

Research Note: Beak morphology of infrared beak-treated laying hens and its impact on production and welfare

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ABSTRACT Despite previous research on the impacts of beak treatment on laying hens, little information exists regarding how variation in beak morphology that can occur following beak treatment affects production, behavior, and welfare. Following infrared beak treatment (**IRBT**), variations in beak shape, such as a shovel beak (bottom beak longer than top), cracks (**Cr**), or bubbles (**B**) may occur if the IRBT equipment is damaged or if a quality control program is not followed at the hatchery. This study aimed to determine if variations in beak morphology post-IRBT impacted laying hen production or welfare. Infrared beak-treated Lohmann LSL-Lite hens (n = 80) were selected from a 56-wk-old flock and randomly assigned into 1 of 8 treatments: flush beak (control), shovel beak extending

0–1 mm (**SB0-1**), 1–2 mm (**SB1-2**), 2–3 mm (**SB2-3**), 3–4 mm (**SB3-4**), or >4 mm (**SB > 4**), Cr, or B. Hens were housed in individual cages for 4 wk and production (body weight, feed intake, egg production, and egg quality), and welfare (behavior and histology) parameters were evaluated. Consumption of different particle sizes was assessed by measuring feed particle size of refused feed. Data were analyzed as a one-way ANOVA, in a completely randomized design using PROC GLM (SAS 9.4). The results indicated that the beak morphologies examined had minimal effects on the production or welfare of the hens. Histological assessment did not show the presence of neuromas in the beak tissue, suggesting that the hens were not experiencing chronic pain from the IRBT procedure.

Key words: beak treatment, behavior, beak shape, body weight, shovel beak

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INTRODUCTION

Feather pecking is a concern within the egg production industry because the behavior can be a precursor to cannibalism, which is known to spread rapidly within a flock once started and can result in mortality levels of up to 30% (Glatz, 2000). It is a concern from both an animal welfare and economic standpoint, and because of this, there has been significant research conducted on how best to prevent and reduce the damage resulting from feather pecking. One of the most common preventative methods used has been beak treatment. Infrared beak treatment (**IRBT**) is one of 2 predominant methods of beak treatment used for commercial laying hens. However, IRBT differs from more traditional methods such

as hot-blade trimming (**HBT**) because it does not result in the immediate loss of the beak tip. Rather, the infrared-treated tissue sloughs off gradually, allowing the bird more time to adapt to the change in beak shape.

Beak treatment alters beak shape, either intentionally through treatment protocol or unintentionally through tissue regrowth (Marchant-Forde et al., 2008). Altered beak morphologies such as shovel beaks (bottom beak longer than top) as well as beaks with a crack (**Cr**) (visible Cr on the top and/or bottom beak) or bubble (**B**) (blister-like formation under the tissue of the beak tip) are significantly less common in IRBT birds as compared with HBT birds (Carruthers et al., 2012). Beaks that have any detectable difference between the top and bottom have been classified as “severe abnormalities” and may be a welfare concern (Kajlich et al., 2016). However, it is still unclear how these beak shapes impact hen welfare and production.

Beak shape may have important implications for laying hen production and welfare as it has been suggested that elongation of the bottom beak relative to the top beak (shovel beak) may alter the bird’s ability

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Table 1. Treatment groups used in the present study.

Treatment name	Description
C	Control; top and bottom beak length are flush
SB0-1	Shovel beak, with bottom extending 0–1 mm past top
SB1-2	Shovel beak, with bottom extending 1–2 mm past top
SB2-3	Shovel beak, with bottom extending 2–3 mm past top
SB3-4	Shovel beak, with bottom extending 3–4 mm past top
SB > 4	Shovel beak, with bottom extending greater than 4 mm past top
Cr ¹	Beak with a crack formation
B ²	Beak with a bubble formation

¹Beak with a visible crack on the top and/or bottom beak (Carruthers et al., 2012).

²The presence of a blister-like formation under the tissue of the beak tip (Carruthers et al., 2012).

to pick up feed particles. Prescott and Bonser (2004) reported that hens with shovel beaks had reduced feeding ability, meaning they were less successful at grasping and ingesting pellets when they were presented as a thin, single layer. Glatz (2003) found that birds with short upper beaks resulting from HBT had lower feed intake over a 7-wk period, but there were no differences in the consumption of different feed particle sizes between birds with long and short upper beaks, suggesting that beak shape does not impact the hens' ability to consume different sizes of feed particles. More recently, Struthers et al. (2019) studied the effect of beak shape on the productivity of infrared beak-treated layer pullets and hens and found no differences in feed intake or egg production during rearing or laying between birds with a shovel beak compared with birds with untreated beaks. Other research has suggested that beak-treated hens may be subject to chronic pain, especially if the presence of a B is indicative of neuroma formation (Glatz, 2009). However, McKeegan and Philbey (2012) found no evidence of neuroma formation or abnormal nerve growth up to 50 wk post-IRBT suggesting that IRBT did not result in chronic pain.

The objective of this study was to determine if differences in welfare and production existed between infrared beak-treated hens with different beak morphologies (shovel beak, B, or cracked tissue) and infrared-beak treated hens with a symmetrical beak (top and bottom beak lengths are approximately equal).

MATERIALS AND METHODS

This work was approved by the University of Saskatchewan's Animal Research Ethics Board and adhered to the Canadian Council on Animal Care guidelines for humane animal use (2009).

Birds, Housing, and Husbandry

Eighty infrared beak-treated Lohmann LSL-Lite hens (56 wk of age) were selected from a production flock based on beak morphology. Visual observation of the beak was used to place hens ($n = 10$ hens per treatment) into the treatment groups described in Table 1. Approximately 5,000 hens were examined to locate the 70 birds

that had beaks varying from the standard "flush" or symmetrical shape that was used as a control. Calipers were used to measure shovel beak length by placing the calipers at the tip of the upper beak and measuring the length in a straight line to the tip of the lower beak. As hens were selected and removed from the production flock, they were randomly placed into individual cages (30.5 cm wide \times 45.7 cm long \times 43.1 cm tall). All hens had *ad libitum* access to a commercial layer diet (coarse crumble; 4 mm diameter and 3–4 mm length) and water (1 nipple per cage). Trough feeders ran along the front of the cages, and dividers were installed to ensure there was no feed access for hens from neighboring cages. Feed was topped up each morning to a depth of approximately 5 cm. The photoperiod during the experiment was 14L:10D (10 lux), and barn temperature was maintained at 20°C.

Data Collection

Following a 1 wk adjustment period, all hens were individually weighed and body weight recorded at 57 wk of age. This was repeated at the end of the trial (61 wk of age). Each hen was fed from a preweighed bag of feed, and this feed bag along with any refusals remaining in the feed trough were weighed on a weekly basis from 57 to 61 wk of age to calculate individual feed intake. Feed refusals were collected during the final week of the trial for feed particle size assessment to aid in determining if beak shape impacted the hen's ability to consume a coarse crumble feed. It was hypothesized that if one or more of the treatment groups (particularly hens that had a large shovel beak [SB3-4, SB > 4]) were forced to peck more at their feed to successfully ingest the pellets, that would result in increased breakage of feed particles and a higher percentage of fines in the feed refusals. Before the final week, all previous feed was discarded from the feed troughs and bags. New feed was provided from preweighed bags and handled gently to reduce the chance of breakage of the feed particles. Particle size separation was conducted using a Ro-Tap testing sieve shaker (Tyler Industrial Products, Mentor, OH). Sieve time was set to 30 s per sample. Sieve sizes were 0.4 mm, 0.6 mm, 0.8 mm, and 2.0 mm. Egg production was recorded 5 D per week and then adjusted to a 7 D basis for statistical analysis. Cracked, broken, and shell-less eggs were recorded. Egg quality was measured on the final week of the trial. All eggs were individually marked for treatment identification, weighed, and their specific gravity recorded. Specific gravity was assessed using the floatation method described by Holder and Bradford (1979). Salinity baths ranged from 1.060 to 1.100 and increased in increments of 0.005.

Hen behavior was recorded in 3 cages per treatment for 14 continuous hours per day (length of photophase) for 3 days at 57, 58, 59, and 60 wk of age. Videos were recorded using Canon Vixia HFR700 camcorders that captured the entire cage. All video data were analyzed using a scan sampling technique at 10 min intervals.

Table 2. Ethogram used to assess the behavior of Lohmann LSL-Lite hens with different beak morphologies.

Behavior	Description ¹
At the feeder	Head in feeder, appears to manipulating and ingesting feed
At the drinker	Beak in contact with drinker
Beak wiping ³	Rapid stroking of alternate sides of the beak on floor or sides of cage
Scratching ³	Using foot to scratch head, neck, or beak
Sham dustbathing ³	Attempts to dust bath on cage floor or in feed trough
Gentle peck ³	Pecks delivered toward feathers of a neighbor
Aggressive peck ³	Pecks delivered at neighbor with intent to harm
Walking ³	Taking one or more steps
Standing	Standing, showing no apparent movement, feather may or may not be extended
Resting	Breast or body in contact with cage floor, eyes may be opened or closed, feathers may or may not be extended
Environmental peck	Pecks directed at cage floor, wall or roof, and around feed trough
Preening ²	Self-manipulation of own feather with beak, may be performed while standing or resting
Feather ruffle ²	Body shaking with feathers raised
Wing flap ²	Extension and flapping of wings
Wing stretch ²	Slow extension and stretching of wing
Leg stretch ²	Slow extension and stretching of leg

¹Adapted from Marchant-Forde et al. (2008).

²Denotes a comfort behavior.

³Denotes a low incidence behavior.

The ethogram used for behavior identification is presented in Table 2. Because the sampling technique used may not have been effective for low incidence behaviors (Rose, 2000), these behaviors were excluded from the discussion.

At the end of the trial, 4 birds from the C, SB > 4, Cr, and B treatment groups were randomly selected for beak histology sample collections. Selected hens were euthanized via cervical dislocation; beaks were removed and stored in 10% neutral buffered formalin. Samples were decalcified for 36 h, trimmed into sagittal cross sections of 5 mm, embedded in paraffin wax, cut to 5 µm thickness, and stained with hematoxylin and eosin stain. The sectioned samples were examined under a light microscope (Olympus BX51, Tokyo, Japan) by a veterinary pathologist. To avoid bias, the pathologist was blind to which samples belonged to which treatment, and all slides were evaluated at the same time.

Statistical Analyses

The experiment was designed as a one-way ANOVA, in a completely randomized design with 10 replicates per treatment (bird as replicate unit). Data were analyzed using PROC GLM (SAS 9.4, Cary, NC) with Duncan's

Multiple Range Test to separate means. Percentage data were checked for normality using PROC UNIVARIATE (SAS 9.4) and log transformed (data log + 1) before analyses. Differences were considered significant when $P \leq 0.05$.

RESULTS AND DISCUSSION

Beak morphology did not affect body weight or feed intake during the 4 wk experimental period (Table 3), which suggests that the beak morphologies tested did not negatively impact the hen's ability to consume feed and gain weight during the experimental period when compared with the infrared beak-treated hens that served as controls in the present study. Reduced feed intake has been reported in pullets and hens with shovel beaks intentionally created by HBT (Gentle et al., 1982; Lee and Craig, 1990). However, feeding ability and intake did improve later in life, indicating that the treated birds adapted to their new beak shape (Gentle et al., 1982; Lee and Craig, 1990). Other research has found when IRBT was used to intentionally create a shovel beak, treated birds did not have reduced body weight or feed intake during early life (Struthers et al., 2019).

Table 3. Effect of beak morphology on the production performance of Lohmann LSL-Lite hens from 57 to 61 wk of age.

Production parameters	Beak morphology							P-value	SEM	
	C	SB0-1	SB1-2	SB2-3	SB3-4	SB > 4	B			
Body weight, kg										
57 wk	1.69	1.75	1.89	1.83	1.90	1.83	1.86	1.79	0.32	0.024
61 wk	1.71	1.76	1.90	1.85	1.94	1.84	1.89	1.80	0.24	0.024
Body weight gain, g/hen	0.02	0.01	0.01	0.02	0.04	0.01	0.03	0.01	0.95	0.007
Feed intake, g/hen/D	113.0	112.6	110.7	116.0	119.1	111.8	115.5	110.5	0.81	1.417
HDP, %	97.2	87.1	90.8	96.8	95.2	94.4	94.0	92.4	0.56	1.287
HHP, %	96.8	86.8	90.8	96.4	95.2	89.4	93.6	92.4	0.56	1.440
Egg weight, g	61.9	64.6	63.9	65.2	62.9	62.2	64.6	63.5	0.53	0.448
Specific gravity	1.081	1.081	1.083	1.080	1.082	1.081	1.082	1.083	0.64	0.0004

Abbreviations: B, presence of bubble formation in beak; C, top and bottom beak length equal; Cr, presence of cracks in beak; HDP, hen-day production; HHP, hen-housed production; SB0-1, bottom beak 0–1 mm longer than top; SB1-2, bottom beak 1–2 mm longer than top; SB2-3, bottom beak 2–3 mm longer than top; SB3-4, bottom beak 3–4 mm longer than top; SB > 4, bottom beak >4 mm longer than top.

Table 4. Effect of beak morphology on the percent distribution of feed particle size of refused feed from Lohmann LSL-Lite hens.

Mean particle size	Beak morphology						B	Cr	P-value	SEM
	C	SB0-1	SB1-2	SB2-3	SB3-4	SB > 4				
>2.0 mm	63.90	63.40	55.44	57.90	56.80	53.89	61.50	63.60	0.18	0.012
2.0 mm	20.30	21.40	24.44	24.00	24.90	25.11	22.00	21.40	0.28	0.006
0.8 mm	4.40	4.30	5.67	5.20	4.90	6.00	4.20	4.30	0.44	0.002
0.6 mm	3.70	3.70	4.56	4.30	4.20	4.78	3.70	3.50	0.57	0.002
0.4 mm	7.30	6.70	9.22	8.10	8.50	9.33	7.80	6.70	0.21	0.003

Abbreviations: B, presence of bubble formation in beak; C, top and bottom beak length equal; Cr, presence of cracks in beak; SB0-1, bottom beak 0–1 mm longer than top; SB1-2, bottom beak 1–2 mm longer than top; SB2-3, bottom beak 2–3 mm longer than top; SB3-4, bottom beak 3–4 mm longer than top; SB > 4, bottom beak > 4 mm longer than top.

Measuring particle size can be used to evaluate feeding ability or efficiency. If birds with shovel beaks are not able to peck and grasp pellets effectively, this may result in increased pecking at the feed, increased breakage of the feed pellets, and a higher percentage of fines in the residual feed. [Gentle et al. \(1982\)](#) found that feeding efficiency (number of pecks per gram of pellets ingested) was reduced for HBT-treated hens with a shovel beak. Treated hens had to peck 3 to 5 times more to consume the same amount of feed as untreated hens, and this was likely because of the treated hens' being less effective at grasping the pellets and successfully swallowing them ([Gentle et al., 1982](#)). [Glatz \(2003\)](#) also found no differences in particle size distribution of remaining (refused) feed between hens with long or short top beak lengths.

The distribution of particle size for refused feed did not differ between treatment groups in the present study ([Table 4](#)). Large size particles (>2.0 mm) made up the majority of the residual feed sieved, suggesting that even the hens with the longest shovel beaks did not have to continually peck at their feed to grasp and consume it, resulting in less fines in the feed. However, feed presentation may play a role in the hen's ability to feed. In this study, feed was presented as a deep layer in the feed trough. Beak-treated hens with shovel beaks may have more difficulty grasping and consuming feed if

feed is presented as a thin, single layer ([Prescott and Bonser, 2004](#)).

Hens that were fed either a fine or coarse particle size had no differences in egg production, egg weight, or egg quality over a 30 wk period, suggesting that they were able to easily consume multiple different particle sizes and receive a balanced diet ([Ege et al., 2019](#)). Although beak treatment was not mentioned, these birds were reared under "standard management practices", which likely included beak treatment ([Ege et al., 2019](#)). The different beak morphologies tested in the present study did not impact egg production or quality ([Table 3](#)). These results agree with prior research ([Dennis et al., 2009](#); [Ege et al., 2019](#); [Struthers et al., 2019](#)) and are not surprising considering the feed intake and body weight data. In the present study, there was variation in particle size distribution, which allowed the option of particle selection. However, because the particles of the coarse crumble feed were homogenous in their nutrient content, even if particle selection did occur, production was not influenced in the present study.

Increased inactivity and decreased performance of comfort behaviors can be indicators of pain following beak treatment ([Duncan et al., 1989](#); [Marchant-Forde et al., 2008](#)). In the present study, no differences in inactive (standing and resting) or comfort behaviors

Table 5. Effect of beak morphology on the behavior (percent of time) of Lohmann LSL-Lite hens from 57 to 60 wk of age.

Behavior (% of time)	Beak morphology						B	Cr	P-value	SEM
	C	SB0-1	SB1-2	SB2-3	SB3-4	SB > 4				
At the feeder	20.23	23.31	21.28	17.50	21.25	19.09	20.15	25.00	0.81	1.063
At the drinker	2.76	2.06	1.28	2.00	2.91	1.15	2.61	3.45	0.11	0.229
Standing	22.39	22.20	28.92	19.96	28.03	22.66	33.08	27.27	0.39	1.500
Resting	28.02	30.10	25.13	39.29	24.08	35.60	16.17	23.85	0.11	2.068
Environmental peck	5.25	6.16	6.56	11.01	4.35	6.91	6.50	4.60	0.84	0.978
Comfort ¹	18.82	13.63	14.93	7.93	16.66	11.61	17.97	12.97	0.15	1.045
<i>Low incidence behaviors</i>										
Beak wiping	0.45 ^{a,b}	0.24 ^{b,c,d}	0.37 ^b	0.07 ^{c,d}	0.00 ^d	0.71 ^a	0.27 ^{b,c,d}	0.34 ^{b,c}	<0.01	0.051
Scratching	0.27	0.30	0.27	0.64	0.30	0.31	0.44	0.10	0.20	0.048
Gentle peck	0.03	0.03	0.03	0.10	0.00	0.03	0.10	0.03	0.89	0.018
Aggressive peck	0.24	0.20	0.17	0.20	0.24	0.84	0.03	0.14	0.50	0.088
Sham dustbathing	0.78	0.71	0.44	0.71	0.78	0.61	1.28	0.55	0.25	0.079
Walking	0.76	1.04	0.64	0.58	1.39	0.47	1.38	1.68	0.25	0.141

^{a-d}Means within a row with different superscripts are significantly different ($P \leq 0.05$).

Abbreviations: B, presence of bubble formation in beak; C, top and bottom beak length equal; Cr, presence of cracks in beak; SB0-1, bottom beak 0–1 mm longer than top; SB1-2, bottom beak 1–2 mm longer than top; SB2-3, bottom beak 2–3 mm longer than top; SB3-4, bottom beak 3–4 mm longer than top; SB > 4, bottom beak > 4 mm longer than top.

¹Comfort: preening, preening while resting, feather ruffle, wing flap, wing stretch, leg stretch.

(preening, feather ruffling, wing flapping, wing stretching, and leg stretching) were observed between treatments, suggesting that birds were not experiencing chronic pain (Table 5). Neuroma formation, a cause of chronic pain, may occur following HBT, depending on the age at treatment and the severity of treatment (Schwean-Lardner et al., 2016). There is still limited research available regarding neuroma formation following IRBT. In the present study, histologic samples showed that the beak tissue had fully healed as evident by complete regeneration of the dermis, epidermis, and rhamphotheca. None of the submitted samples showed evidence of neuroma formation, which is conclusive with the findings of McKeegan and Philbey (2012).

In conclusion, the different beak morphologies tested in the present study did not negatively affect hen production when compared with infrared beak-treated hens that had symmetrical top and bottom beak lengths, suggesting that if elongation of the bottom beak beyond the top occurs, birds are still able to consume feed and gain weight. The IRBT procedure as well as the different beak morphologies also did not appear to negatively impact welfare or result in long-term pain.

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