Laser Beak-Trimming

A report for the Australian Egg Corporation Pty Ltd

By Philip Glatz

July 2004

AECL Publication No 04/05
AECL Project Number SAR-45A

ISBN 1 920 835 19 9
ISSN 1440-6845

Laser Beak Trimming
Publication No. 04/05
AECL Project No. SAR-45A

Researcher Contact Details
Dr Phil Glatz, South Australian Research and Development Institute, PPPI,
Roseworthy Campus, Roseworthy, SA 5371. Phone: (08) 83037786, Fax: (08)
83037689, e-mail: glatz.phil@saugov.sa.gov.au

AECL Contact Details
Dr Irene Gorman, Research Manager
Suite 4.02, Level 4, 107 Mount Street
North Sydney
NSW 2060

Phone**:** 02 9409 6999
Fax**:** 02 9954 3133
email: irene@aecl.org
Internet: http://www.aecl.org

Published in July 2004

Foreword

Given the continuing welfare scrutiny of using a hot blade to cut the beak, attempts have been made to develop more welfare friendly methods of beak trimming. The alternative methods, which have been used, have been cold blade trimming, arc trimming, robotic trimming, chemical trimming and infrared trimming. The traditional hot blade method for trimming is still the most popular method. Cost of lasers is falling dramatically and potential of developing a laser machine for mass beak trimming of birds at large hatcheries is considerable.

An ophthalmic laser was able to cut through the outer layers of keratin, but the inner bone portion could not be fully severed. For a number of birds, incomplete cuts were made on the beak. Subsequently a green laser, ND Yag and $C0_2$ laser were tested. The CO_2 laser with a 1 second pulse, 50-micron spot size and power rating of 10W was the most effective laser in cutting a beak sample. The results indicate there is potential to develop a laser beak trimming machine.

This project was funded from industry revenue, which is matched by funds provided by the Federal Government and is an addition to AECL's diverse range of over 150 research publications. It forms part of our R&D program, which aims to support improved efficiency, sustainability, product quality, education and technology transfer in the Australian Egg Industry.

Most of our publications are available for viewing, downloading or purchasing online through our website, www.aecl.org.

Dr Irene Gorman
Research Manager
Australian Egg Corportion Limited

Acknowledgments

Acknowledgment is given to the following colleagues and organisations that provided support, assistance, encouragement and advice during the project.

- The Australian Egg Corporation Limited for providing funds to undertake this work.
- Dr. Tony Moore for his advice and for undertaking the laser trimming on live birds.
- Mr. Victor Previn, Managing of Ellex Lasers Pty Ltd for his advice and providing the ophthalmic lasers for the experiment.
- Prof. Jesper Munch of the Physics Department University of Adelaide for conducting laser cuts on beak samples with a green, ND Yag and $C0_2$ laser.
- Mrs. Belinda Rodda and Mrs. Sandy Wyatt for care of birds during the trials.

Contents

List of Figures

Executive Summary

An ophthalmic laser set at 1.5W, with a 4 second pulse using a 50-micron spot size successfully cut through an upper beak sample (including the bony portion) from a cull day-old male chicken. The beak sample was kept on ice and subjected to laser treatment within 3 h. Two passes of the laser beam were required to complete the cut. There was insufficient power in the laser beam to cut the beak tissue in one action. The use of the binocular viewer enabled a close up view of the beak while the laser was cutting the tissue. Fitting of conventional hot blade machines with such a viewer would be useful and enable operators to locate the exact spot to cut the beak and increase precision.

Live bird studies with 5-day-old chickens established the spot size to enable coagulation of the tissue and prevent bleeding. When a 50-micron spot size was used for a duration of 2 seconds there was insufficient energy density of the laser beam on the tissue to cause coagulation and the beak began to bleed. The spot size was increased to 200 microns with a cutting time of 2 seconds. The birds vocalised more in response to the increase in energy density indicating they were perhaps feeling more discomfort. There was no bleeding from the wound indicating that the 200 micron spot size was effective in sealing the wound as there was no blood loss.

The laser was able to cut through the outer layers of keratin, but was not able to cut the inner bone as previously found with beak samples from killed chickens. The laser beam was passed across the bony tip numerous times for a number of birds without success. The chicks were positioned such that laser cuts were made from dorsal, ventral and lateral position of the beak. Because the birds being used for this aspect of the trial were 5 days-of-age it was postulated that laser cutting of the beaks of day-old chickens would be more successful than cutting the beaks of chickens that were five days-of-age. However when using the opthalmic laser set at 1.5W, with a 200 micron spot size and 4 second pulse the bony tip on day old chickens was still too hard for the opthalmic laser to penetrate. After the chickens were killed the bony tip in the beak tissue may lose some of its hardness or hardness may have been reduced by storage on ice.

There was no significant difference in the beak length and body weight of control birds, laser trimmed or trimmed with a hot blade. There were no apparent problems with healing of the beak stump. The cuts that were made looked cleaner and straighter than the hot blade cuts. As the birds aged the beak tissue sloughed off at first as the stump wound healed. Then regrowth of the beak occurred. There was one bird where the bony tip appeared to be effectively cut and cauterised. The beak regrowth of this bird was substantially less than other birds.

The lack of success in being able to cut the bony portion of the beak with an opthalmic laser was considered to be due to the lack of power. A green laser, ND Yag and CO_2 laser were tested. The CO_2 laser with a 1 second pulse, 50-micron spot size and power rating of 10W was the most effective laser in cutting a beak sample.

These experiments have shown that there is potential to use lasers for beak trimming. This project has demonstrated the spot size required to cauterise the beak, and the power to cut the beak. Further work is now required to develop a prototype laser beak-trimming machine with automatic measurement and laser trimming of the beak to the required standards.

General Introduction

Welfare concerns

Discussions with experienced Australian beak-trim operators revealed that the main problems being faced with the practice, particularly for inexperienced staff, is to ensure the appropriate length of beak is left on the bird after trimming. In addition, further problems encountered are maintaining correct blade temperature and ensuring effective cauterisation of the stump to prevent regrowth of the beak. Beak trimming has always been a concern for welfare groups and in many European countries beak trimming is banned despite more recent research providing credibility for the operation (Lunam *et al.,* 1996). Nevertheless there remains criticism of the practice. Lack of precision when beak trimming can lead to variable beak length and beak imperfections. To overcome these problems the industry has been proactive and developed a beak trimming training manual and trainer's guidelines.

Beak trimming methods

Given the continuing welfare scrutiny of using a hot blade to cut the beak, attempts have been made to develop more welfare friendly methods of beak trimming. The alternative methods which have been used have been cold blade trimming, arc-trimming, robotic trimming, chemical trimming and infrared trimming. The infrared method of trimming is gaining popularity in the layer industry but the traditional hot blade method of trimming is still the most popular method (Glatz, 2000).

The method that offers considerable promise for future development is laser trimming. Lasers are used widely in human medicine particularly for surgery. The general public and welfare groups would probably perceive that laser trimming is a milder, more technologically advanced method. The new laser machines on the market are smaller, more flexible and easier to transport than earlier models. Cost of lasers is falling dramatically and there is considerable potential for developing a laser machine for mass beak trimming of birds at large hatcheries and for trimming and retrimming older birds.

Objective

- To examine the feasibility of developing a laser beak-trimming machine to improve the consistency of beak trimming and improve bird welfare.

Chapter One: Review

History of beak-trimming

The word debeaking has been a term used to describe the practice although the process does not remove the whole beak as the term debeaking implies. More recently scientists, have used the term partial amputation instead of beak-trimming, although the beak does re-grow and receptors are functional in the regenerated beak tissue (Glatz, *et al.* 1998).
Paring of the tip of the top beak (Kennard, 1937; Robinson, 1961) and beak burning were the first methods used by poultry farmers to control cannibalism in laying flocks. A gas torch was used by T. E. Wolfe in the San Diego county in California to burn off part of the upper beak of the hen and was very effective in controlling pecking vices especially feather pulling (Sundaresen and Jayaprasad, 1979). Later a neighbour of Wolfe, W.K. Hopper adapted a tinner's soldering iron by giving it a chisel edge, which enabled the operator to apply downward pressure on the upper beak to sear and cauterise the beak. The Lyon Electric Company took up some of these modifications, to develop the first beak-trimming machine.

The Lyon Electric Company first brought out a heated knife attachment for a homemade beak support and frame. The name for the machine "debeaker" was coined in 1942 and was registered in 1943.

Beak trimming methods

Gas beak-trimming

This machine consists of a hot plate and cutting bar operated using a foot lever. The efficiency of the machine varies with gas pressure and wind conditions. Generally it is slow to use and it is a useful portable machine for beak trimming small numbers of birds (Pickett, 1969). Producers can currently purchase a pocket style machine for trimming pullets, which uses gas from a cigarette lighter as its heat source.

Electric soldering iron

Wilfred, *et al.* (1982) reported on a simple inexpensive device used for beak-trimming birds consisting of an ordinary electric soldering iron commonly used by the radio mechanic for soldering. A disk or coin made of brass or copper was welded to the tip of the soldering iron and the projecting edge of the circumference of the disc was sharpened like that of a blade. When the soldering iron was connected to the wall plug the temperature of the sharpened disc at the tip attains the maximum temperature (lead melting point 327°C) within a few minutes, which is quite sufficient for cauterising the beak.

Hot blade machines

Following the development of the "debeaker" in 1943 there have been refinements to the machine including some control of cutting, cauterisation and blade temperature. However control of blade temperature is still assessed mostly by the colour of the blade, although thermocouples are available for measuring blade temperature. The most common indicator of temperature is the dark (dull) red heat with an approximate temperature of 650-750°C. The cherry red colour (850-950°C) is used for toe clipping.

The Lyon Electric Company in San Diego, California has been manufacturing hot blade beak-trimming machines for beak-trimming layers, broilers and turkeys for over 50 years. The Lyon Company (1982) suggest that precision beak-trimming of 6-10 day-old chicks is one of the most accurate methods available, using either the Super V precision beak-trimmer or the Dual Debeaker. The machines have a timed cauterisation of 2 sec and Lyon suggests that when properly done, this method of beak-trimming will last for the productive life of the bird. Both models of the beak-trimmer are available in water-cooled and waterless models. Lyon also market a Super TT Debeaker which has been designed primarily for beak-trimming birds from 3-6 weeks-of-age, but can be used to trim beaks of birds up to 12 weeks-of-age, but proportionally less beak is removed at this age. With the TT method the bird is held sideways at a 90° angle to the blade. Both beaks are trimmed and cauterised simultaneously with an inward slant. Older bird beak-trimming is performed with the Super V beak-trimmer but blades used for cutting are heavier. Lyon recommends that when birds are beak-trimmed up to 12 weeks-of-age, two-thirds of the upper beak is removed but no closer than one-eighth of an inch to the nostril. If the lower beak is trimmed it should protrude beyond the upper beak by one-eighth of an inch. Beak-trimming birds over 12 weeks is generally accomplished by removing two-thirds to three-quarters of the upper beak again determined by the birds age and maintaining a distance of one-eighth of an inch from the nostril. This severity of beak trimming is far greater than is allowed under Codes of Practice in some countries.

Cold blade methods

Kennard (1937) was the first to use a method where the tip of the beak was separated from the deeper structures by traction or tearing. A short cut was made into one side of the beak only, extending into the margins about one-sixteenth to one-eighth of an inch (depending on the size of the beak) at a point one-eighth to one-quarter of an inch posterior to the tip. The flat side of the knife blade was placed against the cut portion of the beak and raised to loosen the edge. The tip was removed by applying traction toward the opposite side and down toward the lower mandible.

Peckham (1984) and Gleaves (1999) report also using a temporary form of beak-trimming using a sharp jackknife. A nick is made in the beak about one-quarter of an inch from the tip, with the thumb holding the cut portion of the beak against the blade. The knife is rolled around the tip of the beak tearing off the horny portion and exposing the quick. If properly done there is little bleeding. It is not recommended to cut into the quick without cauterisation.

Grigor, *et al.* (1995) used a pair of secateurs at 1, 6 or 21 days, to trim the upper beak of turkeys. There was bleeding from the upper mandible, which ceased shortly after the operation. Despite regrowth of the beak a reduction of cannibalism was noted. Gentle, *et al.* (1997) used secateurs to remove one third of the upper beak in Isa Brown chickens. There were very few differences observed between behaviour and production of the hot blade and cold blade trimmed chickens. Gleaves (1999) recommends the use of a dog nail clipper for trimming beaks to protect against early cannibalism.

Robotic beak-trimming

Bock and Samberg (1990) reported information on the “Robot AG 4500” made by Gourlandt Industries Inc., Zoo-Techniquews, France which permits simultaneous, automated beak-trimming, Marek’s (sub-cutaneous injection) and Newcastle-Bronchitis (eye-drop) vaccination of day-old chicks. This equipment has the ability to treat up to 4,500 chickens per hour. While the AG 4500 is suitable for vaccination some problems emerged with the beak-trimming. The chicks were loaded onto the robot by hand being held by cups around their heads. If the chickens were not loaded correctly they could drop off the line, receive excessive beak-trimming or very light trimming because they were not positioned correctly on the holding cups. In addition it was observed that the machine could not beak-trim chickens effectively if there was a variation in the weight or size of chickens. The robot beak trimmer was used in Australia for a short period but was not successful.

Chemical beak-trimming

Lunam and Glatz (1996) reported on the use of capsaicin applied at the time of conventional hot blade beak-trimming to retard beak growth. Capsaicin is a cheap non toxic substance extracted from hot peppers. Applied topically or orally to mammals it induces a short term burning sensation. In contrast to this effect in mammals, capsaicin is reported to induce only mild behavioural responses when applied topically to birds (Mason and Maruniak, 1983). Some bird species demonstrate a preference for food containing capsaicin. However, capsaicin does cause depletion of certain neuropeptides from sensory nerves in birds and thus may cause desensitisation as it does in mammals. Although the long-term effect in birds is not known, capsaicin can cause degeneration of sensory nerves in mammals. It is well known that if the nerve supply is removed or prevented from reinnervating a particular tissue, then the tissue will degenerate. Lunam and Glatz (1995) showed that capsaicin decreases the rate of beak regrowth, and hence the need for re-trimming by its action on the sensory nerves, but operators must avoid contact with the substance during its application to the beak. The feeding ability of birds improved with capsaicin administration in the feed and therefore has the potential to reduce the percentage of birds that do not eat after beak trimming. (Glatz, 1990).

Bio beak-trimming

The Bio-Beaker uses a high voltage electrical current to burn a small hole in the upper beak of chickens. In the 1980's the Bio-Beaker (Sterwin Laboratories, Millsboro, Delaware, USA) was developed which used a high voltage arc (1500 Volt AC electric current) across two electrodes to burn a small hole in the upper beak of chickens. Up to 2000-day-old chicks could be beak-trimmed in an hour using this process. The chicks being bio-beaked struggle as the beak is inserted into the mask of the instrument and also when the current is passed. Grigor*, et al.* (1995) reports that it takes 0.25 seconds to burn a hole in the beak. The primary advantage of the Bio-Beaker is that an adequate beak-trim is achieved during the first day of life, making the unit ideal for use in the hatchery. This allows treated chickens to eat and drink normally for the first few days with their beaks intact. It was originally hoped that after a period of 3-7 days, the portion of the beak forward of the hole (tip of the beak) would die and slough off leaving a rounded stump. The aim was to burn a hole in the upper beak at a point just beyond the horny projection. In about 4 days the chick should begin to lose that portion of the upper beak from the hole to the tip and by 10-14 days-of-age, this portion of the beak should be completely lost from all the chickens.

Unfortunately in many chicks the tip of the beak did not slough off and birds had to be re-trimmed using conventional equipment. In turkeys, however, the bio beaker was more successful (Grigor, *et al.* 1995) with the beak tip falling off in 5-7 days and the wound healing within 3 weeks (Noble and Kestor, 1997). Renner, *et al.* (1989) found that severe arc beak-trimming 1 mm from the nostril in turkeys increased mortality relative to hot blade trimming. In contrast Noble, *et al.* (1994) compared arc trimming and intact beak males and found no difference in mortality of male turkeys.

Not unrelated to the bio-beak process was the method developed for broiler chickens by Smith (1997) who used the hot blade to burn an area near the tip of the upper beak. The procedure allowed a thin base to exist to the tip of the beak. The chick could eat and eventually the upper beak dropped off.

Freeze drying method

O'Malley (1999) used liquid nitrogen to declaw emus but found the conventional hot blade method was more effective. The freeze dry method was costly, time consuming and regrowth of the claws occurred. Development of equipment that could freeze and cut the beaks, however, may be worth investigating.

Infrared beak treatment

Infrared Beak Treatment is a patented process developed for the poultry industry by Nova-Tech Engineering of Willmar, Minnesota, USA. The Nova-Tech beak treatment system uses a non-contact, high intensity, infrared energy source to treat beak tissue and is a bloodless procedure. The infrared technology allows penetration of the hard outer corneum layer of the beak. By penetrating the corneum, the underlying basal tissue of the beak is treated, thus affecting the regeneration of the corneum. Initially, the hard corneum remains intact, protecting the treated soft basal layer tissue. Immediately following the process, the beak looks physically the same as it did before the process and the bird is able to continue to use its beak. However, a closer look at the beak reveals a whitening of the basal tissue and a white dot on the top of the beak. Within a week the beak softens, and by two weeks after the treatment the sharp hook of the beak erodes away as the bird uses its beak. Because the infrared process initially affects mostly the basal tissue, a bird at four weeks of age will have a longer beak than a bird that has undergone a traditional beak cutting method. By twelve weeks of age, however, the infrared treated beak will be shorter than the beak cut with the hot blade.

A head holding fixture (specific for turkeys, chickens and ducks) allows repeatability and accuracy. The head holder was generated from a mould of the specific species average size head. Therefore, the entire front of the bird's cranium becomes the reference point to maintain consistent, repeatable treatment over wide range of bird size. Birds with a larger cranium will naturally reference the beak back farther versus smaller birds.

The amount of infrared energy applied to the beak is fully programmable. Therefore, variations in bird size due to flock age are accommodated. Jim Sieben (pers. comm.) indicates that each bird species and even breeds within a species respond favourably to an appropriate beak treatment setting. Each hatchery can set the treatment level to satisfy their customer's demands and expectations.

The Infrared Beak Treatment process is an integral part of the Poultry Services Processor (PSP). The system was designed to minimize the amount of bird handling. Therefore, the system was designed to administer several treatments after the bird is loaded. Currently a liquid vaccination injection and bird counter are available options. In the future, a nasal vaccination and the eye vaccination will be integrated into the standard PSP unit.

Another advantage of the PSP unit is that it is only leased requiring no capital equipment costs. Nova-Tech Engineering installs and maintains the system for a lease rate. Replacement spare parts and a customer service are covered in the standard lease agreement. The PSP is divided into removable modules and is monitored via a communication system and on site computer. Machine malfunctions can be detected and diagnosed from facilities in the U.S.A.

Laser beak-trimming

Van Rooijen and van der Haar (1997) reported on a laser method, which cuts the beaks of day-old chickens with a laser beam. No details were provided by the authors on the type of laser used, or the severity of beak-trimming. By 16 weeks the beaks of laser trimmed birds resembled the un-trimmed beaks, but without the bill tip. Unfortunately, feather pecking and cannibalism during the laying period were highest among the laser trimmed hens. These results suggest that the severity of beak trimming by laser was insufficient, enabling regrowth of the beaks. It might be expected that use of laser beak-trimming, would enable greater uniformity in beak-trimming and improved welfare because the beak would not require cauterisation. Laser beak-trimming may represent a welfare advance but further work is required with this technology before it can be applied in industry. Van Rooijen reported it might be expected that use of laser beak-trimming, would enable greater uniformity in beak-trimming and improve welfare.

Types of laser machines

Lasers operate by sending energy to the target tissue; the heat is absorbed and in the process if the beam is strongly directed will result in cutting of the tissue. During the procedure patients feel intense emissions of light, each pulse lasting a fraction of a second on the area being treated (www.ienhance.com). Many lasers are equipped with cooling systems to decrease temperature on the treated area, providing a mild anaesthetic effect. Patients normally feel a burning or stinging sensation.

Contour lasers or long pulse erbium lasers

Contour lasers are used in human medicine for surgical applications requiring the excision, incision, ablation, vaporisation and coagulation of tissue (www.sciton.com). Surgical specialities and applications in humans include general surgery, plastic surgery, aesthetic surgery, dermatology, thoracic surgery, oral and maxillofacial surgery and arthroscopy. Use of a long pulse erbium laser allows laser surgeons to independently select the depth of ablation and coagulation. Surgeons are able to choose the depth of treatment required to achieve effective results to within a few microns resulting in an extremely repeatable and uniform treatment.

Image or long pulse ND: Yag lasers

In human medicine the ND Yag lasers are used for hair and treatment of skin lesions. The lasers have an effective cooling system applied before, during and after each pulse, providing some prevention of pain. The system delivers laser energy via a computer controlled large area scanner greatly facilitating the operation (www.sciton.com)

Coherent CO_2 Laser

In the CO_2 laser the pattern generator uses two galvanometers to rapidly steer the beam over a selected pattern (line, hexagon, diamond, square etc.) allowing areas of up to 1 cm^2 to be treated with precise control. When the laser is not actually cutting, the generator scans the aiming beam in an outline to show the areas that will be treated. To cut the beak it is a matter of aligning the orientation and position of the handpiece against a reference point on the beak, press the pedal and cut the beak.

Chapter Two: Materials and Methods

Rationale

The rationale for these studies was to find a laser trimming machine, which could be utilised to cut the beak of chickens and perhaps offer an alternative to hot blade trimming. The hypothesis was that the ophthalmic lasers used in human medicine would have the power to enable efficient cutting and cauterising of the beaks in live chickens.

Nd: YAG Ophthalmic laser

Ellex Lasers Pty Ltd, 74-86 Gilbert Street, Adelaide made available a LQ2106 Integrated Nd: YAG opthalmic laser (Fig 1.) for use in the study. The machine with a weight of 62 kg and dimensions of 940 x 470 mm was mounted on a bench. The laser was set at 1.5 Watts, with a 4 second pulse using a 50-micron spot size. A joystick was used to manoeuvre the green laser beam onto the beak sample. The firing mechanism was set up as a foot pedal leaving the hands free to guide the laser spot onto the beak using the joystick. The operator was provided ocular safety glasses to ensure the operator sustained no eye damage from stray laser beams during the operation.

Figure 1. Opthalmic laser

Beak tissue

One dozen surplus male chicks were obtained on the day of hatch from the HiChick Breeding Company hatchery at Bethel in South Australia. Birds were killed by cervical dislocation. A sharp pair of surgical scissors was used to remove the upper beak about 1 mm below the external nare. Beak sections were kept on ice and immediately transported to the laboratory for laser cutting. The delay between killing the bird and laser trimming of beak sections was about 3 hours. The beak section was embedded in plasticine and fixed to the cross bar at the rear of the laser machine. The laser spot (50-microns) were focused on the tip of the quick (or bone) about 3 mm from the tip of the beak. The foot pedal was activated and with the aid of the binocular viewfinder, the joystick was used to manoeuvre/drag the laser beam across the beak to cut it. The binocular viewfinder on the machine enabled a close view of the laser cutting the beak as it occurred.

Live Birds

Spot sizes and cutting duration

One dozen surplus female layer chicks were obtained on the day of hatch from the HiChick Breeding Company hatchery at Bethel in South Australia. Chicks were reared in a mini brooder and at five days of age taken to the laboratory for trial runs on laser cutting. A range of spot sizes (50, 200 and 1000 microns) with cutting duration of 2 and 4 seconds were examined to determine the most effective treatment for cutting the beak and coagulating the cut tissue to prevent bleeding.

Laser trimming

Thirty day-old Hyline brown chicks were purchased from the Hyline Hatchery in Huntley, Victoria. An experienced beak trimmer removed the beak tip of 10 birds on the day of hatching using a hot blade trimmer. Ten birds were trimmed using the laser trimming method at Ellex Laser Systems laboratory. Ten birds (not trimmed) were the control. Upper beak length (measured with vernier calliper) and body weight were measured at day old, 5, 9 and 12 weeks-of-age. Observations were made on the appearance of the beak stump. Each of the treatment groups were housed in mini brooders maintained at 30, 29, 27.5, and 26°C from weeks 1-4 respectively. At 4 weeks of age birds were transferred to grower cages (10 birds/cage) and housed in a naturally ventilated pullet rearing shed and reared to 12 weeks of age. Chicks were fed from 0-4 weeks on a commercial chick starter crumble and thereafter fed a grower crumble.

Procedure for laser trimming of live chickens

The laser beam was focused onto the edge of the quick (or bone) on the upper beak about 3 mm from the tip of the beak. The chicks were gently picked up, held in the palm of the hand with the thumb at the back of its neck and the forefinger under the throat. When the beam was in position a slight squeezing action was applied to the throat of the bird, the foot pedal activated and the laser beam manoeuvred across the beak surface with the joystick while the laser operator viewed the cutting through the binocular viewfinder. The laser cutting was carried out in the same way that hot blade trimming is conducted with the laser beam cutting the beak across the dorsal surface with the beam coming down from above onto the surface of the beak. In addition cuts were made on the beak in the lateral aspect.

Alternative lasers

Beak samples from surplus day old male chickens from HiChick Breeding Company hatchery were obtained as before and transported to the Physics Department, University of Adelaide. A green laser, ND Yag and $C0_2$ laser were tested. Each laser was set up so that a rapid cut of the beak could be examined. Each laser was set up with a 1 second pulse, a range of spot size and power settings to determine the most effective laser in cutting a beak sample.

Animal ethics

The animal ethics committees of the Department of Primary Industries, South Australia and the University of Adelaide gave approvals for these studies.

Location

The laser trimming was carried out in laboratories in the city of Adelaide and the bird studies at Roseworthy Campus, University of Adelaide located 60 km north of Adelaide and 10 km east of Gawler in South Australia.

Statistical Analysis

Base SAS software (SAS Institute, 1988) was used to analyse the beak length and body weight data. Analysis of variance by GLM procedure was used to determine the significance of the main effects (beak trimming method and age) and interactions on beak length and body weight.

Chapter Three: Results and Discussion

Laser cutting of beak tissue samples

An ophthalmic laser was set at 1.5W, with a 4 second pulse using a 50-micron spot size. The laser successfully cut through an upper beak sample from a cull chicken. Two passes of the laser beam were required to complete the cut. There was insufficient power in the laser beam to cut the beak tissue in one action and cutting took about 10-15 seconds. Nevertheless the cut was very straight and clean. While the cut was being made the characteristic smoke and smell of burnt beak tissue was experienced and caused a problem in the local work environment for people working with other lasers. The use of the binocular viewer enabled a close up view of the beak while the laser was cutting the tissue. Fitting of conventional hot blade machines with such a viewer would be useful and enable operators to locate the exact spot where to cut the beak and increase precision. The toggle switch to manoeuvre the laser beam was easy to operate, although it required some practise to keep the laser beam steady. While looking through the binocular viewfinder it appeared that the cut being made was not straight. However when viewed with the naked eye the cut looked straighter than the cuts made with a hot blade.

Establishing spot size for laser trimming of live birds

The live bird studies with 5-day-old chickens established the spot size to enable coagulation of the tissue and prevent bleeding. When a 50-micron spot size was used for duration of 2 seconds there was insufficient energy density of the laser beam on the tissue to cause coagulation and the beak began to bleed. There was little behavioural response (struggling or vocalising) from the birds in response to the laser cutting the tissue with the 50-micron spot size. The spot size was increased to 200 microns with a cutting time of 2 seconds. The birds vocalised more in response to the increase in energy density indicating they were perhaps feeling more discomfort. There was no bleeding from the wound indicating that the 200 micron spot size was effective in sealing the wound as there was no blood loss. Increasing the spot size to 1000 microns was also effective but the birds struggled and vocalised considerably.

Laser cuts of the beak tissue of live birds

The laser was able to cut through the outer layers of keratin, but was not able to cut the inner bone. Attempts were made to cut the bone (near the tip of the quick) using the 1000-micron spot size. This was not successful. It was considered that there was not enough power in the beam to achieve the cut. The laser beam was passed across the bony tip numerous times for a number of birds without success. The chicks were positioned such that laser cuts were made from dorsal, ventral and lateral position of the beak. Each of these positions for cutting the beak could be utilised in any equipment developed specifically for laser trimming of birds. Because the birds used for this aspect of the trial were 5 days-of-age it was felt that the inner bone might be much harder than a newly hatched chick. Therefore it was decided to proceed with a laser trimming trial using day old chicks. Previously in laser cuts on beak sections from killed chickens it was shown that it was possible to cut the bony portion and it was assumed in a day-old live bird this would also be the case.

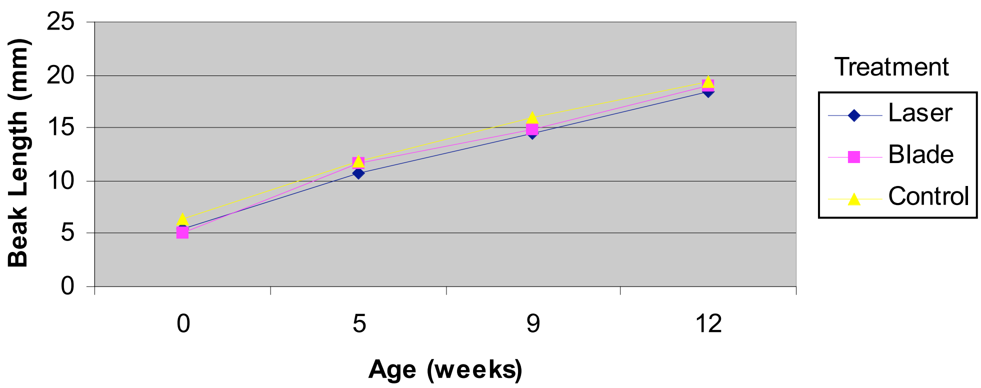
Laser trimming of day-old chickens

It was postulated that laser cutting of the beaks of day-old chickens would be more successful than cutting the beaks of chickens that were five days-of-age. However when using the opthalmic laser set at 1.5W, with a 200 micron spot size and 4 second pulse it would appear that the bony tip at day old was still too hard for the opthalmic laser to penetrate. After the chickens were killed the bony tip in the beak tissue may lose some of its hardness or hardness may have been reduced by storage on ice. Clearly there was a need to use a more powerful laser. There was no significant difference in the beak length (figure 2) and body weight (figure 3) of control birds, laser trimmed or trimmed with a hot blade. In a previous study by Van Rooijen and van der Haar (1997) the beaks of birds trimmed with a laser also regrew to about the same length as the control birds suggesting that either the bony portion of the beak was not cut and cauterised or insufficient beak was removed. In the current study there were no apparent problems with healing of the beak stump. The cuts that were made looked cleaner and straighter than the hot blade cuts. As the birds aged the beak tissue sloughed off at first as the stump wound healed. Then regrowth of the beak occurred. There was one bird where the bony tip appeared to be effectively cut and cauterised. The beak regrowth of this bird (bird L8-figure 4) was substantially less than some other birds. However the beak length of this bird was still 5 mm longer than industry standards at this age and would require further trimming (figure 5).

Use of higher power lasers

The lack of success in being able to cut the bony portion of the beak with an opthalmic laser was considered to be due to the lack of power to cut bony tissue. This is probably not surprising given that opthalmic lasers are used to surgically remove or cauterise soft tissue. Higher power lasers were required. A green laser, ND Yag and CO_2 laser were tested. The CO_2 laser with a 1 second pulse, 50-micron spot size and power rating of 10W was the most effective laser in cutting a beak sample. The lasers were set up in a physics laboratory doing high precision laser experiments. The smoke from the burning tissue caused some problems with the set up of these experiments.

Figure 2. Average upper beak length versus age for laser trimmed, beak tipped and non trimmed birds.



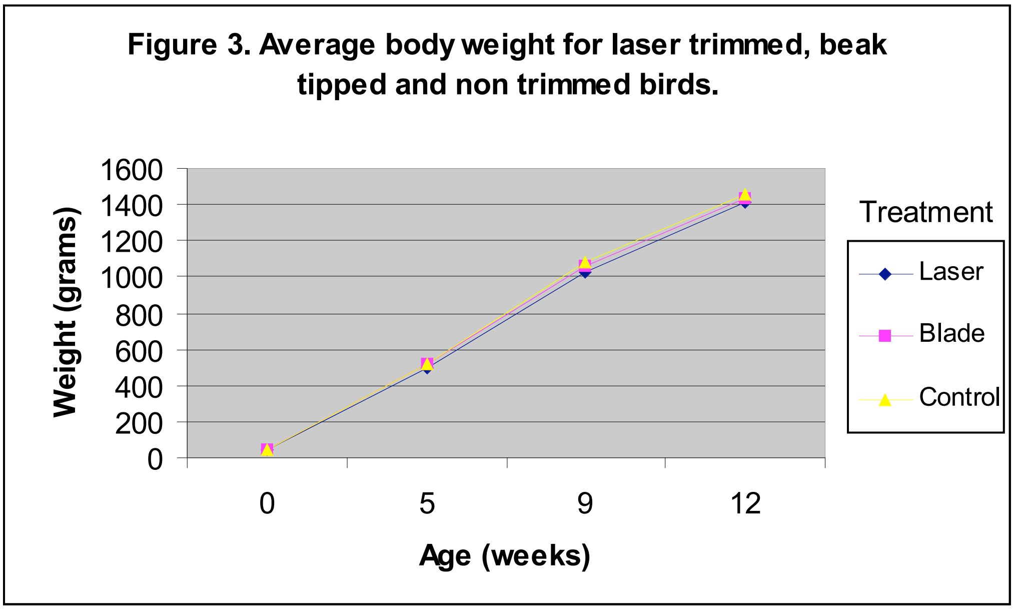


Figure 3. Average body weight for laser trimmed, beak tipped and non trimmed birds.
Weight (grams)
1600
1400
1200
1000
800
600
400
200
0
0
5
9
12
Age (weeks)
Treatment
Laser
Blade
Control

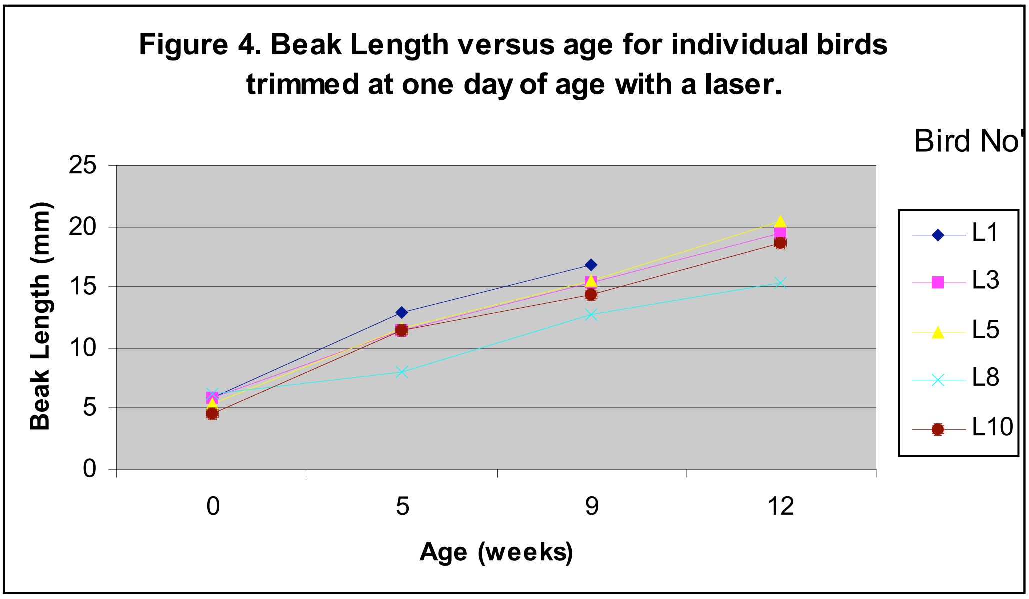


Figure 4. Beak Length versus age for individual birds trimmed at one day of age with a laser.
Bird No'
Beak Length (mm)
25
20
15
10
5
0
0
5
9
12
Age (weeks)
L1
L3
L5
L8
L10

Figure 5. Left of picture is control pullet (not trimmed) versus laser-trimmed pullet at 12 weeks-of-age

Future for laser trimming

These experiments have shown that there is potential to use lasers for beak trimming. This project has demonstrated the spot size required to cauterise the beak, and the power to cut the beak. Further work is now required to develop a prototype laser beak trimming machine. Discussion between the laser specialists after this initial project has recommended the following for any future development.

- Develop a beam shape, which can cut the beak using either a spot beam or one with a 'blade type' appearance. This will require modification and testing with existing equipment.
- Develop the technology to automate the cutting process (beak measurement, cutting position and cutting time). A computer-controlled system could take an instant photograph of each beak, followed by measurement and then automatic positioning of the laser to cut near the bony tip of the beak.
- It is envisaged there will be a bird handling facility where chicks can be either manually picked up, one in each hand, and the beaks placed in a hole or placed onto a device with a head holding fixture. An instant measurement would be made of the beak length and the laser beam directed at the appropriate spot on the beak to achieve the correct cut and cauterisation. This process should take 1-2 seconds/bird. For operator safety it would be necessary for the laser equipment to operate in a well or chamber to avoid worker exposure to the laser beams.

Chapter Four: Implications

Precision of beak trimming and improvement in poultry welfare could be obtained by developing a laser beak-trimming machine.

Chapter Five: Further research

- Develop a prototype laser beak-trimming machine.
- Research the beam shape required for the most effective cutting of the beak.
- Utilise computer technology to automate the beak trimming process (beak measurement, cutting position and cutting time).
- Develop a bird handling facility for manual or automatic laser trimming.

Chapter Six: Communications Strategy

Subject to AECL approval the findings from this study will be communicated to Industry as follows:

Present the results of this study to the following conferences if possible:

- 2005 Poultry Science Symposium in Sydney
- 2005 European Welfare Symposium

Findings will also be communicated via:

- Refereed scientific journals
- Magazines
- Presentations at producer meetings

Chapter Seven: References

EN.REFLIST