koene, 2004). This is a condition which can occur when the pullet's lower reproductive tract ruptures resulting in exposure of prolapsed tissue from the vent region. This condition is a result of hens that have excessive fat cover entering production or poor muscular elasticity. Once neighbouring birds notice the abnormal tissue or the presence of blood, they are drawn due to their investigative nature and will often continue to peck at the area, tearing tissue, damaging the reproductive tract and eventually pulling out internal organs. This behaviour is commonly known as a pick-out (Neal, 1956). Birds that are not beak trimmed or are improperly beak trimmed have the greatest potential to do harm to neighbouring birds.

2.8.3.3 Head Pecking

Head pecking is a behaviour that is commonly exhibited by dominant birds and directed at subordinate birds in the flock. The severity of pecking directed at the head region can vary, but in severe cases the areas above and surrounding the eyes, ear lobes, and wattles become inflamed as well as dark and necrotic following such offences (Glatz, 2005b).

2.8.4 Maintenance (Comfort) Behaviours

Maintenance behaviours, also referred to comfort behaviours, are movements such as leg and wing stretching and flapping, feather ruffling, resting, preening and dust-bathing, which increase the bird's physical comfort (Allaby, 1999). These behaviours are essential physically for anatomical maintenance as well as the maintenance of good feather plumage. For example, the action of preening, dust-bathing and feather ruffling regulates the amount of feather lipids and maintains the condition and structure of both feathers and down all while reducing parasites. When plumage condition or other comfort behaviours are compromised, it has the potential to negatively influence bird welfare (Van Liere and Bokma, 1987) as well as affecting the quality of research being performed in a research setting (Fölsch et al., 2010). If birds are unable to maintain feather plumage, their ability to regulate their body temperature may be compromised, which in turn can jeopardize the bird's comfort and efficiency.

Leg and wing stretching are essential for bone strength, density and stability, therefore reducing the incidence of osteoporosis and ultimately bone fractures (Whitehead, 2004). Maintenance behaviours are partially dependant on the substrates available and partially on the amount of space provided per bird (Appleby et al, 2004). Such behaviours have been seen to decrease with increased stocking density (Appleby et al, 2004).

Observing behaviour throughout the day allows a better understanding of how birds are feeling as well as judge their comfort and well-being. By recording the length of time or frequency of such behaviours, bird comfort and welfare can be judged. If acceptable welfare is found, this in turn is indicative of the general bird well-being that has been achieved.

2.9 Supplementing Beak Trimming Techniques

Beak trimming poultry is a production practice that may be perceived negatively by the general public. Because the general public consumes egg products, they essentially control the market through purchase choices and thereby direct industry change to alternative production practices. For example, in 2012 Europe will enforce a ban on cage-housed production systems, which will restrict poultry producers to floor or alternative housing of their flocks. Studies have shown that cage-housed laying hens show a significant decrease in aggressive feather pecking and therefore a reduction in cannibalistic mortalities (Rodenburg and Koene, 2007). Without cages and without an alternative to beak trimming, the outcome could be devastating. There have been various methods studied that could potentially accompany or supplement beak trimming in reducing the incidence or severity of harmful behaviour. Each of these supplementing techniques has its strengths and weaknesses and is best suited to a certain production system.

2.9.1 Light Intensity

As mentioned earlier, a decrease in light intensity has the potential to decrease the activity of those birds resulting in a decrease in cannibalistic behaviour (Kjaer and Vestergaard, 1999). Kjaer and Vestergaard (1999) also found that there was an increase in gentle feather pecking at lower light intensities, < 3 lux, whereas severe feather pecking was increased with increasing light intensity at > 30 lux. However, the drawback with the use of low intensity is that birds have problems navigating their environment as well as recognising neighbouring birds (D'Eath and Stone, 1999; Rodenburg and Koene, 2007). Very low light intensity in itself may pose an animal welfare concern due to changes in behaviour and alterations to eye morphology (Harrison et al., 1968).

2.9.2 Genetics of Feather Pecking

As production systems have evolved, breeding companies have adapted their selection to accommodate the high production demand of their customers as well as the needs of specific production systems (Craig, 1982). Feather pecking has been shown to be a heritable trait (Kjaer and Sorensen, 1997; Rodenburg et al., 2003) and individual selection against feather pecking (Kjaer et al., 2001; Su et al., 2005; Rodenburg and Koene, 2007), intact feather cover, liveability (Lay et al., 2011) or group selection against mortalities (Craig and Muir, 1993) has been shown to be feasible. It appears that breeding companies are attempting to select against pecking behaviour in their breeding programs

(Albers and Van Sambeek, 2002; Besbes, 2002) as the prevalence of cannibalism has been shown to vary between strains (Allen and Perry, 1975; Craig, 1992; Curtis and Marsh, 1992; Craig and Muir, 1996; Kjaer, 2005). Research has shown that the development and cause of feather pecking and cannibalism is largely due to fearfulness and serotonergic functioning (Bolhuis et al., 2009). Recent research has shown a relationship between fearfulness and 5-HT activity related to feather pecking (Bolhuis et al., 2009).

Breeding companies are continually researching the heritability of certain traits to develop a superior breed that benefits both production and hen welfare. However, even the most superior of genetics can perform poorly and bird welfare can deteriorate if the production system is poorly managed. Therefore, it is essential for each production system to adhere to standard operating procedures to ensure the optimum level of production and the highest level of animal welfare at all times.

2.9.3 Enriched Cages

The goal of enriched cages is to have birds interact more effectively with the cage environment and to facilitate natural avian behaviours, while at the same time maintaining the advantages of the battery cage system. Researchers hoped that providing environmental enrichment would decrease the incidence of harmful stereotypic behaviours. Enriched cages allow for increased movement due to the decreased stocking density and provide amenities that permit expression of key behaviours such as perching, dust-bathing and nesting. Although the increased room allows for greater movement, resulting in increased bone strength (Schwean-Lardner, 1995) and display of natural behaviours, the feather cover of these birds may not be superior to those housed in traditional caged systems (Schwean-Lardner, 1995) due to increased feather pecking. In the latter research, a larger group size may have been responsible for this negative effect rather than the use of an enriched cage per se. Research by Guesdon and his colleagues (2007) comparing standard cages to 2 designs of furnished cages with and without beak trimming, showed a higher incidence of mortalities in the standard cages. Mortalities were fewest in the beak trimmed furnished cages, which lead researchers to conclude that by including environmental enrichment, birds spend less time displaying harmful stereotypic behaviour and more time engaging in their environment. Interestingly, when beak-trimmed hens were compared to non-trimmed hens in the same study, mortalities were greatest (>40%) in the non-treated birds compared to treated (<5%) due to cannibalism. Therefore, it appears that combining enriched cages with beak trimming can result in very low levels of cannibalism.

The use of enriched cages allows for increased bird welfare, as the birds are allowed to interact with the environmental enrichments and thereby decrease the time spent on performing harmful behaviour that escalate to cannibalism. The enriched system does have its share of drawbacks such as an increased cost and spatial requirements. As with any production system, if such a system is poorly managed or not adapted accordingly to the strain requirements and temperament, production and animal welfare can decline.

2.9.4 Novel Objects

The inclusion of novel objects in a cage setting is believed to direct the bird's attention away from neighbouring birds and redirect it to other stimuli within or surrounding the cage. To achieve this, objects or materials such as string or plush toys and food ingredients are secured in or around the cage (Jones, 2001). Jones et al. (2000) as well as Jones (2001, 2002) found that baling string was a desirable pecking object as judged by increased interaction time than other novel items. Providing novel stimuli, such as string, has been shown to reduce gentle and aggressive feather pecking in an experimental flock (Jones et al., 2000; Jones 2001, 2002). Researchers noted that it was important that the stimuli hold the bird's interest for an extended period of time. By altering the height and location of the stimuli, this can rekindle the interest of birds.

2.9.5 Nutrition

The use of nutritional changes to affect feather pecking is a very interesting area. By including certain feed ingredients, it may be possible to deter birds from aggressive and harmful behaviours. Increasing fibre in diets has been shown to reduce feather pecking (Choct and Hartini, 2004; Van Krimpen et al., 2005). This effect is thought to be related to the increased time required to consume the lower energy diets and as a result less time for other behavioural expression and perhaps they are fulfilling a fibre requirement. Inclusion of *ad libitum* silage in the diet has also been shown to decrease aggressive and feather pecking behaviour when compared to control birds fed a nutritionally balanced diet (Steenfeldt et al., 2007; Johannson, 2008). In Johannson's research, hens chose to consume silage, which is low in nutritional value, even though they had *ad libitum* access to their laying hen ration. Again, increased time focused on the silage may have reduced time for aggressive behaviour. Nutrient deficiency can also lead to investigative pecking and potentially feather pecking and cannibalism. For example, research has shown that a dietary mineral, protein or amino acid (including tryptophan, lysine, methionine, and threonine) deficiency can increase the incidence of feather pecking behaviour leading to cannibalism (Cain et al., 1984; Ambrosen and Petersen, 1997; Choct and Hartini, 2005; Van Krimpen et al., 2005). A diet deficient in protein can result in a bird with poor plumage and feather cover that attracts other birds to feather peck, which in turn can escalate into cannibalistic behaviour (Cain et al., 1984).

Each of these methods appears to have some effect on reducing both the incidence of damaging behaviours as well as cannibalism. However, if implemented alone, these techniques have little chance of reducing these behaviours and cannibalism enough to maintain animal welfare standards. When combined with another supplementary technique and/or the beak trimming, it can result in a very low incidence of cannibalism and therefore increased bird welfare.

2.10 Conclusion

The Infrared trimming technique, although more common in today's industry, continues to undergo much research to establish a welfare friendly technique that serves to take the place of earlier practiced methods. Understanding the physiological changes that occur post trimming in both infrared and traditional hot-blade techniques can help to achieve an acceptable level of welfare. Despite the fact that beak trimming in a moderate fashion and at a young age has been shown to have minimal effects on welfare and a decreasing effect on cannibalism, variation in severity can still be an issue. When the impacts of severity are understood, industry professionals can tailor procedures and husbandry practices to instill uniformity and achieve a high level of animal production without hindering animal welfare. Continued research regarding severity of treatment on the production and welfare effects of both HB and INF techniques on White Leghorn pullets and hens is limited, it is therefore is the ultimate objective of this research.

3.0 EFFECTS OF DEGREE OF INFRARED AND HOT-BLADE BEAK TREATMENT ON THE PERFORMANCE OF WHITE LEGHORN HENS

3.1 Abstract

Three experiments were conducted to study the degree of beak treatment on bird growth and performance using pullets derived from different hatcheries each using different strains and different beak treatment techniques. The techniques used to modify beak length were: Exp. 1 - infrared (IF) using varying guide-plate hole sizes (H, Strain 1); Exp. 2 - IF using variable IF intensity (I, Strain 2); and Exp. 3 - hot-blade (HB) using varying guide-plate hole sizes (H, Strain 3). Beak treatments included a control (C), and an attempt to remove or treat 20, 40 and 60% of the beaks of day-old chicks. Pullets were brooded and reared in floor pens from 0 to 17 wks and then housed in battery cages from 18 to 59 wks of age; an egg production trial was initiated at 19 wks of age. Altering beak length according to the objective was only successful for HB trimming, resulting in mature hen beaks 14, 31 and 39% shorter than C birds. IF trimming (H and I) resulted in beaks that were 30-36% shorter than untreated pullets regardless of attempted severity. Growth rate was reduced for all treated birds during portions of the brooding and rearing period, but with the exception of the HB-60% treatment, which remained lower, did not have an important impact on body weight during the laying period. Hen-day egg production, egg weight and specific gravity were unaffected by treatment in all experiments, but hen-housed egg production was lowest for untreated birds in all experiments as a result of higher mortality due to cannibalism. Feed intake was lower for hens treated with the IF-H and HB techniques compared to their respective controls, however failed to affect the IF-I experiment. In conclusion, beak treatments caused minor

effects on hen performance and can be considered acceptable from a performance standpoint. The reduced incidence of cannibalism for all trimmed birds emphasizes the long-term beneficial impact of beak treatment.

Key Words: beak, welfare, trimming, hot-blade, infrared, cannibalism

3.2 Introduction

The process of shortening beaks has been utilized in the poultry industry since the early 1930's when the Ohio experiment station blunted the tips of adult laying hens, broiler breeders, and turkeys in order to reduce the occurrence of damaging and cannibalistic pecking behaviour when an outbreak occurred (Kennard, 1937). The beak trimming process has since been refined and performed on pullets less than two weeks of age; most commonly on newly hatched chicks while still at the hatchery. Despite generally accepted benefits for beak trimming in terms of aggression and cannibalism, it is often criticized on animal welfare grounds, and the procedure has been banned in some countries (Dennis et al., 2009). Beak trimming is viewed as a mutilation or amputation by advocate groups and consequentially is considered by some to be an animal welfare concern (Potzsch et al., 2001).

One disadvantage of hot-blade (HB) beak trimming is pain immediately post treatment, which is demonstrated by a reduced ability to consume feed, a reduction in locomotive and consumptive behaviours, and an increase in lethargy and the expression of guarding behaviours (Eskeland, 1981; Gentle et al., 1990; Marchant-Ford et al., 2008). Tucking the beak under the wing, which has been linked to a pain response, is an example of a guarding behaviour (Gustafson et al., 2007). Another suggested disadvantage is long-term pain associated with neuroma formation (Glatz, 2005a). In contrast, the elimination of this process poses an animal welfare concern of its own as beak trimming has served to significantly reduce the prevalence of aggressive and damaging feather pecking leading to cannibalism thereby improving the welfare of the birds especially in larger group-housed flocks (Tauson et al., 1992). With moderate (~40% removal) beak trimming, the acute pain noted above is believed to be short term, and these effects need to be counterbalanced against the long-term welfare concerns of preventing feather pecking and cannibalism. Although long-term pain associated with neuroma formation has been demonstrated in adult hens following HB beak trimming (Hester and Shea-Moore, 2003), more recent research with birds trimmed at a young age and in a moderate fashion does not show neuroma formation (Glatz, 1987; Gentle et. al, 1997). Trimming beaks has also been shown to improve the bird's feed efficiency, and it is speculated that this is primarily due to a reduction in feed wastage (Bell and Kuney, 1991; Dennis and Cheng, 2010; Marchant-Forde and Cheng, 2010).

A more recently adopted beak length control technique is infrared treatment (IF), which has not been studied to the same degree as HB trimming. Nova-Tech Engineering Inc. (Willmar, MN) has developed a beak treatment technique that utilizes infrared energy to penetrate the outer rhamphotheca (outer horn), underlying epithelial, connective tissue, and boney regions of the beak (Gentle and McKeegan, 2007). This automated procedure accommodates different cranial and beak sizes by increasing infrared intensity, varying guide-plate size and/or adjusting mirrors used to reflect infrared energy onto the lower beak. Roughly two weeks post treatment, beak tissue proximal to the treatment site is healed and the remaining beak is sloughed to expose a shortened but healed beak tip (Dennis and Cheng, 2010).

Despite considerable information on beak shortening from past work, understanding the impact of the degree of treatment of day-old chicks on bird welfare and performance requires additional research. This relates to the acceptability of variation in beak treatment due to chick size and other factors during the treatment process. The objective of beak trimming should be to reduce damaging behaviour leading to cannibalism while minimizing the impact on bird welfare (Gentle and McKeegan, 2007; Marchant-Forde et al., 2008; Dennis et al., 2009). Therefore, the objective of this research was to determine the effects of severity of beak treatment on beak healing and the performance of laying hens. Three experiments were conducted using pullets derived from three separate hatcheries each using a different method to treat different strains of White Leghorns. The treatments applied were: IF with severity altered via guide-plate hole size, IF with severity varied through infrared intensity, and HB varied through guide-plate hole size.

3.3 Materials and Methods

3.3.1 Beak Treatments

Newly hatched White Leghorn pullets from of three different strains had beak treatments applied in separate hatcheries in Western Canada and were accordingly divided into three experiments. Beak treatments included an untreated control (C) and three levels of treatment severity. The objective of the beak treatments was to remove approximately 20, 40 and 60% of the beak from tip to nares of day-old chicks. The method of achieving the desired amounts of beak damage/removal was established in conjunction with hatchery staff. The treatment methods applied were as follows: 1) Experiment 1 - infrared treatment with severity varied by increasing the guide-plate hole size at a consistent energy intensity of 48 (unit defined by Nova-Tech Engineering Inc.) for a duration of 57 seconds (the guide-plate hole sizes were 25, 23, 21, relating to plate thickness, measured in mm which resulted in least to most severe plates, respectively) 2) Experiment 2 - infrared treatment with severity affected by increasing infrared energy intensity (35, 45 or 55 for a duration of 57 seconds using the 25 plate hole size); and 3) Experiment 3 - hot-blade treatment in which severity was varied through increasing guide-plate hole size (4, 5 and 6 mm in diameter).

3.3.2. Brooding and Rearing Management and Experimental Design

Six hundred pullets were transported from each hatchery (600 x 3 = 1800 total pullets) to the University of Saskatchewan and housed in litter floor pens until housing in cages at 17 wks of age. Straw covered floor pens (2.3 x 2.0 m) each housed 50 pullets on a specific strain by treatment basis (3 strains x 4 treatments x 50 pullets; N = 600). Each experiment x severity (treatment) was replicated three times (3 pens per treatment).

Pullets were fed commercial chick starter (crumble, 0-6 wks), grower (crumble, 6-17 wks) and pre-lay (mash, 17-19 wks) diets that met or exceeded bird nutrient requirements (NRC, 1994) on an *ad libitum* basis. Two cardboard egg trays were used as extra feeders for the first 7 d along with one small tube feeder (36 cm in diameter) from 0-6 wks. One large feeder (43 cm in diameter) was used per pen from 7-17 wks. Supplemental water was provided in ice cube trays for the first seven d along with Lubing nipple drinkers (6 nipples per pen; nipple 4078). The brooding and rearing lighting program consisted of

23L:1D (20 lux) from 0-7 d of age, 21L:3D (10 lux) from 8-14 d of age, and 8L:16D (2 lux) from 2-17 wk of age with incandescent light bulbs used as the light source. Lighting was reduced to 2 lux at 4 wks of age as feather pecking leading to cannibalism was noted in the control treatments in all experiments. Temperature at housing was 35°C, and was reduced to 22°C by d 35.

3.3.3 Egg Production Period Management and Experimental Design

A total of 864 White Leghorn pullets from the original 1800 (288 of each of the 3 strains used) were moved into commercial-type battery cages at 17 wks. Data for the production period were collected for 40 wks from 19 to 59 wks of age. Two cages consisting of 6 birds per cage (500 cm^2/bird) were utilized per replication with 6 replications per treatment. The dimensions of the cages were 58.5 cm wide x 51.0 cm deep. The height of the cage measured 43.2 cm at the front of the cage, and 39.4 cm at the rear of the cage (Figure 3.1). The grid size of the wire floor was 2.5 x 4.0 cm. Nutritionally balanced (met or exceeded NRC, 1994 requirements) mash form feed was provided *ad libitum* during the laying period. Water was supplied with Lubing nipple drinkers (1 nipple per cage; nipple 4077).

Light was provided by incandescent bulbs and scheduled to simulate dawn and dusk lighting. This was performed by staggering the “on” and “off” times of three separate banks of lights within the barn. Lights turned on at 05:45, simulating dawn until achieving 10 lux at 06:00. Lights began simulating dusk at 20:00 and achieved darkness by 20:15hr (0 lux). Light for the remainder of the 14.5 hr day was maintained at 10 lux (06:00 - 20:00). Barn temperature was maintained at approximately 20°C.

Figure 3.1 One of the six repetitions per treatment housed in the cage barn at 17 wks

3.3.4 Data Collection

Pullets were weighed at 0, 8, 15, 22, 28, 77 and 119 d of age. In order to study the healing process, two chicks of each treatment were killed by cervical dislocation at 0, 7, 14, 28 d post-treatment. Beak tissue was harvested and fixed in 10% neutral buffered formalin, embedded in paraffin, sectioned at 5 μm thickness and stained with hematoxylin and eosin (H&E). A histological appearance of acute, sub-acute or chronic was assigned based on the cellular infiltration, cellular damage and regenerative changes of the beak.

Beak lengths for all birds were measured at 1 d of age for the HB chicks, and 2, 11, 18, 38, and 59 wks of age for all treatments in all three experiments. Measuring beak length for IF chicks at 1d was not attempted as the beaks had not yet sloughed, and the exact demarcation point for the treatment was difficult to judge accurately. The upper mandible was measured from the end of the nares to the tip of the beak on both sides with digital callipers.

Feed intake was not measured during the brooding and rearing period, but was assessed every four wks during the egg production portion of the experiment. All hens were weighed at the beginning (19 wks of age) and end (59 wks of age) of the egg production period.

Egg production was recorded by replication five d per week. Abnormal eggs were identified and recorded at the time of collection. Egg production was corrected to a seven-d week basis for analysis. Once every four wks, all eggs were individually marked, weighed, and their specific gravity recorded using salt solutions ranging from 1.060 to 1.100, increasing by increments of 0.005.

Birds were checked daily for evidence of illness, cannibalism, or mortalities. Dead birds were weighed and sent to Veterinary Diagnostic Services of the University of Saskatchewan to determine cause of death. Any hens that were being actively, severely pecked were removed from the trial when blood was evident and classified as cannibalism mortality. These hens were placed in non-experimental cages to recuperate.

3.3.5 Statistical Analysis

A Completely Randomized Design was used during the brooding and rearing period, with four severities and three replications per treatment. During the laying period, each experiment was again a Completely Randomized Design, with four severities and six replications per treatment. Normality of distribution was assessed and data log + 1 transformed prior to running the ANOVA if necessary. Analysis was performed using the General Linear Model (GLM) of SAS (SAS 9.1, 2002). Duncan's Multiple Range Test was used to separate the means when differences, as judged by ANOVA, were statistically significant ($P \leq 0.05$). Treatment effects were considered significant when $P \leq 0.05$ unless otherwise specified.

3.4 Results

3.4.1 Beak Length (Table 3.1)

For all experiments, beak treatment reduced beak length at each recording (Table 3.1). However, both attempts to alter beak length using IF treatment failed to alter severity and

Table 3.1 Effect of infrared and hot-blade beak treatment on beak length, measured nare to beak tip (mm)

	Control	% beak removal / damage goal			SEM[1]
		20	40	60	
Experiment 1. Infrared treatment with severity varied by guide-plate hole size					
2 wks	9.85[a]	4.98[c]	4.89[c]	5.46[b]	0.626
11 wks	16.97[a]	11.13[b]	10.49[c]	11.23[b]	0.793
38 wks	19.11[a]	13.15[b]	12.16[c]	13.04[b]	0.583
57 wks	18.97[a]	12.99[b]	12.08[c]	12.91[b]	0.581
Experiment 2. Infrared treatment with severity varied by infrared intensity					
2 wks	8.63[a]	4.92[b]	5.37[b]	4.61[b]	0.509
11 wks	17.01[a]	12.01[b]	12.04[b]	11.55[b]	0.679
38 wks	18.95[a]	13.26[b]	13.18[b]	12.97[b]	0.528
57 wks	18.93[a]	13.22[b]	13.16[b]	12.87[b]	0.533
Experiment 3. Hot-blade treatment with severity varied by guide-plate hole size					
0 d	5.71[a]	4.36[b]	3.26[c]	2.45[d]	0.053
11 wks	17.12[a]	14.88[b]	11.51[c]	10.00[d]	0.844
38 wks	19.38[a]	16.76[b]	13.45[c]	11.88[d]	0.614
57 wks	19.60[a]	16.97[b]	13.17[c]	11.83[d]	0.645

[1] SEM – standard error of the mean.
[a,b,c,d] Means within rows with unlike letters differ ($P<0.05$).

all resulted in beak lengths that were approximately 30 to 36% shorter than the control treatment at 11 wks of age. Hot-blade treatment was successful in affecting the degree of beak shortening at levels that approximated the 20, 40 and 60% goals. At 11 wks post-treatment, beak length was 14, 31 and 39% shorter than the control treatment for the 20, 40 and 60% treatments respectively (Table 3.1). Although beak growth occurred between 11 and 38 wks, the treated birds maintained approximately the same proportional size in relationship to the control birds. Beak length at 57 wks of age was similar to that at 38 wks and again relationships among treatments within an experiment did not change.

3.4.2 Experiment 1 – Infrared Treatment with Severity Varied by Guide-plate Hole Size

Body weight for pullets treated with the IF method, (with severity varied by guide-plate hole size) was not affected by treatment severity and was not different than the control birds at 8, 15 and 22 d of age (Table 3.2). At 28 d of age, pullets from both 40 and 60% severity treatments were lighter than birds from the control treatment, however no difference was noted between treatment severities. At 77 d, birds from the 40% treatment were lighter than the control pullets, but again no differences were found as a result of attempted severity level. Body weights at 18, 38 and 60 wks of age were not affected by treatment.

Birds that received IF treatment ate less feed in comparison to control hens during the laying period (Table 3.2). Treatment did not affect feed to egg mass ratio, hen-day egg production, incidence of abnormal eggs, egg weight or egg specific gravity, but hen-housed egg production was found to be lower for the control treatment compared to all

Table 3.2. Effect of infrared treatment with severity varied by guide-plate hole size on pullet body weight, hen productivity and egg quality

	% beak removal / damage goal				
	Control	20	40	60	SEM[1]
Body weight, kg					
0 d	0.034	0.034	0.033	0.033	0.00008
8 d	0.072	0.070	0.068	0.070	0.0005
15 d	0.120	0.117	0.113	0.116	0.0014
22 d	0.171	0.165	0.161	0.164	0.0015
28 d	0.251[a]	0.244[ab]	0.238[b]	0.240[b]	0.0019
77 d	0.915[a]	0.893[ab]	0.873[b]	0.894[ab]	0.0053
18 wks	1.250	1.230	1.227	1.228	0.0048
38 wks	1.777	1.740	1.711	1.743	0.0088
59 wks	1.870	1.853	1.825	1.862	0.0104
Laying period results					
Feed intake, g/hen/d	113.9[a]	105.7[b]	107.2[b]	107.3[b]	0.001
Feed to egg mass ratio	2.09	1.98	2.03	2.06	0.019
Egg production (HD)[2], %	91.98	90.41	90.93	89.37	0.774
Egg production (HH)[2], %	75.03[b]	86.33[a]	86.01[a]	86.90[a]	0.980
Double yolk, %	0.33	0.24	0.38	0.24	0.038
Soft shelled eggs, %	0.49	0.36	0.34	0.34	0.043
Cracked eggs, %	0.23	0.17	0.26	0.23	0.027
Broken eggs, %	0.39	0.24	0.27	0.23	0.031
Abnormal[3], %	0.14	0.11	0.07	0.09	0.017
Egg weight, g	59.1	59.2	58.2	58.4	0.205
Specific gravity	1.089	1.087	1.087	1.087	0.001

[1]SEM - standard error of the mean
[2]HD - hen-day egg production; HH- hen-housed egg production.
[3]Abnormal includes flat sided or abnormally shaped eggs.
[a,b] Means within rows with unlike letters differ ($P<0.05$).

treated hens. Differences in mortality due to cannibalism approached significance (P=0.06) and were high for the control treatment (15.28%) and not present or found at low levels for the 20 (0.0%), 40 (2.78%) and 60% (0.0%) in IF treatments (Table 3.3). When individual cannibalism per repetition in the control treatment was viewed, 50% of the replications showed evidence of cannibalism (Table 3.4).

Histological examination of IF-H treated beaks demonstrated minor differences between treatment severities regarding shape and appearance of the beak tip. Necrosis with few inflammatory cells and slight discoloration of the tissue at the site of insult was evident for all treatment severities immediately following treatment (Figures 3.2 and 3.3). There was evidence that boney tissue was removed as a result of IF treatment. Prior to sloughing (1-2 wks) sub-dermal connective tissue regenerated, with evidence of thin epidermal and rhamphotheca layers surrounding the connective tissue and deeper bone layer. At 7 d, necrotic tissue had not yet sloughed and remained attached to the beak tip (Figure 3.4). Two weeks post treatment in the 40% group, the beak appeared blunted, connective tissue healed with a thin epithelium and rhamphotheca layer visible (Figure 3.5). By three wks post-treatment, all severities maintained a blunted appearance and all sub-dermal tissues were healed. Neuroma formation was not evident for any of the treated birds.

Table 3.3 Effect of beak treatment on mortality (19 to 59 wks of age)[4]

	Control	% beak removal / damage goal 20	40	60	SEM[1]
Experiment 1. Infrared treatment with severity varied by guide-plate hole size					
Cannibalism, %[2]	15.28	0.00	2.78	0.00	-
Infection, %	2.78	1.39	0.00	0.00	-
Other, %[3]	1.39	4.17	6.94	6.94	-
Total, %	19.44	5.56	9.72	6.94	-
Experiment 2. Infrared treatment with severity varied by infrared intensity					
Cannibalism, %	9.72[a]	0.00[b]	0.00[b]	1.39[b]	-
Infection, %	1.39	0.00	1.39	2.78	-
Other, %	0.00[b]	2.78[ab]	6.94[a]	0.00[b]	-
Total, %	11.11	2.78	8.33	4.17	-
Experiment 3. Hot-blade treatment with severity varied by guide-plate hole size					
Cannibalism, %	23.61[a]	4.17[b]	0.00[b]	0.00[b]	-
Infection, %	0.00	0.00	1.39	0.00	-
Other, %	4.17	6.94	1.39	8.33	-
Total, %	27.78[a]	11.11[b]	2.78[b]	8.33[b]	-

[1]SEM – standard error of the mean.
[2]Differences approached significance (P=0.06).
[3]Other includes mortality or removal from trial due to fatty liver hemorrhagic syndrome, cage layer fatigue, impacted oviduct, broken wing.
[4] Data presented are actual data. Data were transformed prior to analysis and separation of means is based on transformed data. SEM not presented as does not relate to actual data.
[a,b] Means within rows with unlike letters differ (P<0.05).

Table 3.4 Number of birds culled for or dying as a result of cannibalism in individual replications of the untreated control hens in Experiments 1, 2 and 3 (19 – 59 wks)

	IF-H[1]		IF-I[2]		HB-H[3]	
Replication	Number	%	Number	%	Number	%
1	5	41.7	0	0	3	25.0
2	0	0	2	16.7	1	8.3
3	1	8.3	3	25.0	1	8.3
4	0	0	0	0	2	16.7
5	0	0	2	16.7	6	50.0
6	5	41. 7	0	0	4	33.3

[1] IF-H – Experiment 1. Infrared treatment with severity varied by guide-plate hole size.
[2] IF-I – Experiment 2. Infrared treatment with severity varied by infrared intensity.
[3] HB-H – Experiment 3. Hot-blade treatment with severity varied by guide-plate hole size.

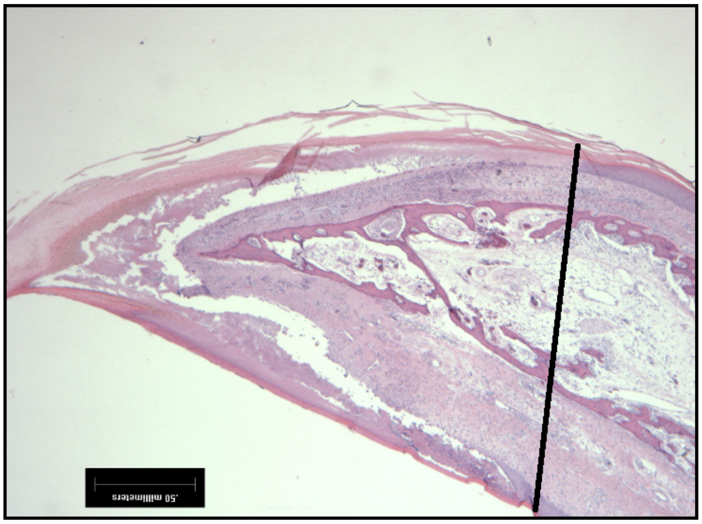

Figure 3.2 IF-H 40% treated at d 0 with slight discoloration and thinning of rhamphotheca tissue layer. The line divides the treated and un-treated areas.

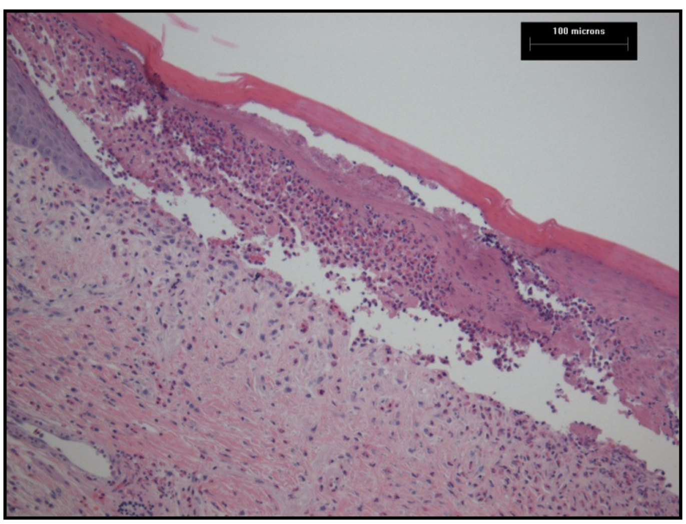

Figure 3.3 IF-H 40% treated at d 0 with slight discoloration due to acute, severe, locally extensive necrosis and fragmentation of rhamphotheca tissue layer**.**

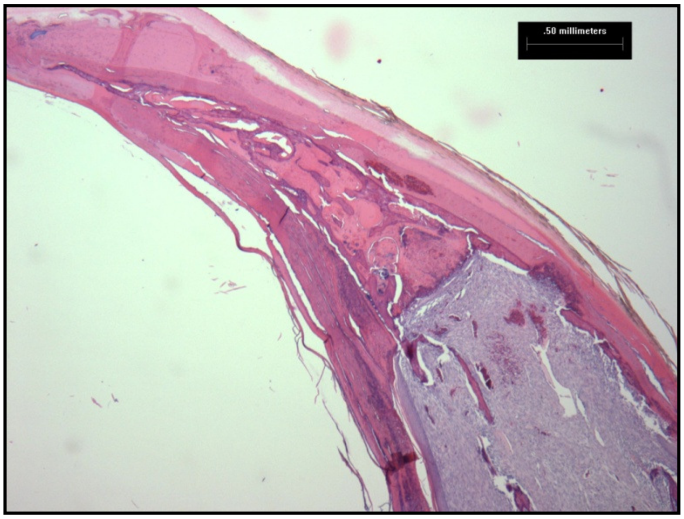

Figure 3.4 IF-H 40% treated d 7 shows the necrotic tissue prior to sloughing. The connective tissue has healed and there is evidence of regeneration of the epithelium and rhamphotheca.

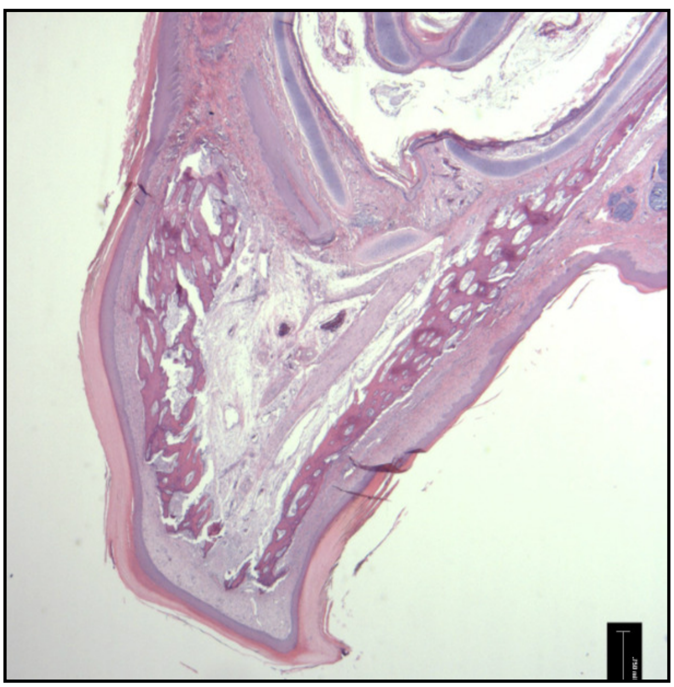

Figure 3.5 IF-H 40% treated d 14 shows all sub-dermal tissues healed, resulting in a blunted appearance.

3.4.3 Experiment 2 – Infrared Treatment with Severity Varied by Infrared Intensity

Treatment did not affect body weight at 8 d of age, but at 15 d all treated birds were significantly lighter when compared to the control pullets (Table 3.5). By 22 d, pullets from both the 40 and 60% treatments were lighter than birds from the control treatment. The 20% treatment resulted in an average weight that was intermediate to these weights and not statistically different than birds from the control and 40% treatments. No body weight differences were noted for the remainder of the brooding and rearing period or the early laying period. At 59 wks, body weights for both 40 and 60% treatments were lighter than the 20% group, but not different than the control treatment.

During the laying period, treatment did not affect feed intake, feed to egg mass ratio, hen-day egg production, egg weight or specific gravity (Table 3.5). A higher incidence of double yolk eggs was produced by hens in the 20% treatment compared to the control and 60% birds; hens from the 40% treatment produced an intermediate incidence. Hens in the 20 and 40% treatments produced a higher incidence of soft-shelled eggs than the control birds. No treatment effects were found for the number of cracked, broken or abnormal eggs. Hen-housed egg production was found to be lower for the control treatment hens in comparison to birds from all other treatments. The incidence of cannibalism was higher for the control treatment than all of the IF treatments (Table 3.3). Half of the control treatment replications had cannibalized birds (Table 3.4). The incidence of "other" mortality was higher for the 40% severity treatment than the control

Table 3.5 Effect of infrared treatment with severity varied by infrared intensity on pullet body weight, hen productivity and egg quality

	% beak removal / damage goal				
	Control	20	40	60	SEM[1]
Body weight, kg					
0 d	0.037[a]	0.036[a]	0.034[b]	0.034[b]	0.0015
8 d	0.097	0.100	0.083	0.084	0.0034
15 d	0.125[a]	0.116[b]	0.109[b]	0.108[b]	0.0026
22 d	0.193[a]	0.185[ab]	0.177[bc]	0.176[c]	0.0021
28 d	0.276	0.268	0.260	0.261	0.0025
77 d	0.879	0.898	0.891	0.960	0.0179
18 wks	1.277	1.298	1.295	1.298	0.0052
38 wks	1.723	1.755	1.715	1.715	0.0088
59 wks	1.832[ab]	1.875[a]	1.823[b]	1.800[b]	0.0104
Laying period results					
Feed intake, g/hen/d	114.2	114.1	114.5	113.5	0.0004
Feed to egg mass ratio	2.05	2.03	2.03	1.99	0.012
Egg production (HD)[2], %	91.67	92.20	92.29	92.96	0.491
Egg production (HH)[2], %	83.48[b]	90.13[a]	88.55[a]	88.92[a]	0.651
Double yolk, %	0.22[b]	0.45[a]	0.35[ab]	0.20[b]	0.032
Soft shelled eggs, %	0.20[b]	0.50[a]	0.56[a]	0.34[ab]	0.049
Cracked eggs, %	0.17	0.12	0.24	0.15	0.021
Broken eggs, %	0.21	0.11	0.20	0.23	0.022
Abnormal[3], %	0.04	0.11	0.10	0.08	0.014
Egg weight, g	60.5	61.1	61.1	61.3	0.225
Specific gravity	1.085	1.083	1.086	1.087	0.001

[1]SEM - standard error of the mean
[2]HD - hen-day egg production; HH- hen-housed egg production.
[3]Abnormal includes flat sided or abnormally shaped eggs.
[a,b,c]Means within rows with unlike letters differ (P<0.05).

and 60% treatment groups. The “other” category consisted of birds that died of causes other than cannibalism or infection and included mortality or culling due to fatty liver hemorrhagic syndrome, cage layer fatigue, impacted oviduct, or broken wings.

In general, histological observations of the morphology of the beak were similar for Experiments 1 (IF-H) and 2 (IF-I). Histologically in all three severities, the beak appeared soft with necrotic tissue at the treatment site on day 0 (Figure 3.6). Sub-dermal beak tissue healed prior to sloughing and resulted in a blunted beak tip. The 40% severity at 14 d post treatment showed connective tissue that appeared thickened towards the lingual surface of the beak. Some inflammation was noted in the boney tissue region of one chick at 21 d; however, sufficient coverage and regeneration of connective tissue, epithelium, and rhamphotheca were present (Figure 3.7). The connective tissue and epithelium retained their blunted appearance, but the rhamphotheca regenerated some of its original hook-like appearance. Neuroma formation was not identified in any of the beak samples examined.

3.4.4 Experiment 3 – Hot-Blade Technique with Severity Varied by Guide-plate Hole Size

Severity of HB trimming affected body weight at 8, 28 and 77 d of age as well as 18 and 38 wks of age (Table 3.6). For all ages, birds from the 60% treatment were lighter than those from other treatments. At 59 wks of age, differences were not significant, but a numerical decrease in body weight was still apparent for birds in the 60% treatment.

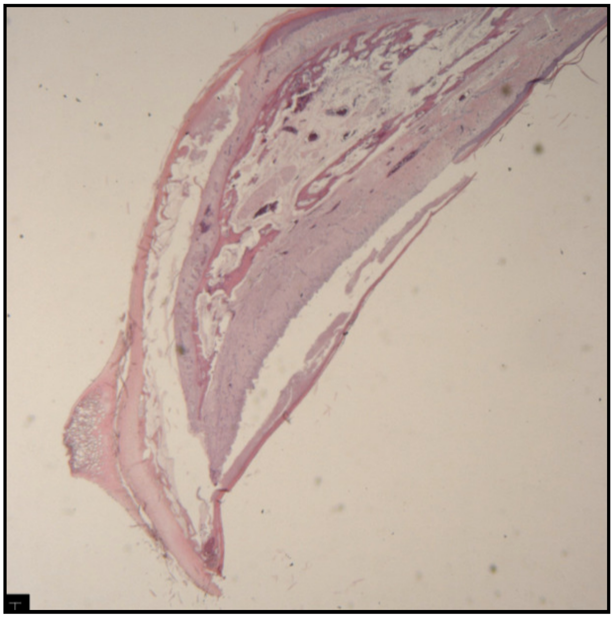

Figure 3.6 IF-I 40% treated beak at d 0, note necrosis and tissue separation due to softness of the rhamphotheca.

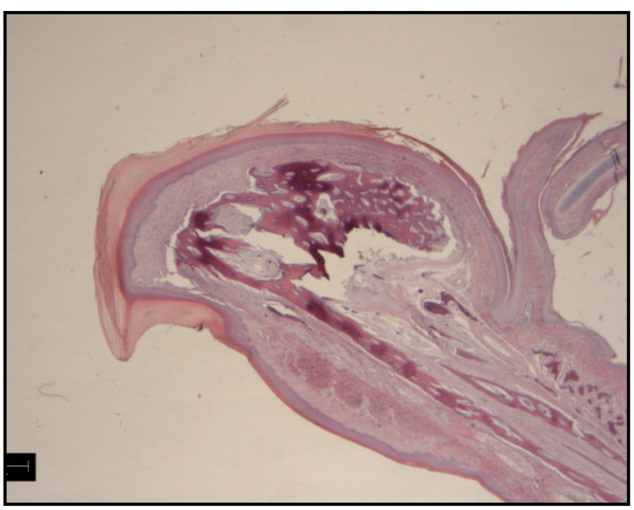

Figure 3.7 IF-I 40% treated at d 21 shows healing of all sub-dermal layers. Boney tissue is involved in this severity of treatment. Sufficient regeneration of connective, epidermal and rhamphotheca tissue layers. Note thickening of rhamphotheca layer and hook-like appearance after only 21d post treatment.

Table 3.6 Effect of hot-blade treatment with severity varied by guide hole plate size on pullet body weight, hen productivity and egg quality

	% beak removal / damage goal				
	Control	20	40	60	SEM[1]
Body weight, kg					
0 d	0.041	0.040	0.040	0.040	0.0292
8 d	0.076[a]	0.076[a]	0.072[ab]	0.064[b]	0.0026
15 d	0.117	0.117	0.116	0.108	0.0015
22 d	0.182	0.183	0.183	0.172	0.0017
28 d	0.259[a]	0.264[a]	0.264[a]	0.251[b]	0.0019
77 d	0.818[a]	0.826[a]	0.822[a]	0.802[b]	0.0038
18 wks	1.250[a]	1.253[a]	1.232[a]	1.182[b]	0.0085
38 wks	1.725[a]	1.725[a]	1.700[a]	1.630[b]	0.0122
59 wks	1.833	1.855	1.848	1.760	0.0167
Laying period results					
Feed intake, g/hen/d	116.8[a]	114.7[ab]	111.3[bc]	108.3[c]	0.0009
Feed to egg mass ratio	2.13	2.12	2.08	2.06	0.013
Egg production (HD)[2], %	89.71	90.63	89.49	89.00	0.537
Egg production (HH)[2], %	71.27[b]	85.98[a]	86.89[a]	85.26[a]	0.890
Double yolk, %	0.47	0.56	0.39	0.41	0.050
Soft shelled eggs, %	0.31	0.41	0.51	0.53	0.044
Cracked eggs, %	0.26[ab]	0.41[a]	0.28[ab]	0.21[b]	0.030
Broken eggs, %	0.18	0.35	0.37	0.32	0.031
Abnormal[3], %	0.14	0.21	0.13	0.22	0.022
Egg weight, g	60.6	59.5	59.9	59.2	0.246
Specific gravity	1.086	1.083	1.085	1.088	0.001

[1] SEM – standard error of the mean.
[2] HD - hen-day egg production; HH – hen-housed egg production.
[3] Abnormal includes flat sided or abnormally shaped eggs.
[a,b,c] Means within rows with unlike letters differ ($P<0.05$).

Throughout the egg production period, feed intake was higher for control birds than those with HB beak treatment (Table 3.6). This treatment method showed a linear decrease in feed consumption with increasing severity of treatment. No treatment effects were found for feed to egg mass ratio, hen-day egg production, double yolk, soft, broken, or abnormal egg numbers nor for egg weight and specific gravity. Hen-housed egg production was significantly lower for the control treatment compared to the other three treatments. The 20% treatment hens in the HB method produced more cracked eggs than those in the 60% treatment while levels for birds in the control and 40% treatments were intermediate. The percentages of total mortality and birds dying or culled due to cannibalism were higher for the control treatment than all trim severity treatments (Table 3.3). Each replication of the intact treatment in Experiment 3 showed evidence of cannibalism with a prevalence of 8.33-50.00% (Table 3.4).

Histological examination of the HB treated beaks immediately post trimming showed necrosis, haemorrhage and inflammation of the beak epithelium, underlining connective tissue, and boney regions relating to the site of insult regardless of trim severity. The degree of damage correlated to the severity of treatment and as severities increased, so did the amount of sub-dermal tissue damage. Immediately post trimming, the beak tip appeared inflamed with all of the structures including boney tissue being affected (Figure 3.8). At 7 d post treatment, connective tissue surrounded the previously exposed boney tissue (Figure 3.9). The epithelial and rhamphotheca layers surrounding the connective tissue appeared healthy, yet thin on the beak tip surface. The sample in Figure 3.9 showed a minor collection of debris at the site of insult, which was relatively rare in examined

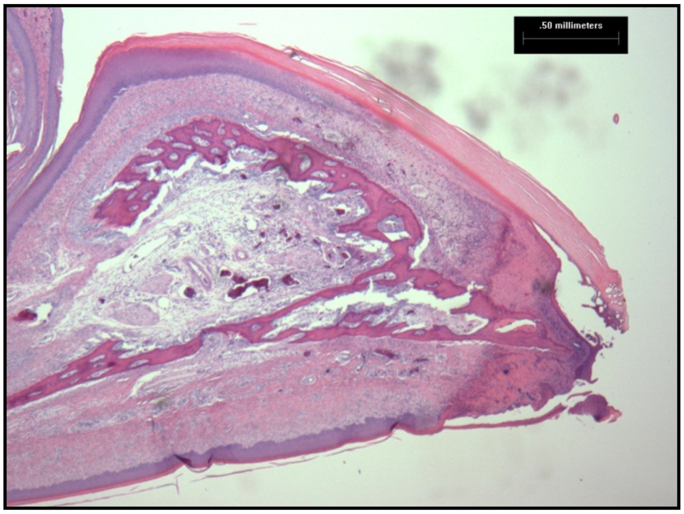

Figure 3.8 HB 40% treatment d 0 shows discoloration of the tissue, indicating locally extensive necrosis, and haemorrhage following treatment.

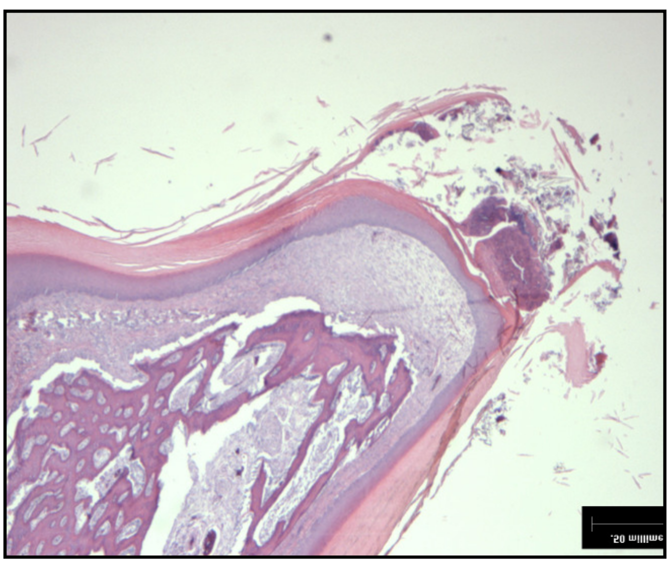

Figure 3.9 HB 40% treatment d 7 shows healing of connective tissue and rhamphotheca layer. Some minimal debris appears at the sight of insult.

samples. By 2 wks post treatment connective tissue and epithelium appeared healed and a thin rhamphotheca layer was evident; the beak demonstrated a blunted appearance (Figure 3.10). No evidence of neuroma formation was present in any of the treatment severities in this experiment.

3.5 Discussion

Four treatment severities were chosen for each of the three trimming methods to determine the effects of severity on the growth and performance of White Leghorn pullets and hens. The traditional HB method was used along with two variations of IF treatment. Ideally, a treatment severity that results in a beak blunted enough to reduce or eliminate aggressive and damaging pecking behaviour while causing the least amount of pain, discomfort, or distress to the bird would result in the best welfare. The goal of achieving four treatment severities for each treatment method proved successful for the HB treatment method only and will be discussed first.

3.5.1 Hot-Blade Beak Trimming with Severity Varied by Guide-plate Hole Size

The HB method resulted in beak lengths at the time of trimming that were 23.7, 43.0, and 57.1% shorter than the control treatment and approached the goal of 20, 40, and 60% removal. Eleven wks post-treatment the shortening was 14, 31, and 39% for these treatments compared to the control, and these proportions were relatively constant to the end of the laying period. The maintenance of proportional beak size and lack of re-growth is not in agreement with Gentle and McKeegan (2007) where birds showed significant re-growth for both IF and HB trimming methods. The lack of beak re-growth is an important

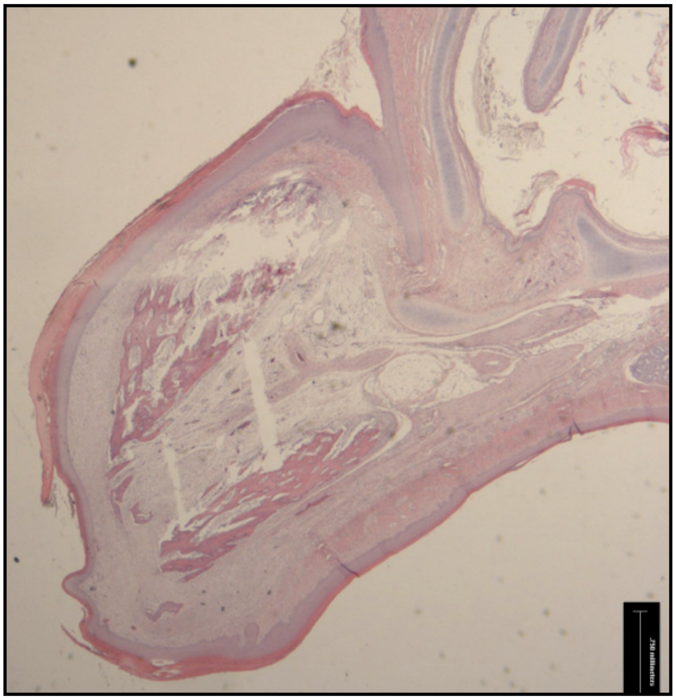

Figure 3.10 HB 40% treatment d 14 shows some boney tissue involvement. A blunted appearance with sub-dermal healing and a thin rhamphotheca layer.

factor in minimizing feather pecking and cannibalism, and the lack of consistency between trials demonstrates that a clear understanding of the procedure is necessary to ensure consistency.

In general, the present research demonstrates that HB trimming can be manipulated accurately to produce the desired degree of beak shortening and that it can effectively control beak growth for the production life of the hens.

The impact of severity of HB beak trimming is best seen in regards to body weight. Less severe treatments did not affect body weight but the 60% severity reduced this parameter at most of the time points examined. There are a number of potential reasons for the reduction in body weight including a reduced ability to eat. Lower feed intake during the laying period for this treatment supports this explanation. Alternately, the decrease in body weight might indicate both acute and chronic pain post-treatment. Breward and Gentle (1985) found evidence of a decrease in feeding motivation due to the presence of pain as a result of nerve and tissue damage after trimming. Histological examination of the degree of healing after the trimming procedure in this research would be supportive of an acute pain effect, but this appeared to be short-term. The fact that the 60% treatment continued to have a lowered body weight could also indicate the presence of chronic pain and possible neuroma presence. Histological examination failed to find the presence of neuroma formation in any of the treatments, and suggests this is not the reason for the weight effect. Earlier research has also shown a reduction in body weight with the HB method when trimmed at 1 d of age (Glatz and Lunam, 1994; Gentle et al., 1997) that lasted weeks to months (Lee and Craig, 1990; Davies et al., 2004; Gentle and McKeegan, 2007). Gentle and McKeegan (2007) found that birds which were HB treated had a decrease in bodyweight for a 4 wk period compared to un-treated hens; however, those that were IF treated only showed a 3 wk weight decrease compared to their respective control treatment. Recent research (Dennis and Cheng, 2010) showed that body weights in IF treated birds were consistently higher when compared to HB treated birds. Contrary to what was seen in this trial for the 60% severity treatment, body weights reached normal levels just prior to or during the laying period in previous trials (Glatz, 1987; Lee and Craig, 1990). Kuenzel (2007) suggests that removal of greater than 50% results in decreased welfare parameters, however Gentle et al. (1997) suggest that less than 50% removal results in extensive re-growth. In addition to the degree of beak shortening, factors such as cauterizing temperature and time of beak exposure are factors that influence the response to HB treatment and can possibly account for variable results between experiments. Regardless of the reason for the reduction in weight for the 60% severity group, this effect suggests that this degree of beak shortening is at or nearing the extent that can be recommended based on the welfare of the bird.

Feed intake was not measured during the brooding and rearing period because of difficulty in accurate measurement due to feed wastage. However, feed consumption decreased in a linear fashion with increasing HB trim severity during the lay period. The reduction in feed intake has already been discussed for the 60% severity in relationship to reduced body weight. Recalling that body weights of birds from 20 and 40% treatments were not affected in comparison to the control birds and that there was no effect of these treatments on hen-day egg production and egg weight, one can postulate that this reduction in apparent feed intake is actually a reduction in feed wastage. This has been suggested extensively in previous research (Lee and Craig, 1990; Bell and Kuney, 1991;

Craig, 1992; Glatz and Lunam, 1994; Gentle et al., 1997; Davis et al., 2004; Marchant-Forde et al., 2008).

Histological examination of the HB treatment beak shows that regardless of the treatment severity, necrosis, haemorrhage and inflammation occur immediately after treatment. However, regeneration of all treatments occurred as soon as a week later. The open, ulcerated beak after trimming appears to be vulnerable to the collection of debris and secondary bacterial infections, having the potential to cause an increase in pain and inflammation. In addition, it can be speculated that bacterial invasion may weaken portions of the beak and result in later beak defects. Beak tissue of the milder (20%) severity resembled that of an un-treated bird three wks following trimming, which raises the question if this treatment was severe enough to retain its blunted conformation. This theory is supported by Gentle and McKeegan's (2007) research that compared IF to HB trimming in broiler breeder chicks. Gentle and McKeegan (2007) found significant re-growth in both IF and HB treatments 42 days following treatment however, their values remained different than the control treatments. The 40% treatment retained a blunted appearance and demonstrated adequate healing of connective tissue, epithelium, and rhamphotheca layers two wks post-trimming, which suggests its superiority in comparison to the other HB severity levels.

3.5.2 Infrared Beak Treatment

Both infrared methods failed to affect the degree of beak shortening and resulted in beak length values that were similar to the beak removal achieved by the 40% HB treatment (30 to 36% shorter than the control). Altering the guide-plate hole size or increasing energy intensity alone did not alter beak length and more research in collaboration with the equipment supplier is necessary to determine how to effectively and accurately affect degree of beak removal. Due to the fact that our goal of achieving three severities of beak trimming levels with both infrared methods was unsuccessful, the discussion on each method will focus on comparing the intact to treated birds in each respective infrared trimming method. The data also permits non-statistical comparison of the results from two hatcheries using a similar treatment technique.

Body weight for IF-H treated birds was not affected immediately post-treatment (8, 15, and 22 d of age), demonstrating that these birds were able to eat normally with their treated beaks. This finding is supportive of the use of this beak shortening technique and has been shown previously (Dennis et al., 2009). Beaks are believed to slough roughly two wks post treatment, therefore birds retain use of their beaks post-treatment unlike those treated by the HB method. A reduction in weight is noted in the treated birds from 28 to 77 d of age but this disappears by 126 d. Since histology suggests that beaks are healed by this point and no pain is indicated by body weights close to time of treatment, it is probable that the reduction in weight is due to the birds adjusting to their post-sloughed beak confirmation. A later loss of the lower beak in comparison to the upper beak may have added to the adaptation period and body weight reduction (Marchant-Forde et al., 2008).

The body weight of birds treated with the IF-I method was not affected by treatment at 8 d of age, but at 15 d of age birds from all treated groups were lighter than the control. The effect of IF-I treatment on body weight disappears by 28 d. A portion of the body weight effect for the IF-I birds could also be due to adjustment to the beak being sloughed, but the earlier appearance suggests there may be an alternate explanation as well, possibly related to the differences in IF treatment.

The IF-H method resulted in an overall decrease in feed intake in comparison to intact beak controls without a decrease in productivity or weight loss, which leads to the conclusion that this is due to a decrease in feed wastage. The IF-I method did not show an effect on feed intake even though beak lengths are comparable to those in the IF-H method. The explanation may relate to the strains used for the two techniques or the nature of the specific IF technique. There was no effect of either IF method on hen-day production, egg weight, or shell quality indicating that hen welfare was not affected in a major way by the treatment. There were minor effects seen in the incidence of soft-shelled eggs for the IF-I treated groups but no clear trend. This increase in soft-shelled eggs is opposite to what has been found in earlier research by North (2002). These researchers found that birds with intact beaks produced a higher incidence of laying soft-shelled eggs compared to trimmed birds. They suggested that this was due to the presence of higher stress levels in the intact birds, which would lead to higher oxytocin and adrenaline levels. The increase in these hormones could potentially increase oviduct contraction reducing the time spent in the shell gland being calcified. This decreased time in the shell gland could result in an increase in soft-shelled or shell-less eggs (Pizzolante et. al., 2007).

Histologically post treatment the beaks appeared inflamed with minimal evidence of haemorrhage. Even though the treatment reduced or eliminated blood supply to the beak tip, the birds appeared to retain use of their beaks until 1-2 wks following treatment. Prior to the necrotic tissue sloughing, sub-dermal tissues regenerate and heal, resulting in a fully healed and blunted beak tip. Interestingly, in Experiment 2 (IF-I), discoloration of the histological sample immediately post treatment indicated a more severe treatment than was seen in Experiment 1 (IF-H). This might be due to the IF method used, which utilized increasing infrared intensity to achieve a greater severity of treatment.

When comparing treated to control birds in both of the IF methods, there is a reduction in death due to aggressive behaviours leading to cannibalism that is consistent and agrees with previous research (Marchant- Forde et al., 2008; Dennis et al., 2009; Dennis and Cheng, 2010). A low level of cannibalism was found in some IF treatments, suggested that even though the IF method effectively reduced cannibalism, additional methods of control such as reduced light intensity, diet modification and environmental enrichment would decrease the prevalence of this behaviour even more.

3.5.3 Overall Mortality

Mortality was greatest in the control treatments in all three experiments, indicating that the intact beak was the cause of the majority of death loss. The majority of dead birds were due to cannibalism, pick outs, and prolapses. Once aggressive pecking leading to cannibalism was initiated in a cage, it often escalated and spread throughout the cage and affected up to 50% of the population within a replication (Table 3.4). This supports the hypothesis that cannibalism is a learned behaviour (Cloutier et al., 2002) as it was noted that neighbouring cages of intact treatments had a higher incidence of cannibalism. Death due to cannibalism was decreased or eliminated by trimming in the HB method, which is supported by Kuo et al. (1991) who correlated increasing severity of trim to decreasing levels of mortality. Historical research has shown that beak trimming at d 0, regardless of severity, reduces death loss due to cannibalism (Carson, 1975; Lee, 1980). Of note, the only mortality due to cannibalism in the treated birds was found in the 20% treatment in the Experiment 3, which raises the question if 20% removal (or the achieved 14% shortening) is severe enough to decrease or eliminate cannibalism.

3.6 Implications and Conclusions

In conclusion, the objectives of this research were not entirely met because differences in severity were not achieved for both IF methods. The HB method achieved severity goals, but had minor effects on production and therefore could be considered acceptable from a performance standpoint. Despite the equal production, the 60% severity level of HB treatment reduced weight and may be near the maximum degree of beak shortening that can occur without significant hen welfare concerns. Establishing the effects of severity of beak trimming is an important question as it may impact both the production and welfare of laying hens, as well as the nature of equipment adjustment at the hatchery. Welfare implications relate to effective beak trimming with minimal adverse effects on the bird, while equipment adjustment relates to the need to change settings to accommodate factors such as chick size that impact cranial and beak size and result in degree of treatment.

Cannibalism is a major animal welfare concern in poultry flocks and this research adds support for the use of beak trimming as a major method to control this vice. Although there is evidence in this trial and from previous research that acute pain occurs post-treatment for HB trimming and possibly for IF treatment, these effects appear to be short-term and of much less consequence in comparison to the high death loss due to cannibalism.

4.0 EFFECTS OF DEGREE OF INFRARED AND HOT-BLADE BEAK TRIMMING ON THE BEHAVIOUR AND FEATHER CONDITION OF WHITE LEGHORNS

4.1 Abstract

Three experiments were conducted to determine the impact of day-old beak trimming on the behaviour and feather condition of White Leghorns. Pullets were derived from separate hatcheries utilizing different strains and trimming techniques. The techniques used to modify beak length were: Exp. 1 - infrared (IF) using varying guide-plate hole sizes (H, Strain 1); Exp. 2 - IF using variable IF intensity (I, Strain 2); and Exp. 3 - hot-blade (HB) using varying guide-plate hole sizes (H, Strain 3). Beak treatments included a control (C), and an attempt to remove or treat 20, 40 and 60% of the beaks of day-old chicks. Pullets were housed on litter floor (0-17 wk) and conventional cages (18-59 wk). Altering beak length was only successful for the HB technique, with beak lengths 14, 31, and 39% shorter than the control. IF trimming, (H or I) resulted in beak lengths that were 30-36% shorter than the control treatment regardless of attempted severity. Behaviour was monitored via scan sampling on 8 occasions between 0 and 55 wks. Evidence of pain at 1d post-treatment in the HB method was supported by a significant decrease in running and litter pecking, as well as a numerical decrease in walking, preening and an increase in resting behaviour. Behaviour was unaffected by IF (H or I) methods at 1 d of age except for a reduction in preening for the IF-I treated chicks, suggesting reduced or a lack of pain. Beyond minor effects of IF treatment after beak sloughing, behavioural effects of treatments in all experiments from 1 to 16 wks were primarily restricted an increase in object pecking in IF-I and HB-H treated birds.

Treatment impacted a number of behaviours during the laying period but in many cases, the effects were not consistent for treatment or treatment severity. In general, untreated birds expressed more aggressive pecking and feather pulling during laying and in particular at 21 wks. Treated birds tended to object peck more often than control hens. Treatment effects on H:L ratios and tonic immobility were mostly insignificant. Feather plumage was superior for treated birds compared to C hens in all experiments. In conclusion, beak treatment affects bird behaviour, which serves as a useful tool to establish the impact of these procedures on bird welfare.

Key Words: beak trimming, infrared, hot-blade, behaviour, welfare

4.2 Introduction

Beak trimming (beak treatment) has been practiced in the poultry industry for nearly a century (Kennard, 1937) in order to improve the welfare and productivity of birds. It has done so by reducing the occurrence of aggressive feather pecking and cannibalism. Although this process was once believed to be a painless procedure as the beak was perceived to lack nerves (Kennard, 1937), it is now apparent that it is vastly innervated (Breward, 1984; Gentle, 1992). The primary method of beak trimming has traditionally used a hot cauterizing blade (hot-blade; HB) to shorten the beaks of birds at variable ages. Therefore, with the use of hot-blade trimming, any amount of beak trimming should be perceived as a painful procedure (Breward, 1984; Breward and Gentle, 1985; Gentle, 1986).

Pain as a result of HB trimming can occur in three phases: painless, acute, and chronic (Cheng, 2005). Immediately following insult, the bird enters a painless phase that can last up to 24 hours post-treatment (Gentle, 1991; Cho, 2008). Following the painless phase, birds experience an acute pain phase, which lasts the length of the healing process, typically days to weeks (Gentle, 1986; 1991). Finally, if beaks are improperly trimmed (too severely or at an older bird age) pain can enter the chronic phase. Chronic pain is defined as pain which outlasts the healing process (Gentle, 1991; Cheng, 2005) and is usually due to the presence of neuromas (Gentle et al., 1997a; Kuenzel, 2007). Neuromas are bundles of severed nerve endings that send out sprouts that spontaneously fire causing extensive pain. An increased prevalence for neuroma formation and chronic pain is found if beaks are more severely trimmed at a later age (Eskeland, 1981; Gentle, 1986, 1991; Marchant-Forde et al., 2008). Animal welfare activists believe beak trimming is a mutilation or amputation and must be omitted in production for the protection of the birds (Potzsch et al., 2001). As a result, some jurisdictions are considering or have banned this management technique.

Genetic selection for more docile strains is considered an alternative to beak trimming (Craig and Muir, 1991; 1996), but it has not eliminated cannibalism in all settings (Hester, 2005). If birds are trimmed properly by skilled individuals and at a young age, neuroma formation, and chronic pain is absent or less prevalent (Breward and Gentle, 1985; Gentle et al., 1990; Gentle, 1991). The open wound and sudden change in beak morphology associated with the HB technique contributes to acute pain and stress immediately post-trimming. However, an alternate technique, infrared treatment, has been shown to improve the well-being of birds. After treatment at day of hatch, beak tissue gradually sloughs off within 7 to 10 days, which enables chicks to retain use of their beaks for the first few days of life (Glatz, 2005b; Marchant-Forde et. al., 2008). It also protects the beak until it has an opportunity to heal prior to loss of the proximally treated portion of the beak. The status of pain phases associated with infrared trimming is not as well understood as for HB trimming. However, Gentle and McKeegan (2007) found few behavioural changes following IF treatment suggesting a lack of pain post-treatment. Improved feather condition and a lack of negative effects on immune function, egg production and body weight in IF treated birds when compared to HB treated has also been reported (Dennis et al., 2009).

The bird welfare implications of management techniques play an important role in technique adoption by the poultry industry and also acceptance by consumers of poultry products. Monitoring behavioural, physical, and physiological responses to such techniques provides a better understanding of what the bird is experiencing. The objective of this study was to use behaviour, feather condition, heterophil : lymphocyte ratio and tonic immobility to assess the welfare implications of variable degrees of beak shortening using infrared and HB treatment methods.

4.3 Materials and Methods

4.3.1 Experiments and Treatments

Three experiments were conducted to examine the impact of different severities of beak trimming in day-old White Leghorn pullets. Each experiment involved a different commercial hatchery, a different White Leghorn strain and a different treatment technique to affect beak length. In each experiment, the objective was to remove 20, 40 or 60% of the beak and then compare degree of trimming to an untreated control group. The experiments and treatments were as follows: 1) Experiment 1 - infrared treatment with severity varied by altering the guide-plate hole size (21, 23, 25; Unit defined by Nova-Tech Engineering Inc.) at a consistent energy intensity of 48 (Unit defined by Nova-Tech Engineering Inc.) for a duration of 57 seconds; 2) Experiment 2 - infrared treatment with severity varied through increasing infrared energy intensity (35, 45, or 55 for a duration of 57 seconds; guide-plate hole size - 25); and 3) Experiment 3 - hot-blade treatment with a 2 second cauterization period with severity that was varied by using different guide-plate hole sizes (4, 5 and 6 mm in diameter).

4.3.2 Birds and Management

Six hundred pullets from each experiment were raised on straw covered litter floor pens (2.3 x 2.0 m) until cage housing at 17 weeks of age. Experimental replications consisted of 50 bird pens and each treatment was replicated three times. Pullets were fed a mash-form chick starter from 0-6 wks, a pullet grower from 6-17 wks, a pre-lay diet from 17-19 wks and a laying hen diet for the remainder of the experiment on an *ad libitum* basis. Perches were introduced into pens at 3 wks of age. At 17 wks of age, pullets were moved to a conventional cage facility where they were randomly housed according to treatment. Pullets were housed 6 hens per cage (500cm^2/bird) and 2 cages were used per replication. Each treatment was replicated six times for the laying period, which lasted from 19 to 59 wks of age. The dimensions of the cages were 58.5 cm wide x 51.0 cm deep. The height of the cage measured 43.2 cm at the front and 39.4 cm at the rear of the cage. The grid size of the wire floor was 2.5 x 4.0 cm.

The brooding and rearing lighting program consisted of 23L:1D (20 lux) from 0-7 d of age, 21L:3D (10 lux) from 8-14 d of age, and 8L: 16D (2 lux) from 2-17 wk of age with incandescent light bulbs used as the light source. Lighting was dropped to 2 lux as feather pecking leading to cannibalism was noted in the control treatments in all strains at 4 weeks of age. Temperature at housing was 35°C, and was reduced to 22°C by 35d. Lights during the laying period were turned on at 05:45, simulating dawn until achieving 10 lux at 06:00. Lights began simulating dusk at 20:00 and achieved darkness by 20:15hr. Light for the remainder of the 14.5 hr day was maintained at 10 lux (06:00 - 20:00). Barn temperature during the laying period was approximately 20°C.

4.3.3 Data Collection

4.3.3.1 Behaviour Observations

Behaviour was observed at 24 hrs post-treatment, as well as at 1, 3, 4, 8 and16 wks of age during the brooding and rearing period, and 21, 38 and 55 wks of age during the laying period. Lights during both periods turned on at 06:00, with observations commencing at 08:00. Observations were completed in one day during the brooding and rearing phase and ran for three consecutive days during the production cycle in order to complete observations prior to feeding at 12:00. The entire pen (50 pullets) of the three replications were observed during the brooding and rearing stage, and the entire replication (12 birds) in four of the six replications for each experimental treatment were observed during the laying period by one observer. A white lab coat was worn by the observer for all observations, and movement in and out of the rooms was restricted during the observation period. Order of replication observation was randomly determined. A five-minute adjustment period was allowed prior to commencing one-minute scans for a period of 10 minutes. The number of birds displaying any of the behaviours listed on

Table 2.1 was recorded every 60 seconds (for a period of 10 minutes per replication observed) and subsequently transformed to a percentage of birds within the group.

4.3.3.2 Heterophil : Lymphocyte Ratio

Blood (2 mL) was collected from 36 birds per treatment at 25 and 55 wks of age. Blood samples were derived from the brachial vein and collected into vacutainers containing EDTA. Vials were agitated immediately after sample collection to ensure the EDTA mixed with the blood sample to prevent coagulation. Samples were refrigerated and smeared on slides the following day. The smears were air-dried and then a Wright-Giesma stain was applied. Heterophil to lymphocyte ratio was attained by counting 100 granulocytes on the smeared and stained slide. Out of those 100 cells, the ratio of heterophils to lymphocytes was calculated (Gross and Siegel, 1983).

4.3.3.3 Tonic Immobility

Tonic immobility was determined at 27 and 57 wks of age. A modification of the technique used by Jones and Faure (1981) was used for this trial. One hen from each replication was randomly selected and placed on its back on a wooden cradle with its legs extending from the cradle. Pressure was placed on the hen's breast and a hand covered the head for a ten-second induction period. Following the ten second period, pressure was released and the latency for the hen to 'right' itself was recorded. If the hen righted itself in ten seconds or less, the procedure was repeated (Zulkifli et al., 2000). Hens were allowed three attempts to be induced. If hens failed to be induced after three attempts, birds were allotted a score of 0 (Zulkifli et al., 2000). The maximum potential score was 600 seconds or ten minutes per bird (Campo and Carnicer, 1993; Zulkifli et al., 2000).

4.3.3.4 Feather Score

Feather condition scoring was recorded at 38 and 57 wks of age. Two independently working individuals scored all birds in the experiment and values were averaged for statistical analysis. Five body areas (breast, wings, vent, back, neck) were scored on a scale derived from Davami et al. (1987). Scores ranged from 1 to 4, 1 having poor to no plumage, and 4 being fully feathered. Scores were totalled to attain an overall feather score.

4.4 Statistical Analysis

Statistical analyses were performed on each experiment (completely randomized design) using the ANOVA general linear model procedure of SAS (SAS 9.1, 2002). All data was tested for normality of distribution utilizing the Proc Univariate procedure. Data that failed to follow a normal distribution (behaviour, mortality, tonic immobility) were normalized using a log + 1 transformation prior to analysis. Duncan's multiple range test was used to separate the means when the ANOVA proved significant. Unless otherwise noted, level of significance was defined as $P \leq 0.05$.

4.5 Results

4.5.1 Beak Length

Beak treatment in all three experiments reduced beak length in comparison to the beaks of untreated control birds. However, the objective of affecting the degree of beak shortening was only accomplished for HB trimming (Experiment 3). HB trimming results approached the 20, 40 and 60% beak shortening goals immediately post-trimming and resulted in 14, 31 and 39% shorter beaks for these treatments based on measurements taken from 11 wks of age to trial end. Infrared treatment (Experiments 1 and 2) failed to alter degree of beak shortening and resulted in beak lengths approximately 30 to 36% shorter than the intact beaks of the control treatment at or after 11 wks of age. Details of treatment effects on beak length are reported in Chapter 3 (Table 3.1).

4.5.2 Bird Behaviour

Behavioural observations in this research are extensive and include data collection from the day after beak treatment to near the end of the laying period (Tables 4.1 to 4.9). Data for low incidence behavioural expression (<1.0%) were not included in tables because of space and the questionable interpretation value of statistical analysis completed on values that are close to zero. Data from all three experiments are presented in each table for comparison purposes. Although comparisons across experiments cannot be made statistically because of the confounding effects of hen strain and hatchery, comparing results does demonstrate trial-to-trial variation. Replications from all experiments were randomly assigned to pens/cages in brooding and rearing as well as laying facilities.

Table 4.1 Effect of beak shortening technique and severity of treatment on pullet behaviour 1 d post-treatment (% of time exhibited)[4]

	Exp. 1 Infrared treatment (H)[1]					Exp. 2 Infrared treatment (I)[1]					Exp. 3 Hot-blade (H)[1]				
Behaviour	C[2]	20	40	60	SEM	C	20	40	60	SEM	C	20	40	60	SEM
Rest	0.27	1.20	0.13	0.60	-	9.76	11.06	8.37	9.07	-	10.93	23.27	13.81	47.21	-
Stand	80.80	85.77	76.12	81.40	-	60.51	62.73	65.65	66.58	-	53.60	63.67	67.24	39.98	-
Walk	1.48	1.63	1.46	2.14	-	3.82	3.66	6.87	4.90	-	4.07	1.87	1.90	1.60	-
Run	2.12	0.86	0.53	0.87	-	2.53	2.03	2.52	1.95	-	1.27[a]	0.20[b]	0.34[b]	0.07[b]	-
Eat	7.07	4.33	13.47	2.93	-	1.00	5.77	4.22	3.47	-	15.55	5.53	10.10	8.07	-
Drink	0.13	0.87	0.40	0.33	-	6.14	5.66	3.61	5.23	-	1.27	3.07	1.73	1.27	-
Object P.[3]	0	0	0.51	0.13	-	2.41	0.84	0.88	0.95	-	0.27	0.80	0.34	0.53	-
Feather P.	0.13	0.07	0.07	0.07	-	0.81	0.51	1.22	0.61	-	0.27	0.13	0.61	0.20	-
Aggressive P.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Litter P.	5.51	3.80	5.57	7.98	-	2.94	3.03	4.69	4.56	-	11.00[a]	0.67[b]	1.71[b]	0.34[b]	-
Preen	2.22	1.42	1.74	3.28	-	9.84[a]	4.60[ab]	1.84[b]	2.42[b]	-	2.13	0.60	1.88	0.60	-

[a,b] Means within a row and experiment with the different superscript letters are significantly different ($P < 0.05$).
[1] Degree of beak shortening attempted using different plate-hole (H) sizes or infrared energy intensity (I).
[2] C – untreated control; 20 –targeted percent beak removal; 40 – targeted percent beak removal; 60 – targeted percent beak removal.
[3] P – peck.
[4] Data presented are actual data. Data were transformed prior to analysis and separation of means is based on transformed data. SEM not presented as does not relate to actual data.

Table 4.2 Effect of beak shortening technique and severity of treatment on pullet behaviour 1 week post-treatment (% of time exhibited)[4]

	Exp. 1 Infrared treatment (H)[1]					Exp. 2 Infrared treatment (I)[1]					Exp. 3 Hot-blade (H)[1]				
Behaviour	C[2]	20	40	60	SEM	C	20	40	60	SEM	C	20	40	60	SEM
Rest	51.66	20.78	24.53	34.69	-	39.77	40.68	35.47	39.55	-	13.06	16.74	16.44	12.09	-
Stand	10.63	22.02	22.11	14.92	-	17.84	16.07	19.31	8.91	-	29.00	24.10	32080	29.27	-
Walk	5.31	7.81	9.06	8.03	-	7.24	6.09	6.59	7.99	-	6.67	6.74	5.59	6.38	-
Run	0.88^{b}	8.41^{a}	2.60^{ab}	1.91^{b}	-	2.00	2.14	2.56	7.74	-	3.02	1.25	1.77	1.74	-
Eat	13.14	13.36	9.66	15.40	-	11.34^{a}	8.68^{ab}	5.37^{c}	6.78^{bc}	-	11.21	9.72	8.64	8.38	-
Drink	2.03	3.72	3.88	3.55	-	2.96	2.88	4.30	2.98	-	1.73	2.99	1.73	1.96	-
Object P.[3]	1.29	3.37	5.16	2.96	-	0.69	3.41	3.33	2.84	-	2.19	2.57	6.43	7.82	-
Feather P.	0.34	0.68	0.96	0.70	-	0.69	0.70	1.10	0.79	-	0.64	0.97	1.75	1.89	-
Aggressive P.	0	0	0	0.14	-	0	0	0	0.16	-	0	0	0	0	-
Litter P.	8.63	10.32	12.95	9.49	-	12.98	14.03	14.23	15.51	-	23.85	25.35	14.27	22.08	-
Preen	5.37	7.29	7.59	6.76	-	3.11^{b}	4.06^{ab}	6.24^{a}	6.06^{a}	-	8.32	7.08	8.93	6.98	-

^{a,b,c} Means within a row and experiment with the different superscript letters are significantly different ($P < 0.05$).

[1] Degree of beak shortening attempted using different plate-hole (H) sizes or infrared energy intensity (I).

[2] C – untreated control; 20 –targeted percent beak removal; 40 – targeted percent beak removal; 60 – targeted percent beak removal.

[3] P – peck.

[4] Data presented are actual data. Data were transformed prior to analysis and separation of means is based on transformed data. SEM not presented as does not relate to actual data.

Table 4.3 Effect of beak shortening technique and severity of treatment on pullet behaviour 3 weeks post-treatment (% of time exhibited)[5]

	Exp. 1 Infrared treatment (H)[1]					Exp. 2 Infrared treatment (I)[1]					Exp. 3 Hot-blade (H)[1]				
Behaviour	C[2]	20	40	60	SEM	C	20	40	60	SEM	C	20	40	60	SEM
Rest	1.21	3.67	3.18	1.69	-	7.60	2.80	4.97	4.53	-	3.79	4.86	6.91	4.73	-
Stand	14.13	26.78	25.95	26.96	-	29.23	27.68	34.63	34.45	-	24.32	31.16	28.60	28.24	-
Walk	17.70[a]	6.55[b]	6.42[b]	7.51[b]	-	8.09	9.53	6.96	7.20	-	8.08	7.39	7.84	7.60	-
Run	5.21	2.39	1.97	1.75	-	1.98[b]	5.94[a]	1.45[b]	2.90[b]	-	3.48	1.67	1.96	2.25	-
Eat	12.48	11.49	9.71	10.98	-	13.31	12.94	8.87	10.09	-	14.16	11.59	10.98	8.41	-
Drink	2.20	2.81	2.03	3.11	-	3.37	3.50	2.23	2.89	-	3.28	3.12	1.77	2.42	-
Object P.[3]	0.85	3.51	4.59	1.04	-	2.17[b]	8.01[a]	7.83[a]	7.86[a]	-	2.17	3.19	3.91	5.85	-
Feather P.	24.52	6.31	11.37	11.77	-	2.39	1.71	5.51	3.24	-	5.42	3.12	5.39	11.16	-
Aggressive P.	0.57	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Litter P.	15.64	31.05	28.49	26.98	-	22.54	21.00	19.71	20.82	-	26.46	25.44	23.07	22.40	-
Perch[4]	0	0	0	0	0	0	0	0	0	0	0.92	0.87	0.59	0.51	-
Preen	4.58	4.72	5.89	7.78	-	8.16	6.10	6.86	4.88	-	7.02	6.59	8.32	5.49	-

[a,b] Means within a row and experiment with the different superscript letters are significantly different ($P < 0.05$).
[1] Degree of beak shortening attempted using different plate-hole (H) sizes or infrared energy intensity (I).
[2] C – untreated control; 20 –targeted percent beak removal; 40 – targeted percent beak removal; 60 – targeted percent beak removal.
[3] P – peck.
[4] Birds were perching on water lines.
[5] Data presented are actual data. Data were transformed prior to analysis and separation of means is based on transformed data. SEM not presented as does not relate to actual data.

Table 4.4 Effect of beak shortening technique and severity of treatment on pullet behaviour 4 weeks post-treatment (% of time exhibited)[5]

	Exp. 1 Infrared treatment (H)[1]					Exp. 2 Infrared treatment (I)[1]					Exp. 3 Hot-blade (H)[1]				
Behaviour	C[2]	20	40	60	SEM	C	20	40	60	SEM	C	20	40	60	SEM
Rest	0.65	0.87	1.42	1.44	-	9.35	6.47	10.67	5.69	-	4.66	7.11	7.30	1.88	-
Stand	42.21	33.05	32.51	37.85	-	29.92	30.19	31.13	24.95	-	21.60	38.44	32.00	33.05	-
Walk	7.01	5.38	5.44	4.13	-	8.96	6.36	7.24	10.39	-	9.38	10.22	8.46	10.13	-
Run	0.07	0.22	0.30	0.08	-	4.83	1.16	2.36	1.71	-	4.44	1.70	1.34	1.50	-
Eat	11.55	12.10	14.77	12.17	-	10.49	11.25	10.10	10.47	-	13.88	9.11	10.40	9.84	-
Drink	2.33^{a}	2.88^{a}	1.12^{b}	2.04^{ab}	-	3.03	3.39	2.71	2.82	-	2.64	2.44	3.17	2.52	-
Object P.[3]	0	0.94	0.45	0.16	-	1.34^{c}	9.18^{a}	4.55^{b}	9.08^{a}	-	1.79	1.85	3.62	5.12	-
Feather P.	18.54	10.62	8.97	14.64	-	3.71	2.19	5.51	3.37	-	11.66	5.19	11.47	10.99	-
Aggressive P.	0	0	0	0	0	0	0	0.31	0	-	0.16	0	0	0	-
Litter P.	13.87	29.87	29.49	23.81	-	16.89	20.78	16.32	19.38	-	22.16	16.07	12.78	19.31	-
Perch[4]	0.65	0.22	1.64	0.23	-	1.12	0.16	0.52	0.69	-	0.23	0	0.37	0.30	-
Preen	2.47	3.59	3.50	3.15	-	9.19	8.11	7.49	10.77	-	8.66	6.82	8.49	4.55	-

[a,b,c] Means within a row and experiment with the different superscript letters are significantly different ($P < 0.05$).
[1] Degree of beak shortening attempted using different plate-hole (H) sizes or infrared energy intensity (I).
[2] C – untreated control; 20 –targeted percent beak removal; 40 – targeted percent beak removal; 60 – targeted percent beak removal.
[3] P – peck.
[4] Perches were introduced at 4 weeks of age.
[5] Data presented are actual data. Data were transformed prior to analysis and separation of means is based on transformed data. SEM not presented as does not relate to actual data.

Table 4.5 Effect of beak shortening technique and severity of treatment on pullet behaviour 8 weeks post-treatment (% of time exhibited)[4]

	Exp. 1 Infrared treatment (H)[1]					Exp. 2 Infrared treatment (I)[1]					Exp. 3 Hot-blade (H)[1]				
Behaviour	C[2]	20	40	60	SEM	C	20	40	60	SEM	C	20	40	60	SEM
Rest	8.30	9.38	6.85	8.26	-	1.32	2.08	0.53	0.27	-	2.16	5.48	1.32	5.70	-
Stand	52.01	44.97	46.38	50.05	-	60.50	57.24	65.05	50.49	-	48.93	58.10	60.29	54.85	-
Walk	3.31	2.48	4.59	2.79	-	2.54	2.13	4.19	4.23	-	2.08	1.87	0.94	2.48	-
Run	0.61	0.30	0.15	0.16	-	0.87	0.08	0.45	0	-	0.40	0.24	0.16	0.15	-
Eat	6.47	6.80	11.36	11.36	-	6.48	11.63	7.40	7.79	-	8.61	6.23	5.13	6.75	-
Drink	3.03	4.67	2.94	2.95	-	2.64	1.87	1.04	3.14	-	2.83	2.60	1.71	1.84	-
Object P.[3]	0.54	2.80	2.67	1.66	-	0.69	0.77	1.75	1.17	-	0	0.39	0.54	0.88	-
Feather P.	9.29	10.21	7.29	6.03	-	1.16	1.87	0.80	0.81	-	1.53	1.33	4.00	5.44	-
Aggressive P.	0	0	0	0	0	0.54	0.72	0.85	0.09	-	0.96	0.47	0.41	0.85	-
Litter P.	8.55	10.57	10.93	9.19	-	16.61	15.84	12.23	26.20	-	23.25	15.52	17.37	12.58	-
Perch	1.30	0.98	2.11	0.63	-	2.63	1.55	2.90	2.87	-	5.54	2.72	2.20	2.12	-
Preen	5.61	5.64	3.16	5.82	-	3.18	3.10	2.20	1.96	-	2.68	4.76	4.64	4.35	-

[1] Degree of beak shortening attempted using different plate-hole (H) sizes or infrared energy intensity (I).
[2] C – untreated control; 20 –targeted percent beak removal; 40 – targeted percent beak removal; 60 – targeted percent beak removal.
[3] P – peck.
[4] Data presented are actual data. Data were transformed prior to analysis and separation of means is based on transformed data. SEM not presented as does not relate to actual data.

Table 4.6 Effect of beak shortening technique and severity of treatment on pullet behaviour 16 weeks post-treatment (% of time exhibited)[4]

Behaviour	Exp. 1 Infrared treatment (H)[1]					Exp. 2 Infrared treatment (I)[1]					Exp. 3 Hot-blade (H)[1]				
	C[2]	20	40	60	SEM	C	20	40	60	SEM	C	20	40	60	SEM
Rest	0.56	0.54	0.73	1.01	-	2.93	5.42	3.32	3.44	-	2.46	1.49	3.70	1.84	-
Stand	66.21	58.73	62.60	67.26	-	48.20	50.35	52.57	47.08	-	51.89	56.48	55.41	57.21	-
Walk	4.31	3.79	3.06	3.92	-	3.60	4.91	6.17	3.02	-	3.27	4.03	4.53	5.03	-
Run	0.40	0.55	0.80	1.26	-	1.23	0.50	1.06	1.14	-	0.34	0.66	0.68	0.98	-
Eat	4.19	8.67	8.07	3.81	-	4.89	6.27	7.20	5.19	-	4.19	3.86	5.13	5.38	-
Drink	3.58	3.94	2.83	3.19	-	2.99	2.48	2.40	2.54	-	2.92	2.37	2.85	0.87	-
Object P.[3]	0.71	1.41	1.31	0.24	-	1.06	2.17	1.67	1.70	-	1.94^{b}	2.21^{b}	3.11^{b}	6.52^{a}	-
Feather P.	3.50	3.24	2.25	2.44	-	3.29	1.30	1.18	2.46	-	4.03	4.02	1.76	2.63	-
Aggressive P.	0.32	0.08	0.16	0.16	-	2.95	1.02	1.39	1.81	-	2.50	1.15	0.84	0.25	-
Litter P.	8.96	11.34	9.21	9.32	-	10.89	11.86	7.22	11.04	-	10.01	6.81	8.84	8.79	-
Perch	2.23	3.08	3.53	2.95	-	8.11	3.06	4.55	5.49	-	7.75	8.29	4.78	4.75	-
Preen	4.08	3.93	4.73	3.71	-	7.34	9.50	8.35	12.73	-	6.33	7.02	7.80	5.12	-

[a,b] Means within a row and experiment with the different superscript letters are significantly different ($P < 0.05$).
[1] Degree of beak shortening attempted using different plate-hole (H) sizes or infrared energy intensity (I).
[2] C – untreated control; 20 –targeted percent beak removal; 40 – targeted percent beak removal; 60 – targeted percent beak removal.
[3] P – peck.
[4] Data presented are actual data. Data were transformed prior to analysis and separation of means is based on transformed data. SEM not presented as does not relate to actual data.

Table 4.7 Effect of beak shortening technique and severity of treatment on pullet behaviour 21 weeks post-treatment (% of time exhibited)[4]

	Exp. 1 Infrared treatment (H)[1]					Exp. 2 Infrared treatment (I)[1]					Exp. 3 Hot-blade (H)[1]				
Behaviour	C[2]	20	40	60	SEM	C	20	40	60	SEM	C	20	40	60	SEM
Rest	4.17^{c}	8.33^{b}	6.67^{b}	11.88^{a}	-	14.79^{a}	8.13^{b}	13.23^{a}	12.40^{a}	-	8.23	11.46	7.92	9.38	-
Stand	32.71^{b}	33.44^{b}	44.69^{a}	40.00^{a}	-	21.35^{b}	29.69^{a}	31.15^{a}	28.96^{a}	-	38.02^{a}	26.46^{b}	30.10^{b}	31.88^{b}	-
Eat	22.92	18.23	21.25	21.67	-	12.60^{b}	19.48^{a}	18.75^{a}	20.31^{a}	-	17.40	15.63	18.85	18.96	-
Drink	5.10^{ab}	4.79^{ab}	6.35^{b}	3.44^{b}	-	10.21	10.21	9.69	8.02	-	10.94^{ab}	12.60^{a}	7.60^{c}	8.96^{bc}	-
Object P	0.73^{b}	1.15^{b}	3.13^{a}	2.71^{a}	-	1.15	0.63	0.73	1.46	-	0.10^{c}	0.83^{bc}	1.88^{a}	1.77^{ab}	-
Aggressive P.	1.35^{a}	0.10^{b}	0.00^{b}	0.10^{b}	-	0.73	0.52	0.42	0.31	-	1.67^{a}	1.46^{a}	0.21^{b}	0.21^{b}	-
Feather P.	11.25^{a}	10.42^{a}	4.69^{b}	6.25^{b}	-	11.15^{a}	4.69^{b}	4.90^{b}	4.17^{b}	-	12.29	10.31	10.31	12.92	-
Feather pull	1.35^{a}	0.31^{b}	0.31^{b}	0.31^{b}	-	0.63^{a}	0.52^{a}	0.00^{b}	0.00^{b}	-	0.63	0.31	0.83	0.42	-
Preen	19.48^{a}	20.94^{a}	12.29^{b}	12.81^{b}	-	25.52	23.75	20.63	22.19	-	7.92^{c}	15.94^{ab}	18.54^{a}	14.06^{b}	-

[a,b,c] Means within a row and experiment with the different superscript letters are significantly different ($P < 0.05$).
[1] Degree of beak shortening attempted using different plate-hole (H) sizes or infrared energy intensity (I).
[2] C – untreated control; 20 –targeted percent beak removal; 40 – targeted percent beak removal; 60 – targeted percent beak removal.
[3] P. – peck.
[4] Data presented are actual data. Data were transformed prior to analysis and separation of means is based on transformed data. SEM not presented as does not relate to actual data.

Table 4.8 Effect of beak shortening technique and severity of treatment on pullet behaviour 38 weeks post-treatment (% of time exhibited)[4]

	Exp. 1 Infrared treatment (H)[1]					Exp. 2 Infrared treatment (I)[1]					Exp. 3 Hot-blade (H)[1]				
Behaviour	C[2]	20	40	60	SEM	C	20	40	60	SEM	C	20	40	60	SEM
Rest	1.35^{b}	4.69^{a}	5.57^{a}	4.17^{a}	-	15.45^{a}	13.96^{a}	13.44^{ab}	10.58^{b}	-	12.90^{a}	5.06^{b}	3.75^{b}	5.84^{b}	-
Stand	62.06^{a}	49.58^{bc}	45.73^{c}	54.58^{b}	-	30.01^{c}	40.10^{b}	48.75^{a}	35.65^{bc}	-	41.60^{c}	49.01^{b}	42.26^{c}	68.56^{a}	-
Eat	6.62^{c}	12.29^{b}	22.21^{a}	16.04^{b}	-	26.60^{a}	26.98^{a}	10.63^{b}	24.36^{a}	-	13.49^{c}	20.67^{b}	30.10^{a}	7.85^{d}	-
Drink	16.89^{a}	6.56^{bc}	7.47^{b}	3.85^{c}	-	5.81^{ab}	3.96^{bc}	2.19^{c}	6.78^{a}	-	8.93^{b}	6.53^{bc}	13.83^{a}	4.21^{c}	-
Object P.	4.07^{c}	11.04^{a}	5.10^{bc}	7.29^{b}	-	6.43^{c}	6.56^{c}	9.79^{b}	12.75^{a}	-	3.13^{c}	9.60^{a}	2.44^{c}	6.19^{b}	-
Aggressive P.	0.10	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	-	0.00	0.21	0.10	0.00	-
Feather P.	1.90^{b}	4.48^{a}	2.82^{ab}	3.44^{ab}	-	1.81	0.83	1.15	1.56	-	4.50^{a}	1.94^{b}	1.47^{b}	1.81^{b}	-
Feather pull	0.00	0.42	0.31	0.10	-	0.13	0.00	0.00	0.00	-	0.25	0.00	0.00	0.00	-
Preen	3.07^{b}	9.06^{a}	8.86^{a}	8.96^{a}	-	10.85^{a}	5.83^{b}	12.81^{a}	7.38^{b}	-	13.56^{a}	6.03^{b}	3.72^{b}	4.24^{b}	-

[a,b,c] Means within a row and experiment with the different superscript letters are significantly different ($P < 0.05$).
[1] Degree of beak shortening attempted using different plate-hole (H) sizes or infrared energy intensity (I).
[2] C – untreated control; 20 –targeted percent beak removal; 40 – targeted percent beak removal; 60 – targeted percent beak removal.
[3] P. – peck.
[4] Data presented are actual data. Data were transformed prior to analysis and separation of means is based on transformed data. SEM not presented as does not relate to actual data.

Table 4.9 Effect of beak shortening technique and severity of treatment on pullet behaviour 55 weeks post-treatment (% of time exhibited)[4]

Behaviour	Exp. 1 Infrared treatment (H)[1]					Exp. 2 Infrared treatment (I)[1]					Exp. 3 Hot-blade (H)[1]				
	C[2]	20	40	60	SEM	C	20	40	60	SEM	C	20	40	60	SEM
Rest	1.59^{c}	1.88^{c}	4.89^{b}	8.25^{a}	-	10.22	14.76	8.90	10.83	-	5.31^{b}	6.21^{b}	11.05^{a}	6.42^{b}	-
Stand	71.87^{a}	66.08^{b}	59.81^{c}	56.71^{c}	-	51.03^{c}	52.97^{c}	58.46^{b}	65.93^{a}	-	61.96	56.96	60.16	53.83	-
Eat	11.16	13.52	13.25	10.77	-	13.73^{a}	14.96^{a}	13.73^{a}	4.84^{b}	-	10.57^{b}	12.54^{ab}	14.53^{ab}	15.42^{a}	-
Drink	9.48^{a}	8.20^{a}	10.83^{a}	4.59^{b}	-	9.46^{a}	4.74^{b}	4.10^{b}	4.76^{b}	-	13.10^{a}	8.23^{b}	2.49^{c}	3.44^{c}	-
Object P.	1.14^{b}	2.61^{a}	1.52^{ab}	1.06^{b}	-	3.54^{ab}	2.23^{b}	4.23^{a}	4.72^{a}	-	0.58^{bc}	0.42^{c}	2.23^{a}	1.57^{ab}	-
Aggressive P.	0.42	0.00	0.35	0.00	-	0.11	0.00	0.25	0.00	-	0.46^{a}	0.00^{b}	0.00^{b}	0.00^{b}	-
Feather P.	2.01^{b}	2.48^{b}	2.33^{b}	5.72^{a}	-	2.10^{b}	2.01^{b}	1.37^{b}	3.69^{a}	-	1.81	1.37	1.56	3.09	-
Feather pull	0.21	0.10	0.11	0.23	-	0.00	0.00	0.00	0.11	-	0.63^{a}	0.42^{ab}	0.00^{b}	0.00^{b}	-
Preen	0.56^{c}	1.93^{bc}	3.68^{b}	9.26^{a}	-	8.79^{a}	4.98^{bc}	7.11^{ab}	3.94^{c}	-	3.40^{c}	11.77^{a}	6.05^{b}	12.87^{a}	-

[a,b,c] Means within a row and experiment with the different superscript letters are significantly different ($P < 0.05$).
[1] Degree of beak shortening attempted using different plate-hole (H) sizes or infrared energy intensity (I).
[2] C – untreated control; 20 –targeted percent beak removal; 40 – targeted percent beak removal; 60 – targeted percent beak removal.
[3] P – peck.
[4] Data presented are actual data. Data were transformed prior to analysis and separation of means is based on transformed data. SEM not presented as does not relate to actual data.

4.5.2.1 Behaviour 1 d Post-Treatment (Table 4.1)

Infrared beak treatment with attempted modification of beak length using guide-plate-hole size or infrared intensity had minor effects on bird behaviour a day after treatment (Table 4.1). The only statistically significant effect was a reduction in preening behaviour for the 40% and 60% IF-I treated birds. The 20% treatment, had the same beak length, as discussed above, but the preening value for this group was intermediate between the control and other IF treatments. The pullets from Experiment 1 (IF-H treatments) stand out as having a low level of resting compared to birds in the other experiments. Combined with a high level of standing, this would indicate that these birds did not settle in the allotted 5-minute time frame prior to commencing behaviour observations. There are large differences between severities for eating and object pecking in the IF-I experiment. However, none of differences are significant, or follow clear trends.

Hot-blade beak trimming did affect day-old chick behaviour with a reduction in running and litter pecking for all three trimmed treatments; severity of trim did not affect the degree of response. Preening was also reduced in the trimmed chicks but the effect only approached significance (P=0.06). A non-significant reduction in walking (P=0.23) may indicate that HB trimming has the potential to reduce activity at 1-d post treatment. This is counterbalanced with a non-significant increase in resting (P=0.21) for the three trimmed groups in this experiment.

4.5.2.2 Behaviour 1 wk Post-Treatment (Table 4.2)

Despite large differences between treatments, the only behaviour affected by Experiment 1 (IF-H) treatments was running. In particular, the 20% severity running level was higher than for birds from the C and 60% treatments. Object pecking was noted to be numerically higher for treated birds of the IF experiments (IF-I – P=0.2553; IF-H – P=0.1599).

IF-I treatment (Experiment 2) resulted in a reduction in eating behaviour with the 40 and 60% severity levels being lower than for the C birds. The value for birds from 20% treatment was intermediate to the high and low extremes. The number of birds preening was higher for the 40 and 60% treatments compared to the C, and the 20% value was intermediate and not different from other treatments. Object pecking was noted to be numerically higher for treated birds (P=0.160).

In Experiment 3, HB treatment did not affect behavioural expression; however, a non-significant increase in object pecking with increasing severity of treatment was noted (P=0.2553).

4.5.2.3 Behaviour 3 wks Post-Treatment (Table 4.3)

The amount of walking for the IF-H treated chicks was reduced in comparison to the control birds. Although not significant, this is counterbalanced by a numeric increase in litter pecking for the same treatments. No other behavioural expression was affected by IF-H treatment. All IF-I treatments showed a significant increase in object pecking in comparison to the C treatment. Running behaviour was higher for the 20% severity birds than hens from any other treatment. No other behaviours were affected by treatment in Experiment 2. HB trimming did not affect 3 week behavioural expression.

4.5.2.4 Behaviour 4 wks Post-Treatment (Table 4.4)

Drinking behaviour was affected by Experiment 1 (IF-H) treatments. Drinking behaviour was reduced in the 40% IF-H treatment in comparison to birds from the 20% and C groups and the 60% birds displayed an intermediate expression. No other behaviours were affected by treatment. Pullets in all of the IF-I treatments in Experiment 2 performed more object pecking than the control birds. No treatment behavioural effects were noted in Experiment 3 (HB) but differences in resting (P=0.054), standing (P=0.050), eating (P=0.064) and preening (P=0.100) approached significance. The differences in resting did not follow a logical trend based on severity of trimming, making interpretation difficult, particularly since this was not seen at any other observation period except d 1. Standing was again counterbalanced to some extent with litter pecking and therefore, may be related to activity at that specific time point rather than activity in general. Feeding behaviour was numerically lower for all HB treated birds in comparison to those in the C treatment. The level of preening behaviour was also erratic in relationship to severity of trim, but it should be noted that the 60% treatment had the numerically lowest value.

4.5.2.5 Behaviour 8 wks Post-Treatment (Table 4.5)

No significant treatment effects on bird behaviour were noted for any of the three experiments.

4.5.2.6 Behaviour 16 wks Post-Treatment (Table 4.6)

The only significant treatment effect at 16 weeks of age occurred for object pecking in Experiment 3 (Table 4.6). Birds from the 60% HB treatment pecked more frequently at objects in comparison to pullets from the other treatment groups. In Experiment 1 (IF-H), the differences in object pecking among treatments approached significance (P=0.054).

4.5.2.7 Behaviour 21 wks Post-Treatment (Table 4.7)

Resting, standing and object pecking were higher for treated than non-treated hens in Experiment 1 (IF-H) with a tendency for higher values for increased treatment severity. In contrast, expression of aggressive pecking, feather pecking, feather pulling and preening were lower for treated birds, again with some tendency for this effect to be affected by treatment severity. Drinking behaviour was affected by treatment but did not show a clear trend.

In Experiment 2 (IF-I), the expressions of standing and eating were higher in treated birds while the expressions of feather pecking, feather pulling and preening were lower for these birds than the control hens. Treatment affected resting with the 20% treatment resting the least.

Hot-blade treatment (Experiment 3) reduced standing and aggressive pecking and increased object pecking and preening. Drinking was affected by treatment and tended to be lower for the more severe treatments (40 and 60%).

4.5.2.8 Behaviour 38 wks Post-Treatment (Table 4.8)

An increase in resting, eating, object pecking, feather pecking and preening, and decreases in standing and drinking were found for treated birds when compared to untreated birds in Experiment 1 (IF-H). In Experiment 2 (IF-I), standing was increased in treated birds in comparison to the control hens. An increase in object pecking and a decrease in resting were also found for treated hens, but for these behaviours the degree of response increased with severity of treatment. Significant treatment effects were found for eating and drinking behaviour, but differences did not follow clear trends. In Experiment 3, resting, feather pulling, and preening were lower for all treated birds in comparison to the control hens. The 20 and 60% treatment birds stood more and object pecked more than their counterparts in the C and 40% treatments. The treatment ranking for expression of drinking behaviour was 40% > C $\geq$ 20% $\geq$ 60%.

4.5.2.9 Behaviour 55 wks Post-Treatment (Table 4.9)

In Experiment 1, resting and preening increased and standing decreased for treated birds with the degree of response affected by treatment severity (Table 4.9). The 60% severity showed lower drinking behaviour, and higher feather pecking and feather pulling behaviour than the other treatments. Object pecking was affected by beak treatment with the highest level expressed by the 20% treatment.

Standing behaviour increased with severity of treatment in Experiment 2. Treated birds performed less drinking behaviour and preening in comparison to their untreated counterparts. Eating, litter pecking and feather pecking behaviour were affected by treatment but the differences were not accounted for by treatment or severity of treatment.

In the HB experiment, eating behaviour was higher in the 60% treatment compared to all other treatments and in general eating behaviour increased with severity of treatment. Similarly, the highest levels of object pecking were found in the 40 and 60% treatments. Preening behaviour was found at higher levels in all treated hens. Drinking, aggressive pecking and feather pulling behaviours were lower for treated in contrast to untreated birds. The 60% treated birds rested more than other treatments.

4.5.3 Heterophil : Lymphocyte (H:L) Ratio (Table 4.10)

No significance was noted in any of the three experiments for H:L ratios at 25 wks of age (Table 4.10). At 55 wks, the severe treatment in the IF-H method (Experiment 1) showed an increase in heterophil numbers, which resulted in a higher H:L ratio when compared to other treatments (P=0.0485). No significance was noted in either Experiment 2 or 3 at 55 wks of age.

4.5.4 Tonic Immobility (Table 4.10)

At 27 wks of age an increase in the length of tonic immobility was noted for birds in both 20 and 60% treatments in Experiment 2 (IF-I) in comparison to the untreated C hens (Table 4.10). However, no difference was noted between the 20, 40 and 60% treatments. Treatment did not affect tonic immobility in Experiments 1 and 3 at 27 wks of age. At 57 wks, treatment differences approached significance for the IF-I method (P=0.0578). No significance was noted in either the IF-H or HB methods at 57 weeks.

Table 4.10 Effect of beak shortening technique and severity of treatment on hen heterophil : lymphocyte ratio and tonic immobility

	Exp. 1 Infrared treatment (H)[1]					Exp. 2 Infrared treatment (I)[1]					Exp. 3 Hot-blade (H)[1]				
	C[2]	20	40	60	SEM	C	20	40	60	SEM	C	20	40	60	SEM
H:L ratio[3]															
25 wks	0.06	0.11	0.15	0.08	0.013	0.13	0.09	0.12	0.09	0.008	0.07	0.08	0.09	0.09	0.005
55 wks	0.07[b]	0.06[b]	0.08[ab]	0.10[a]	0.005	0.05	0.08	0.08	0.07	0.007	0.08	0.09	0.08	0.09	0.005
Tonic immobility (seconds)[4,5]															
27 wks	318	513	365	344	-	219[b]	461[a]	315[ab]	462[a]	-	380	401	318	257	-
57 wks	397	452	600	341	-	192	422	188	206	-	235	367	391	241	-

[a,b] Means within a row and experiment with the different superscript letters are significantly different ($P < 0.05$).
[1] Degree of beak shortening attempted using different plate-hole (H) sizes or infrared energy intensity (I).
[2] C – untreated control; 20 –targeted percent beak removal; 40 – targeted percent beak removal; 60 – targeted percent beak removal.
[3] Heterophil to Lymphocyte ratio (Gross and Siegel, 1983).
[4] Tonic Immobility (Jones and Faure, 1981).
[5] Data presented are actual data. Data were transformed prior to analysis and separation of means is based on transformed data. SEM not presented as does not relate to actual data.

4.5.5 Feather Condition (Table 4.10)

At 38 wks, feather condition was superior for treated birds in both IF-H and HB methods (Experiments 1 and 3) in comparison to their untreated counterparts (Table 4.10). No difference was noted between severities of treated birds for both IF-H and HB methods. Treatments in Experiment 2 (IF-I) did not result in differences in feather cover. At 57 wks, treated birds in all 3 experiments had better plumage cover than hens in their respective controls.

Table 4.11 Effect of beak shortening technique and severity of treatment on feather score at 38 and 57 wks

	Exp. 1 Infrared treatment (H)[1]					Exp. 2 Infrared treatment (I)[1]					Exp. 3 Hot-blade (H)[1]				
	C[2]	20	40	60	SEM	C	20	40	60	SEM	C	20	40	60	SEM
Feather score[3] 38 wks															
Neck	2.88	3.32	3.21	3.17	0.084	3.60	3.70	3.80	3.72	0.058	3.11[b]	3.74[a]	3.62[a]	3.52ab	0.086
Wings	3.50[c]	3.89[a]	3.64[bc]	3.86[ab]	0.048	3.82	3.96	3.95	3.96	0.29	3.80	3.98	3.93	3.95	0.026
Back	2.69[b]	3.54[a]	3.52[a]	3.49[a]	0.115	3.86	3.96	3.99	3.98	0.019	3.43[b]	3.95[a]	3.72[a]	3.91[a]	0.059
Vent	2.67[b]	3.75[a]	3.58[a]	3.38[a]	0.121	3.50	3.77	3.75	3.87	0.054	2.95[b]	3.65[a]	3.63[a]	3.69[a]	0.093
Breast	3.54	3.99	3.72	3.85	0.067	3.36	3.51	3.44	3.57	0.031	3.22[b]	3.56[a]	3.40[ab]	3.48[a]	0.047
Overall	15.28[b]	18.49[a]	17.66[a]	17.74[a]	0.369	18.15	18.90	18.93	19.10	0.166	16.52[b]	18.89[a]	18.30[a]	18.55[a]	0.270
Feather score 57 wks															
Neck	2.62	2.84	2.74	2.77	0.077	2.97[b]	3.11[b]	3.35[a]	3.33[a]	0.049	2.87[b]	3.25[a]	3.30[a]	3.34[a]	0.060
Wings	2.98[b]	3.63[a]	3.51[a]	3.63[a]	0.079	3.41[b]	3.63[ab]	3.77[a]	3.84[a]	0.053	3.29[b]	3.65[a]	3.60[a]	3.82[a]	0.057
Back	1.86[b]	3.08[a]	2.88[a]	2.80[a]	0.141	3.20[b]	3.70[a]	3.81[a]	3.87[a]	0.071	2.39[b]	3.38[a]	2.99[a]	3.34[a]	0.110
Vent	1.46[c]	2.74[a]	2.25[ab]	1.93[bc]	0.133	2.42[b]	2.86[ab]	2.99[a]	3.26[a]	0.099	1.78[b]	2.31[a]	2.28[ab]	2.51[a]	0.097
Breast	2.63[c]	3.75[a]	3.14[b]	3.46[ab]	0.116	3.05[b]	3.29[a]	3.41[a]	3.36[a]	0.040	2.57[b]	3.29[a]	3.19[a]	3.37[a]	0.083
Overall	11.56[b]	16.04[a]	14.51[a]	14.58[a]	0.463	15.05[b]	16.59[a]	17.33[a]	17.67[a]	0.273	12.89[b]	15.88[a]	15.37[a]	16.38[a]	0.356

[a,b,c] Means within a row and experiment with the different superscript letters are significantly different ($P < 0.05$).
[1] Degree of beak shortening attempted using different plate-hole (H) sizes or infrared energy intensity (I).
[2] C – untreated control; 20 –targeted percent beak removal; 40 – targeted percent beak removal; 60 – targeted percent beak removal.
[3] Feather score (Davami et al., 1987) 1- no feathering, 4- fully feathered

4.6 Discussion

Attempts to modify severity of beak shortening by infrared treatment were unsuccessful and may indicate the need for further research in this area if modification of beak length is desired. The failure to modify length is also related to reliance on hatchery managers to establish how that modification should occur. It is likely that was an unrealistic expectation. Identification and consultation with individuals having more experience in this area might have resulted in better success. Despite the fact that beak lengths for the infrared treated birds were essentially equal regardless of attempted beak shortening, data are presented with treatments separated. However, it is important to remember the similar beak length for all severities from an interpretation perspective.

Hot-blade trimming was successful in modifying beak length and therefore the impact of severity of trim can be judged in this research.

4.6.1 Acute Pain Post-Treatment

An accepted welfare issue related to HB beak trimming is acute pain post-treatment. The results in this research demonstrate behavioural trends for HB treated chicks 1-d after treatment. Behaviour changes included a significant decrease in running and litter pecking, yet a non-significant increase in resting and decrease in both walking and eating behaviours. Relevant to the objectives of this work, severity of HB trimming did not affect these behavioural responses. This research supports the findings of Marchant-Forde et al. (2008) who found inactivity in HB treated birds for the first 24 hrs post-treatment. Similarly, Breward and Gentle (1985) and Gentle et al. (1997a,b) found a reduction in activity, feeding, and preening up to seven d post-treatment. This acute change in behaviour is suggestive that the pullets are experiencing some degree of pain (Duncan et al., 1989; Craig and Lee, 1990). In contrast, Sandilands and Savory (2002) found no indications of pain up to one week post-treatment. In the current research, locomotive and consumptive behaviours returned to normal levels one wk post-treatment indicating some degree of healing had occurred and birds were either experiencing pain at a reduced level or were no longer experiencing pain. With the exception of object pecking, which will be discussed later, the degree of HB treatment failed to affect bird behaviour in a statistically meaningful way for the remainder of the brooding and rearing period.

The behaviour of birds undergoing IF treatment methods was affected differently than those undergoing HB treatment at 1-d post-treatment. No effect of treatment was found for Exp. 1 (IF-H) treatments and only the incidence of preening was affected for Exp. 2 (IF-I) experiment. This suggests that these birds are not experiencing the same degree of pain as the HB treated birds at 24 hrs post-treatment. Similarly, Gentle and McKeegan (2007) found no differences in the behaviour of broiler breeder chicks after IF treatment. Marchant-Forde et al. (2008) found a decrease in activity in IF treated birds (Exp 1 & 2) commencing 3 to 4 days post treatment after showing no effect from day 0 to day 2, which indicates these birds are not experiencing pain immediately post treatment. Changes in behaviour were noted for IF treated chicks later in the brooding period in the present research. In Experiment 2 (IF-I), treatment reduced feeding and increased preening behaviour at 7 days post-treatment. Since IF birds retain normal use of their beaks until sloughing begins (7-10 d post treatment), this may indicate a behavioural response to the loss of the necrotic beak tip and/or a change in beak sensation. Behaviourally, birds in Experiment 1 did not respond the same way as those in

Experiment 2, despite both groups being treated with IF. Only the level of running was affected by treatment at 1 wk post-treatment and since variation in running does not follow a logical trend (treated vs. control), interpretation is difficult. Although not significant, birds treated with IF in this experiment were numerically less active than birds in the control group. At 3 wks post treatment, IF-H trimmed birds walked less than the control birds. Counterbalancing this was a numeric increase in litter pecking for these treatments. How the change in the nature of activity relates to beak loss is not clear. Despite the changes in behaviour in close proximity to beak sloughing for the IF treated birds, it is not possible to equate this change to pain. Based on the histological indication of healing of beak tissue by this time (Chapter 3), an alternate explanation may be more probable. The process of beak loss may in itself change behaviour because of the change in tactile and other stimuli associated with a shorter beak.

4.6.2 Object Pecking

Object pecking, defined as pecking at environmental objects other than feed, water and feathers, was found to be affected by all beak treatments at some point during this research. In all cases, object pecking was found to increase in comparison to the untreated control birds. In addition to the times when this was statistically significant, the trend toward higher values for treated birds was similar at other ages as well. If one takes the average of object pecking from all data collection times from 1 to 55 wks of age in this research, the level of object pecking is higher for treated than control birds. In the case of IF-H treatment the overall means are 1.17, 3.35, 2.99 and 2.14%. For the IF-I experiment, the comparable values are 2.13, 4.12, 4.24 and 5.20% for the C, 20, 40 and 60%

treatments respectively. In the HB experiment a numerically linear relationship with severity of treatment is suggested by values of 1.49, 2.63, 3.02 and 4.47% for the C, 20, 40 and 60% treatments, respectively. Although the latter summarization method lacks statistical validity, it does increase the credibility of those times where differences were statistically significant and suggests that this is a true behavioural change associated with beak shortening. This behaviour is not clearly understood as by this point histology suggests that the beaks are healed. Marchant-Forde et al. (2008) found an increase in pecking behaviour being directed at the feeders in IF treated birds when compared to control birds. They attributed this to the altered morphology due to IF treatment of the beak as well as their reduced feeding ability (Gentle et al., 1982). They also found that HB treated birds displayed an intermediate yet not statistically different level of pecking to the IF and control birds. In the present research, object pecking was classified independently of feeding behaviour and therefore the increase in this behaviour is more likely related to beak morphology or sensation effects than to feeding behaviour.

4.6.3 Aggressive Behaviour

Aggressive pecking and feather pulling were considered indicative of aggressive behaviour and at 21 wks of age there was a general reduction in aggressive behaviour in birds with shortened beaks regardless of treatment. This is demonstrated by reduced aggressive pecking (Experiments 1 and 3) and feather pulling (Experiments 1 and 2). Levels of aggression at 38 and 55 wks of age tended to be low for all treatments, but the trend of reduced aggressiveness for beak shortened birds was again shown by lower aggressive pecking and feather pulling at 55 wks of age for HB treated birds. The finding of increased aggressiveness at 21 wks of age may relate to the fact that the birds had only been re-grouped and housed in the caged facility for 4 wks. Guhl and Allee (1944) found that when a change in flock members occurs, an increase in aggression results until the hierarchy is established. It should also be noted that birds are undergoing sexual maturity during the early laying period, thus hormonal changes may play a role in their behaviour. Newberry et al. (2002) found that between the period of light stimulation prior to cage housing and the onset of lay, an increase in aggression leading to cannibalism was prevalent.

Severity of treatment played a minor role in affecting aggressive behaviour in IF treated birds, but this is likely a reflection of the lack of differences in beak length. In contrast, severity of treatment did affect aggressive behaviour in HB treated hens (Experiment 3) where a significant decrease in aggressive behaviour at 21 wks was seen for both 40 and 60% treatments, but not for the 20% treatment. Similarly, feather pulling behaviour at 55 wks of age was not different for the 20% and control treatment birds. This raises the question as to whether the 20% treatment is severe enough to gain the full benefit of the beak treatment. It is noteworthy that cannibalism was recorded at a low level for the 20% treatment and none was seen for the 40 and 60% treatment severities (Chapter 3).

An overall conclusion is that birds with shortened beaks are less aggressive than those with intact or minimally treated beaks. This is considered a positive attribute and hypothesized to provide a less stressful environment for laying hens (Dennis et al., 2009).

4.6.4 Other Behaviours

A general observation of the results is that there is considerable variability associated with behavioural expression. Considerable effort was made to reduce the influence of outside factors on behavioural expression, but these could not be totally eliminated. It is also clear that bird strain had an important impact on behaviour including how quickly birds settled after observer entry into the research space. Further, social facilitation within an observation pen or cage also plays an important role in increasing the variability between replications within a treatment. This was particularly true during the brooding and rearing period. The consequence of the variability in behavioural expression is the lack of a significant effect even when mean values appear to be quite different between treatments.

Many significant differences in behavioural expression were identified during the laying period, but some of the differences were either not consistent from age to age or among experiments, or did not follow a logical trend based on treatment or treatment severity. Resting behaviour demonstrates within and amongst experiment variation in response to beak treatment. Resting behaviour for the Experiment 1 (IF-H) treated birds was increased at 21 and 38 wks of age and also increased in a linear fashion with the planned severity of treatment at 55 wks of age. This is a relatively consistent effect and suggests a true effect of treatment. The reason for this effect is unlikely to be pain since no effect of treatment was seen later in the rearing period. Instead, it is possible that treated birds rested more due to less cage aggression. However, resting in Experiment 2 (IF-I) treated birds does not follow a treatment or severity trend at 21 wks, shows a tendency to reduced resting with severity of treatment at 38 wks of age and does not show an effect at 55 wks. Although, these experiments cannot be directly compared, it does demonstrate that making generalizations based on one experiment using one type of treatment or strain of hens is not justified. Resting in the HB treated birds in Experiment 3 was not affected at 21 wks, was reduced at 38 wks and was not consistent at 55 wks of age. Interpretation of standing, eating and drinking behaviour is difficult because of similar variability.

Feather pecking behaviour was also affected by treatment during the laying period, with indications from all three experiments for a reduction in this behaviour in treated birds (Experiment 1 – 21 and 38 wks; Experiment 2 – 21 wks; Experiment 3 – 38 wks). However, at 55 wks of age the incidence of feather pecking was higher for the 60% treatment groups in both Experiments 1 and 2. Feather pecking is not considered an aggressive behaviour (Glatz, 2005a), but has the potential to lead to cannibalism so if the reduced incidence seen in this work is a true effect, it would be considered an advantage for beak shortening techniques.

Preening is worthy of investigation in beak shortening research because of the integral role of the beak in this behaviour. Preening has been found to be reduced subsequent to HB treatment (Duncan et al., 1989; Gentle et al., 1997) possibly due to beak sensitivity. After beak healing, it has been suggested that preening increases because of the reduced effectiveness of the shortened beak (Marchant-Forde et al., 2008). In the present research, preening was reduced 1 d post-treatment and increased 1 wk post-treatment for the IF-I treated chicks, but otherwise no treatment effects were noted during the brooding and rearing periods. During the laying period preening was increased in treated animals as a result of IF (Experiment 1 – 21, 38, 55 wks) and HB treatment (Experiment 3 – 21, 55 wks). In contrast, preening was not affected or reduced in Experiment 2 (55 wks) and reduced in Experiment 3 (38 wks). It is not possible to explain the differences in treatment effect or lack of response in preening behaviour as a result of beak treatment, but the possibility of an effect of a reduced aggressive environment warrants consideration. It is noteworthy that aggressive pecking was found at 21 wks of age in the experiments with increased preening in treated birds (Experiments 1 and 3) and that no aggressive pecking differences were found in the hens (Experiment 2) that either did not show an effect or where preening decreased. Further circumstantial evidence can be seen in higher levels of cannibalism in Experiment 1 (15.28%) and 3 (23.61%) hens vs. Experiment 2 (9.72%). Experiment 2 hens are also marketed as being more docile. An increase in preening due to the reduced effectiveness of the beak can be challenged from the data because there was no effect of treatment during the rearing period.

4.6.4 Stress and Fear

Gross and Siegel found that heterophils increased and lymphocytes decreased, increasing the overall H:L ratio when birds were stressed (Gross and Siegel, 1983). It has also been stated that heterophilia and lymphophilia are associated with decreased performance and immune function (Dennis et al., 2009). H:L ratios were assessed at two times in this trial (25 and 55 wks of age) and only the 55 wk assessment in Experiment 1 demonstrated treatment effects. The 60% severity level resulted in a higher H:L ratio compared to both C and 20% severities, yet it did not differ from the 40% severity birds. This finding is somewhat surprising based on the lack of effect at 25 wks of age. Although this suggests increased stress for the 60% group, the overall results do not support that the treatments applied in this research caused chronic stress. This conclusion is supported by the findings that hens sampled at 30 wks of age did not differ in blood cell profile when comparing IF at 0 d to HB treatment at 7- 10 d (Dennis et al., 2009); unfortunately no severity of treatment was stated in this research.

Tonic immobility (fear assessment) has been shown to be an indicator of fear in a bird immediately following induction into the tonic state (Jones, 1990). It has been suggested that the more fearful the bird is, the greater its latency to ‘righten.’ An increase in fear levels can lead to a decrease in production levels (Sefton, 1976). It was found that groups with increased feather pecking were more fearful than those showing lower levels. The finding that latency in the 20 and 60% treatments in the IF-I method increased at 27 wks compared to the control is not in agreement with this work as feather pecking in treated birds was reduced at 21 wks. Further, this finding is surprising as past research in this field has suggested that beak trimming reduces fearfulness, which in turn reduces the latency of TI (Lee and Craig, 1991). It must be mentioned that the beak trimming method used in the latter study was an electric cauterizing de-beaker which made a V-shaped cut and removed half of the upper and slightly less of the lower beak.

4.6.5 Feather Condition

Feather condition is important as plumage serves to protect and insulate birds, preserving body heat which conserves energy that is essential for optimal egg production.

Further, adequate plumage prevents scratches from occurring from neighbouring birds and their environment. The quality of plumage is affected by health, environmental, nutritional and social factors (Carrascal et al., 1998; Bilcik and Keeling, 1999; Dennis et al, 2009). Feather pecking and feather pulling are behaviours that are known to occur in laying hens and are both damaging and painful (Gentle et al., 1997). The intact beak of un-trimmed birds allows feathers to be easily grasped and removed, resulting in exposure of the hen's epidermis. In this research, both beak treatment methods resulted in better feather cover at 57 wks of age and for IF-H and HB techniques as the effect was already obvious at 38 wks. These findings are in agreement with previous research (Blokhuis and Van Der Haar, 1989). The lack of difference between treatments for the IF-I method at 38 wks is of interest and may relate to a strain effect (Preisinger, 2000). The degree of beak removal for the HB treated birds did not affect feather condition as all treated birds had superior plumage scores in comparison to the untreated control birds. Previous research has shown that the degree of beak tissue removal can affect the improvement in feather condition. Removal of less than 25% of the beak tip has been shown to result in no improvement in feather condition (Blokhuis et al., 1987; Sandilands and Savory, 2002). The results of the current study are not in agreement with this finding and this may relate to the persistency of beak shortening during the hen's life.

4.7 Implications and Conclusions

The objective of examining the relationship of degree of beak shortening, bird behaviour and physiology could not be accomplished for both IF methods due to the inability to achieve the desired treatment severities. However, the objective was met for the HB method. Pain post trimming was evident in Experiment 3 by a decrease in investigative, locomotive and consumptive behaviours and an increase in resting behaviour. No evidence of pain was evident in either of the IF experiments post treatment. An increase in object pecking and a general decrease in aggression with treated birds was noted yet not always significant in all three experiments. Improvement in feather condition was noted in treated birds of all three experiments which enhances not only welfare but also production parameters likewise. Overall there was a minor effect on H:L ratio, tonic immobility, and behaviour with increasing severity of treatment. Beak trimming within the parameters used in this trial showed some positive welfare effects. These effects included an improvement in feather condition, and an overall reduction in aggression.

5.0 OVERALL DISCUSSION

The sophistication of beak trimming has greatly evolved from its debut in the early 1900's. Although animal welfarists view this industry practice as a mutilation or amputation, without being properly implemented, the absence of this technique would greatly hinder bird welfare. Cannibalism is a behaviour that affects birds being housed in all management systems and at all degrees of farming intensity. It has been found to be very difficult to eliminate this behavioural trait from a strain through genetic selection and therefore management techniques such as beak treatment are necessary to maintain animal welfare standards.

Due to the need for such management techniques, research determining the least painful yet effective technique of beak treatment has been evolving over the last several decades. The hot-blade (HB) technique has undergone much research throughout the past years with the objective of providing a less painful and more welfare friendly alternative to the traditional methods of beak trimming. More recently, Nova Tech Engineering (Willmar, MN) has developed an innovative beak trimming method, which involves beak shortening by means of infrared energy applied to day-old chicks. Early research on this procedure has suggested that it minimizes acute and chronic pain while maximizing bird welfare via reduced feather pecking and cannibalism. Little evidence is available that reports an ideal severity of treatment for either hot-blade or infrared treatment. An ideal severity would maintain or enhance hen productivity and behavioural expression all while improving bird welfare.

5.1 Severity of Treatment

The degree of beak shortening achieved in the three experiments is shown in Figure 5.1. These figures demonstrate that altering the severity of beak treatment was only successful for the HB technique (Experiment 3) with achieved shortening very close to the research goals. Measuring the upper mandible later in life demonstrated that beak re-growth occurred, but the relative ranking was maintained. For the IF treated birds, measuring at 2 wks of age after beak sloughing ranged from approximately 38 to 50%. Post 11 wks of age the relative beak lengths were very similar with shortening ranging from 30 to 36%, a range that is similar to the value achieved by the 40% HB treatment (~33%).

The HB experiment provides additional information on the optimum degree of treatment that should be applied to laying hens. The severity of HB treatment had minimal effect on overall production and behaviour during brooding and rearing as well as laying cycle. This suggests that all levels are not markedly outside of the range of acceptable treatment. However, there are indications that both the 20 and 60% treatments are at or approaching the limits of treatment severity. The 60% treatment resulted in decreased bird weight lasting the duration of the trial, which implies that these birds had a reduced ability to consume feed. This is supported by the fact that this treatment had the lowest level of feed intake. Feed intake decreased in a linear fashion with increasing HB severity, but only the 60% treatment was affected negatively when major productive

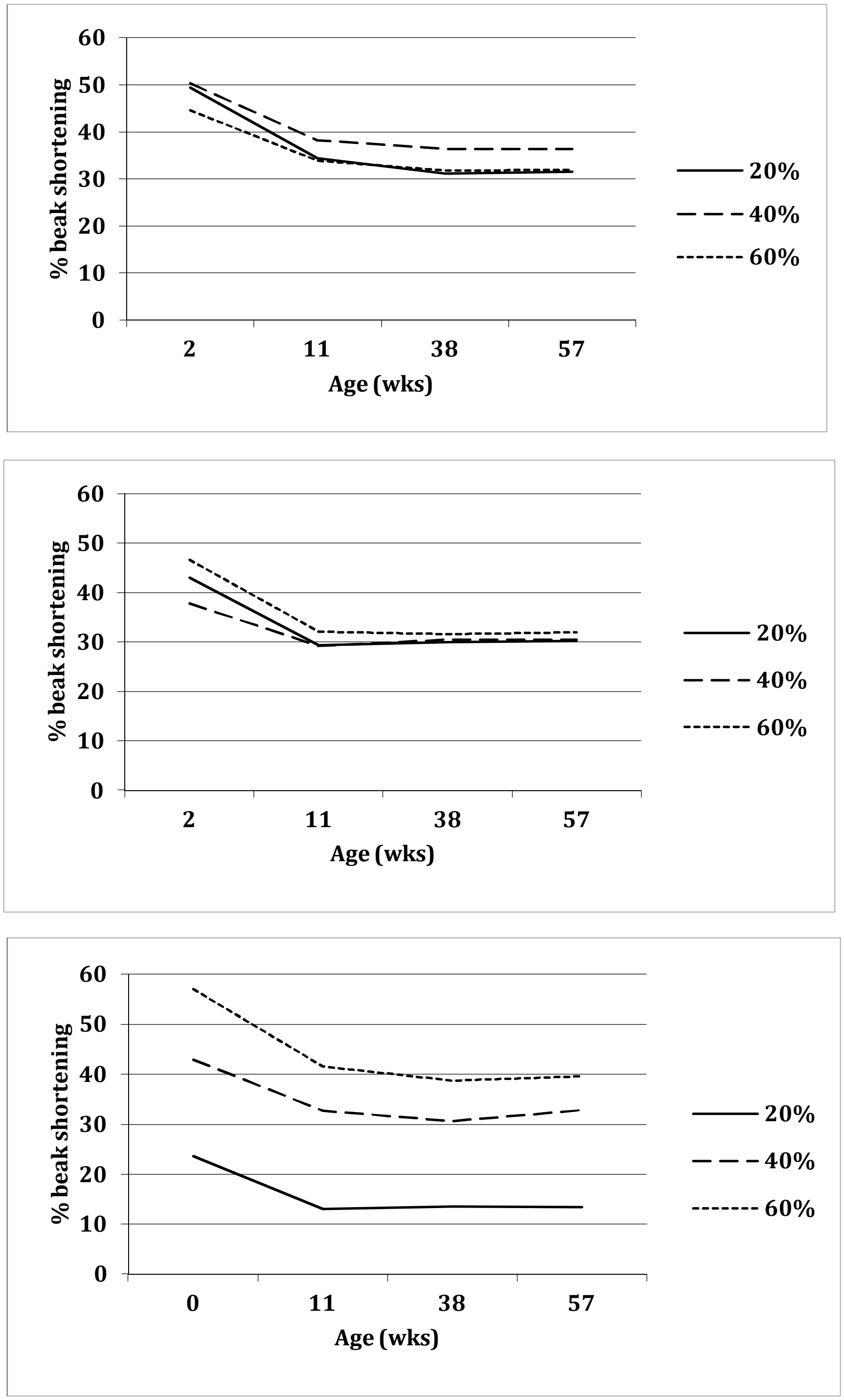

Figure 5.1 Effect of infrared treatment with severity varied by guide-plate hole size (top), infrared treatment with severity varied by infrared intensity (middle) and hot-blade treatment with severity varied by guide-plate hole size (bottom) on beak shortening as a percent of untreated control birds.

energy expenditures (body weight, egg weight and although not significant, feed efficiency (P=0.12)) were considered. This suggests that the reduced feed intake for the 20 and 40% treatments is associated with reduced feed wastage, which has been suggested previously (Lee and Craig, 1990; Bell and Kuney, 1991; Craig, 1992; Glatz and Lunam, 1994; Gentle et al., 1997; Davis et al., 2004; Marchant-Forde and Cheng, 2005). The failure of the 60% treatment to achieve the same body weight suggests that this degree of treatment should not be a target for beak shortening. In contrast, the 20% treatment may be insufficient to achieve the vital goals of preventing aggression and cannibalism. This is demonstrated by the finding that both the control and 20% treatments exhibited more aggressive behaviour than the 40 and 60% treatments. Although not statistically different than other HB treatment levels, there was some cannibalism found for the 20% treatment and none for the 40 and 60% treatments. These data suggest a goal of approximately 40% beak shortening of 1 d old chicks using HB treatment achieves the objectives of reduced aggression and cannibalism with minor effects on bird welfare associated with acute initial pain. This level of treatment is in agreement with others (Craig and Lee, 1990; Hester and Shea-Moore, 2003).

Although the objective of this research was to also attain three treatment severities for IF experiments, the use of altered guide hole size and infrared intensity failed to achieve this goal. This demonstrates that a more precise scientific approach is required, which could likely be achieved in conjunction with experts from the company that manufactured this equipment.

Despite not achieving the severity objectives, treating to this degree (30-36%) proved to have a positive effect on production and welfare parameters throughout both the brooding and rearing and laying cycles. Despite the inability to statistically compare them directly, differences that were found between experiments using IF treatment are of interest.

Birds exposed to IF-H treatment had reduced feed intake while those treated with varying IF intensity did not. Other differences in traits such as behaviour were also noted between experiments. This demonstrates that inherent variability in the nature of equipment and equipment adjustment (hatchery to hatchery variation) and possibly bird susceptibility to treatment and other genetic characteristics may play a role.

5.2 Acute Pain

Pain is an important aspect of beak shortening techniques. No evidence of neuroma formation was found in any of the experiments in this research and therefore the discussion will focus on acute pain after the procedure. The research results obtained from Experiment 3 (HB treatment) show some behaviour trends suggestive of pain 24hrs post-treatment regardless of treatment severity. This was shown by a decrease in running and litter pecking. Other behaviour trends indicative of pain included a decrease eating and walking behaviours as well as an increase in resting for all severities of the HB method 24 hours post treatment. These behavioural trends were relatively short lived, as no differences in behaviour were seen at 7 d of age. Evidence of the 1d old change in behaviour is supported by reduced body weight for treated birds at 7 d of age. As with behaviour, the effect on body weight was also brief with effects no longer found at 15 d.

An exception is the 60% treatment, which continued to show reduced weight for the entire experiment. The latter effect will be discussed in more detail later. Similar results have been obtained where locomotive, consumptive and investigative behaviours are reduced and resting behaviour increased following HB beak trimming (Gentle et al., 1982; Hester and Shea-Moore, 2003; Marchant-Forde and Cheng, 2005).

Based on a lack of treatment effect on 1 d behavioural observation, pain is not evident or appears to be lower for IF treated birds than those treated with HB. Because there is no immediate tissue removal as a result of IF treatment, it appears less traumatic. Infrared treatment damages tissue sub-dermally, which then sloughs within one to two weeks. During the period prior to sloughing, beak morphology changes and the chick learns to adapt to the altered sensitivity of the appendage. In contrast, HB treatment cuts, cauterizes and removes tissue and is likely to increase the presence of pain until healing is achieved. Again, severity of treatment did not change behavioural expression for IF treatment at 1 d of age. For birds treated with IF, there was a short period of reduced weight during the brooding and rearing period that may be the result of an altered ability to eat after beak sloughing. It is possible that this may also be a result of pain, but the histological finding that beaks were healed prior to beak sloughing and the lack of behavioural changes normally associated with pain (Gentle and McKeegan, 2007) are more supportive of the idea that birds were having difficulty adjusting to eating with a shortened beak.

5.3 Bird Behaviour

The data from this trial (Exp. 3) show that C birds are more aggressive when compared to controls between all experiments. The altered beak shape post treatment reduces the bird's ability to damage pen mates and this may impact expression of aggressive behaviour. However, decreased sensitivity of the beak might also be a reason for the decrease in aggressive behaviours that occurred in the more severe treatments of Experiment 3 and with all treated birds in Experiments 1 and 2. It is possible that the feedback that treated birds receive when engaging in aggressive behaviour is different than an intact bird would encounter thereby reducing the drive to continue such behaviour.

Of all of the behavioural data collected throughout this trial, object pecking stood out as being extremely fascinating. Treated birds of Experiment 1 and 2 (IF-H and IF-I respectively) showed an increase (not significant) in object pecking 1 wk post treatment, which was generally maintained throughout the duration of the trial. Treated birds of experiment 3 (HB) also showed a significant increase in object pecking with increasing treatment severity. One week post treatment, the IF treated birds would be experiencing a change in beak morphology and sensation as the necrotic beak tissue erodes and therefore increase object pecking because of the change in tactile stimulation. A similar trend is noted in Experiment 3. It can be hypothesized that the change in beak morphology and sensation of the beak post treatment (IF and HB) causes unfamiliar feedback and stimulates object pecking. Object pecking is defined as an investigative behaviour; perhaps the sensation of the beak has changed due to the altered morphology post trimming, and object pecking evolves from investigative into a stereotypic behaviour due to a level of frustration that the birds are experiencing. Jongman et al. (2008) also found that HB treated birds pecked more often at cages and gave a number of potential reasons for this behaviour. These included an altered sensation in the beak or an altered threshold to potentially painful stimuli that led to more investigative or object pecking behaviour.

5.4 Mortality and Cannibalism

Treated hens in all of the experiments showed a dramatic decrease in total mortality. Statistically only the effects of treatment in Experiment 3 proved significant even though numerically, Experiments 1 and 2 showed a similar trend. The lack of statistical significance is likely due to the result of variability in mortality among treatment replications. Cannibalism was the most significant cause of mortality, and the data in this research clearly demonstrate that beak shortening (regardless of technique) is effective in reducing this major bird welfare concern. The occurrence of cannibalism can vary extensively from trial to trial likely because of different environmental or other cues. Once initiated, it is recognized that cannibalism is a learned behaviour (Cloutier et al., 2002). This agrees with the variability of cannibalism mortality (8.3- 50.0%) between replications in this research. It also corroborates the observation that cages having outbreaks of cannibalism appeared to have an influence on neighbouring hens. These data support that cannibalism is a learned behaviour and indicates that once an outbreak occurs in un-treated birds, regardless of setting, it is difficult to control.

5.5 Comparison of Infrared and Hot-Blade Treatments

Each experiment was run separately due to the hatcheries facilitating different trim techniques supplying different strains of laying hens; therefore, each experiment cannot be compared directly. However, some interesting differences were seen relating to pain and healing when indirectly comparing the two methods. Birds treated by the HB method showed behavioural trends relating to pain one day post treatment, which later resulted in a decrease in weight. Interestingly, the IF techniques both showed a lack of pain behaviour post-treatment. The HB method results in an open wound that can be susceptible to environmental debris and bacteria, whereas with the IF method the beak tip is fully healed prior to sloughing. The intact beak after IF treatment also limits the impact on feed intake and early brooding success as indicated by early weight gain. Retaining full use of their beaks post-treatment and gradual changes in morphology and sensitivity compared to the HB method appears to be advantageous from welfare and production perspectives. From these data alone, the IF trimming method appears to have fewer detrimental effects on bird welfare than the traditional HB method.

5.6 Conclusions

This research supports that beak trimming, regardless of trim technique or severity, reduces the incidence of harmful behaviour leading to cannibalism. It promotes improved production and feather condition throughout the laying cycle. By reducing pain post treatment as well as facilitating a less challenging adaptation to reduced beak length, the IF trimming method has advantages as a beak treatment for laying hens in comparison to the HB technique. Beak trimming alone however, cannot abolish harmful behaviours, and must be used in conjunction with other management techniques for optimum results.

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Appendix A

Percent of available ingredient diet specifications

	Starter	Grower	Pre-lay	Layer
Ingredients[1, 2]	Percent			
Wheat	42.90	42.60	20.06	51.98
Corn-ground	12.00	0.00	0.00	10.00
Soybean meal	0.00	9.26	16.08	14.50
Corn dist grain w/sol	0.00	0.00	0.00	5.00
Ground barley	10.00	42.60	53.06	0.00
Peas/ lentils	10.00	0.00	0.00	0.00
Meatmeal	9.50	0.00	0.00	5.00
Canola meal	7.00	0.00	0.00	0.00
Corn distillers	5.52	0.00	0.00	0.00
Tallow	1.00	0.00	0.00	2.50
Limestone	0.789	1.45	4.75	9.50
Dicalcium phosphate	0.00	1.40	0.00	0.00
Canola oil	0.00	1.00	3.34	0.00
Mono Ca phosphate (21%)	0.300	0.00	0.00	0.74
Sodium bicarbonate	0.280	0.00	0.00	0.04
Lysine HCL	0.160	0.23	0.00	0.13
Potassium chloride	0.104	0.00	0.00	0.00
Common salt	0.00	0.34	0.36	0.27
Choline CHL 60%	0.084	0.10	0.10	0.00
Coccistac	0.00	0.08	0.00	0.00
Methionine	0.082	0.29	0.12	0.20
L-Threonine	0.00	0.05	0.00	0.00
Vit premix	0.080	0.00	0.00	0.06
Min premix	0.065	0.00	0.00	0.08
Vit/Min premix	0.00	0.50	0.50	0.00
Amprol 25%	0.050	0.00	0.00	0.00
DG-200 MG Selenium	0.042	0.00	0.00	0.00
Biotin (B8) 220MG/kg	0.023	0.00	0.00	0.00
Endofeed-wheat (enzyme)	0.020	0.05	0.03	0.00

[1]As –fed basis

[2] Federated Co-op Limited Plant 03 Saskatoon

APPENDIX B

Actual available nutrient diet specifications

	Starter	Grower	Pre-lay	Layer
Nutrient[1]		Actual		
NRC ME Poultry kcal/kg	2,738	2,850	2,844	2,634
Crude protein (%)	19.00	16.00	16.97	19.10
Sodium (%)	0.17	0.17	0.17	0.17
Calcium (%)	0.91	0.92	2.23	3.92
Phosphorus – avail (%)	0.43	0.86	0.44	0.38
NRC Lysine (%)	0.98	0.80	0.77	0.94
NRC Methionine (%)	0.38	0.52	0.36	0.49
NRC MET+CYS (%)	0.73	0.65	0.00	0.81
NRC Threonine (%)	0.64	0.60	0.59	0.63
NRC Tryptophan (%)	0.17	0.20	0.22	0.22

[1] Federated Co-op Limited Plant 03 Saskatoon