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Declawing of Farmed Emus

Harmful or Helpful?

A report for the Rural Industries Research and Development Corporation

by Dr Christine A. Lunam and Dr Philip C. Glatz

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Foreword

Declawing of commercially farmed emus has been a long standing controversial issue. In Australia, declawing is performed to both alleviate damage to the skin during aggressive behaviours and to reduce the risk of injury to handlers, particularly during transport of the emus. Thus, the benefits of declawing are economic, preventing an annual loss to the industry of five million dollars from damaged hides (100,000 hides reduced in value from $80 to $30), improved worker safety and improved animal husbandry by protecting emus from inflicting injury upon themselves.

A major concern by animal welfare groups, farmers and government bodies is that the declawing procedure itself may cause unacceptable levels of discomfort and pain to the emus.

There is no feasible alternative to declawing. Consequently, this report scientifically evaluated the effects of declawing on the welfare of farmed emus to either give credibility to declawing if it is to remain as a husbandry procedure, or to determine if alternative farming methods needed to be developed. Without scientific evaluation of declawing, it was not possible to assess whether declawing is a beneficial husbandry procedure, by preventing emus from injuring themselves, or whether declawing causes unreasonable pain. Without this information, the emu industry would remain in limbo with respect to declawing, vulnerable to criticism by welfare groups, government bodies and the community at large.

The data obtained from this study suggests that declawing does *not* compromise the well-being of the emus. Furthermore, behavioural data suggests that declawing may promote the well-being of the emus by improving social structure in emu flocks and by reducing aggressive behaviours.

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Peter Core
Managing Director
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- Mr Tommy Tonkin for his advice and untiring support in getting this project off the ground.

- Mr Geoff Lean for providing access to his emu farm at short notice to enable filming the behaviour of the emus. Geoff for installing additional fencing on his property specifically for the filming studies and the loan of his portable generator to provide power for the camera equipment. We thank Geoff also for allowing continued access to his property for the duration of this project for video-taping of gait and for the footprint studies, as well as for providing emu tissue for histology and assistance with tissue collection.

- Mr Bruce Makin for providing access to his emu farm for the duration of the project and his hands-on assistance with collection of the footprint data and filming of gait. Bruce's enthusiastic assistance in collection of tissue samples for histology, often at short notice. We are particularly grateful to Bruce for agreeing to slaughter some of his breeder stock so that adequate numbers of clawed control toes could be attained.

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- Ms Lauren Kingston and Mr Tom Loveday for their expert assistance with the preparation of tissue samples for histology and for assistance in obtaining the footprint impressions.

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Executive Summary

Declawing as a husbandry procedure

Declawing has been a long-standing controversial husbandry procedure in commercial emu farming in Australia. The procedure is performed to alleviate scarring of the skin from healed wounds inflicted by the claws during aggressive behaviours of the emus, and to reduce the risk of injury to handlers, particularly during transport of the emus. Thus, the benefits of declawing are economic, preventing an annual loss to the Industry of $5 million from damaged skins (100,000 skins reduced in value from $80 to $30), improved worker safety and improved animal husbandry by protecting emus from inflicting injury upon themselves.

A major concern is that the declawing procedure itself may cause unacceptable levels of discomfort and pain to the emus. To ensure permanent removal of the claw, the distal portion of each toe is removed at the last joint. Severed nerves resulting from the removal of the claw and surrounding tissue may heal abnormally. These abnormal nerves may cause increased sensitivity of the toes and long-term pain. Acute pain could result from altered sensitization of the nerves to touch and temperature. Long-term pain could result from the development of extensive tangles of regenerating nerves, known as traumatic neuromas. Traumatic neuromas can send spontaneous signals to the brain. These signals can be interpreted as chronic pain which can persist for many months or even years. A well-documented example of this phenomenon is phantom limb pain reported by human amputees who feel pain from the "phantom limb" for many years after amputation.

Birds are digitigrade animals, that is they walk on their toes. Moreover the enhanced size and decreased number of toes of the large flightless birds such as emus, are considered to have evolved to accommodate high levels of mechanical stress exerted on the toes, particularly during walking and running. Therefore, declawing which involves partial removal of each toe is likely to pose considerable alteration to the gait of the emu. Surprisingly, no information is available concerning either the functional anatomy of the emu toe or the biomechanics of the emu gait.

It has been suggested in the scientific literature that chronic pain could modify specific walking behaviours including social behaviour. Tissue and bone damage resulting from declawing could result in persistent pain with the emu engaging in protective guarding behaviour and other pain-coping behaviours. The behaviour of declawed emus in a farm environment has not been described despite the importance of declawing to the husbandry and welfare of the emu.

Rationale for this study

At present there is no feasible alternative to declawing. Segregation of emus according to age and sex does not eliminate fighting and bullying among the emus. Consequently, the effects of declawing on the welfare of farmed emus needed to be scientifically evaluated to either give credibility to declawing if it is to remain as a husbandry procedure, or to determine if alternative farming methods needed to be developed. Without scientific evaluation of declawing, it was not possible to assess whether declawing is a beneficial husbandry procedure, by preventing emus from injuring themselves, or whether declawing causes unreasonable pain.

Methodology

A multidisciplinary approach was taken to investigate the effects of declawing on the welfare of farmed emus. The effects of declawing on the histology of the toes were compared with gait and behavioural measurements to assess whether declawing induces discomfort or long-term pain. To this end the study was designed to address the following questions:

- What is the normal histology of the clawed toe? How important are these structures to gait?
- Do the declawed toes demonstrate histopathology that would suggest either increased sensitivity or chronic pain, that is, the presence of either an inflammatory response suggesting the former condition or traumatic-neuromas raising the possibility of long-term pain?
- Does declawing affect the gait of the emus? Is any alteration in gait likely to be the result of increased sensitivity of the declawed toes or as a result of altered weight bearing capacity of the foot?
- Does declawing cause permanent changes in the locomotion and general behaviour of emus in a farm environment? Would these changes suggest that the emus are suffering persistent pain?

Emu chicks were declawed soon after hatch and reared on two commercial emu farms, at Waikerie and Keith, in South Australia. The effects of declawing on gait were assessed by viewing slow motion video recordings of walking and by analysing footprint impressions of clawed emus compared to that of declawed emus. Gait studies were conducted at both Waikerie and Keith. The effects of declawing on behaviour was determined by viewing videotapes of clawed and declawed emus filmed at the emu farm in Waikerie. Toes for histological assessment were obtained at slaughter from two commercial abattoirs in South Australia. All studies were conducted on adult emus.

Effects of declawing on histology and on gait

These studies were designed to assess the effects of declawing on the welfare of farmed emus. Criteria used to assess welfare were the presence or absence of extensive regions of disarrayed nerve fibres (traumatic–neuromas) and inflammation within the declawed toes. The former is indicative of persistent long-term pain, and the latter is associated with acute pain when pressure is applied to the toes. The effects of declawing on gait was evaluated by assessing the pattern and surface area of footprint impressions and by viewing videotape footage of the emus walking.

Thirty emus were declawed at hatch and a further thirty emus were not declawed and served as controls. The emus were raised on commercial farms in South Australia. All studies were conducted on adult emus of similar age.

Histological examination of 60 clawed toes demonstrated the presence of receptors for detecting pressure, numerous blood vessels and many nerve bundles. The skin was very dense and consisted of a thick keratin water-proof layer, with well developed scales, and an inner cellular layer. Beneath the skin, the elastic and collagen fibers were abundant throughout the toes. A type of elastic cartilage (chondroid-tissue) was well developed in the distal region of the toes. No differences were observed in the distribution of these structures between the toes. Toes from 20 declawed emus revealed that all toes had completely healed. There was no evidence of inflammation in the tissue. None of the toes had extensive chaotic nerve-tangles typical of traumatic-neuromas. Small regions of abnormal nerves (microneuromas) were observed in toes of six of the declawed emus. Four emus had microneuromas in at least two but never all six toes.

Declawing significantly altered gait; the 30 declawed emus tended to be more flat-footed than the 30 clawed emus. Declawing increased the surface area of the footprint, thereby reducing the overall pressure exerted on each foot during walking. No statistically significant differences were observed in the footprints between the right and left feet of any individual emu.

These results indicate that declawing close to the time of hatch using a hot-blade de-beaker, leaving part of the distal phalanx intact, is unlikely to compromise the well-being of commercially farmed emus. The absence of both inflammation and extensive neuromas in the declawed toes suggests that the emus do not suffer either acute or chronic pain. The data suggests that the alteration in gait after declawing is a response to the altered weight bearing capacity of the toes, rather than as a result of acute pain inflicted on the toes during walking.

Effects of declawing on behaviour

This study tested the hypothesis that declawing of emus at hatch causes chronic pain, which persists throughout the life of the bird resulting in permanent changes in the locomotor and general behaviour of emus.

One group of 40 emus was declawed on the day of hatch by removing the distal phalangeal joint using a Lyon beak-trimming machine. Another group of 40 emus not declawed were used as the control group. Declawed emus one year of age were allocated to a paddock 250 m x 125 m, while the control emus were placed in an adjoining paddock of the same dimensions. One hour video records of individual emus from each treatment were made from 08:00 and 17:00 h over 2 periods; firstly when food and water was available and secondly during a stress period when food and water was not available after being withdrawn over night.

Inactive, ingestive, posture change, grooming, aggressive and locomotor behaviours were monitored from the video records. There was no behavioural evidence to indicate that declawed emus had a loss of locomotor ability or to suggest declawed emus were suffering from severe chronic pain. To the contrary declawed emus engaged in significantly more bouts and time of the searching behaviour (walking through the paddock with head lowered). Furthermore declawed emus engaged in less stereotype pacing and pecking indicating they were under less stress and not as frustrated as the control birds which were more aggressive.

Modelling analyses revealed that pecking behaviour of emus was most closely related to foraging behaviour. Birds subject to pecking attacks demonstrated high levels of stereotype behaviour presumably to cope with the increased aggression.

The behavioural evidence in this study would suggest that declawing does not compromise the locomotor ability of emus and has the benefit of improving social structure in emu flocks by reducing stereotype behaviour and aggression.

General conclusion

The data obtained from this study suggests that declawing does not compromise the well-being of the emus. The histology of the toes, in particular the absence of both an inflammatory response and extensive neuromas, suggests that acute and chronic pain are unlikely consequences of declawing. Behavioural data suggests that declawing may promote the well-being of the emus by improving social structure in emu flocks and by reducing aggressive behaviours.

1. GENERAL INTRODUCTION

Declawing is increasingly practiced in commercial emu farming in Australia. The procedure is performed to both alleviate damage to the skin during aggressive behaviours and to reduce the risk of injury to handlers, particularly during transport of the emus. Thus, the benefits of de-clawing are economic, preventing an annual loss to the Industry of $5 million from damaged hides (100,000 hides reduced in value from $80 to $30), improved worker safety and improved animal husbandry by protecting emus from inflicting injury upon themselves.

Declawing is however, a controversial issue, the major concern being that the procedure itself may cause unacceptable levels of discomfort and pain to the emus. To prevent regrowth of the claw the distal phalangeal bone of each toe is removed. Severed nerves resulting from the removal of the claw and surrounding tissue may undergo abnormal physiological responses. Peripheral nerve injury can result in increased sensitization of the nerves to mechanical and thermal stimuli, altered pain thresholds and allodynia, a condition in which normally non-noxious stimuli becomes painful (Woolf, 1989).

Another potential concern is the development of potentially painful neuromas that may persist for the life of the emu. Traumatic neuromas consist of abnormal masses of regenerating nerve sprouts. These may form as either large masses or may develop as small scattered multiple fascicles of axons to form microneuromas (Devor and Rappaport, 1990). In domestic fowl, severing the nerves during partial removal of either the toes (Gentle and Hunter, 1988) or beak (Gentle, 1986; Lunam and Glatz, 1995; Lunam *et al.*, 1996) results in the formation of persistent neuromas. Conservative trimming of the beak of layer-chicks on the day of hatch greatly reduces the incidence of neuromas that persist to adulthood (Lunam, *et al.*, 1996). As is the case with beak-trimming of domestic fowl, the development of persistent neuromas in the declawed toes of emus may be dependent both on the age at which declawing is performed, and the amount of tissue amputated.

Birds are digitigrade animals, that is they walk on their toes. Moreover the enhanced size and decreased number of toes of the large flightless ratites, are considered to have evolved to accommodate high levels of mechanical stress exerted on the toes, particularly during running. Therefore, declawing which involves partial removal of each toe is likely to pose considerable perturbation to the gait of the emu. Surprisingly, no information is available concerning either the functional anatomy of the emu toe or the biomechanics of the emu gait.

Zimmerman (1986) reports that chronic pain could modify specific walking behaviours including social behaviour. Chronic pain is observed in orthopaedic disease and in some cases following peripheral injury (Gentle, 1992). It could be inferred that tissue and bone damage resulting from declawing could result in persistent pain with the emu engaging in protective guarding behaviour and other pain coping behaviours. For example in heavy breeds of poultry with arthritic complaints, loss of locomotor function is common (Thorp, 1994). Animals with this condition are unwilling to stand or walk and there is evidence of one legged standing and limping as the bird attempts to cope with the pain. In less painful arthritic conditions animals are observed to change their posture frequently. The behaviour of declawed emus in a farm environment has not been described despite the importance of declawing to the husbandry and welfare of the emu.

A multi-disciplinary approach was taken to investigate the effects of declawing on the welfare of farmed emus. Anatomical structures, in particular the presence or absence of neuromas were compared with behavioural and gait measurements to determine whether declawing induces discomfort or long-term pain. The histology of the intact toes was compared to that of declawed toes to assess the extent of perturbation of the tissue. The effects of declawing on gait were assessed by viewing slow motion video recordings of walking and by analysing footprint impressions of clawed emus compared to that of declawed emus. Behaviour studies tested the hypothesis that declawing of emus at hatch induces pain, which persists throughout the life of the bird resulting in permanent changes in the locomotion and general behaviour of emus in a farm environment.

Emu chicks were declawed soon after hatch and reared on two commercial emu farms at Waikerie and Keith in South Australia. Gait studies were conducted at both Waikerie and Keith and all behavioural studies were carried out at Waikerie. Toes for histological assessment were obtained at slaughter from two commercial abattoirs in South Australia. All studies were conducted on adult emus.

2. OBJECTIVES

- To improve the welfare of farmed emus, worker safety and economic returns to emu farmers
- To determine the effects of declawing on the development of potentially painful neuromas (nerve tangles) in the toes
- To assess the effects of declawing on the biomechanics of walking and general behaviour of emus and evaluate what any changes may mean in terms of well-being
- Allay the current welfare concerns attributed to declawing by the providing sound scientific data for assessment of chronic pain
- To provide the Emu Industry with any welfare implications of declawing

3. EFFECTS OF DECLAWING ON NEUROMA DEVELOPMENT AND GAIT

3.1 Summary

These studies were designed to assess the effects of declawing on the welfare of farmed emus. Criteria used to assess welfare was the presence or absence of extensive regions of disarrayed nerve fibres (traumatic–neuromas) and inflammation within the declawed toes, the former indicative of persistent long-term pain, and the latter associated with acute pain when pressure is applied to the toes. The effects of declawing on gait was evaluated by assessing the pattern and surface area of footprint impressions and by viewing videotape footage of the emus walking.

Thirty emus were declawed at hatch and a further thirty emus were not declawed and served as controls. The emus were raised on commercial farms in South Australia. All studies were conducted on adult emus of similar age.

Histological examination of 60 clawed toes demonstrated the presence of Herbst corpuscles, numerous blood vessels and nerve bundles. The epidermis consisted of a dense outer corneum and an inner thick germinativum. Elastic and collagen fibers were abundant throughout the toes and adipose tissue was extensive in the lateral-ventral dermis. A type of elastic cartilage (chondroid-tissue) was well developed in the distal phalanx. No differences were observed in the distribution of these structures between the toes. Toes from 20 declawed emus revealed that all toes had completely healed. There was no evidence of inflammation in the tissue. None of the toes had extensive chaotic nerve-tangles typical of traumatic-neuromas. Small focal microneuromas were observed in toes of six of the declawed emus. Four emus had microneuromas in at least two but never all six toes.

Declawing significantly altered gait; the 30 declawed emus tended to be more flat-footed than the 30 clawed emus. Declawing increased the surface area of the footprint, thereby reducing the overall pressure exerted on each foot during walking. No statistically significant differences were observed in the footprints between the right and left feet of any individual emu.

These results indicate that declawing close to the time of hatch using a hot-blade de-beaker, leaving part of the distal phalanx intact, is unlikely to compromise the well-being of commercially farmed emus. The absence of both inflammation and extensive neuromas in the declawed toes suggests that the emus do not suffer either acute or chronic pain. The data suggests that the alteration in gait after declawing is a response to the altered weight bearing capacity of the toes, rather than as a result of acute pain inflicted on the toes during walking.

3.2 Introduction

Declawing of emus involves permanent removal of the toenails. To permanently remove the toenails; each toe is partially amputated. Severing nerves during the removal of the claw and surrounding tissue may result in the development of abnormal masses of regenerating nerves known as neuromas. These may persist for the life of the emu. In humans, nerves within the neuroma-mass may discharge a continuous barrage of action potentials that are perceived as chronic pain (Devor and Rappaport, 1990). This raises the possibility that neuromas within the declawed toes may generate spontaneous action potentials resulting in persistent long-term pain.

In domestic fowl, severing of nerves during partial amputation of the beak (Gentle, 1986, Lunam and Glatz, 1995; Lunam *et al.*, 1996) results in the formation of neuromas. Furthermore, an electrophysiological study has demonstrated neuromas in the beaks of domestic fowl generate spontaneous action potentials (Breward and Gentle, 1985), similar to that of nerves associated persistent phantom limb pain in humans.

Neuromas have been reported in the toes of domestic fowl after declawing (Gentle and Hunter, 1988). A pilot study of the microscopic anatomy of the emu toe (Lunam, 1997) has revealed that the histology of the emu toe is similar to that of the domestic fowl (Lucas and Stettenheim, 1972); both species having similar distribution of scales, sensory receptors, blood vessels and nerves. These similarities reveal that structures within the avian toe have been highly conserved during evolution, which suggests that the likelihood of neuromas persisting in toes of de-clawed emus is similar to that in the toe stumps of domestic fowl.

The enhanced size and decreased number of toes of the large flightless ratites, are considered to have evolved to accommodate high levels of mechanical stress exerted on them particularly during running. Therefore, the partial amputation of each toe of the emu is likely to pose considerable perturbation to gait. Surprisingly, with the exception of the pilot study (Lunam, 1997) no information is available concerning either the anatomy of the emu toe or the biomechanics of the emu foot.

These studies were designed to assess the effects of declawing on the welfare of the emus as indicated below.

- The histological studies were designed to determine the anatomical structures of the clawed emu toe and to examine the effects of declawing on the histopathology of the emu toes, in particular the presence or absence of potentially painful neuromas.
- The biomechanical studies were designed to investigate the effects of declawing on the gait of the emus.
- Biomechanical measurements were compared with the histology to assess whether any alteration in gait resulted from the presence of potentially painful neuromas in the declawed toes, or alternatively whether it occurred as a readjustment to alterations in pressure exerted on the foot pad and toes after declawing.

3.3 Materials and Methods

Emus

Emu chicks were declawed at one day of age. The declawing procedure involved removal of each of the three toes at the distal phalangeal joint using a commercial beak-trimming machine that both cuts and cauterises the tissue. According to the procedure of O'Malley (1995) the blade was angled to retain the ventral aspect of the distal phalanx. Chicks were intensively reared on sawdust litter during initial brooding and then given free access to large open paddocks with food and water *ad libitum* on two commercial emu farms in South Australia, Bruce Makin's farm at Keith and Geoff Lean's farm at Waikerie. Chicks that were not declawed were similarly bred and reared on each property. The declawed emus were reared in separate paddocks from the clawed emus.

Histopathology of the emu toes

Toe stumps from adult emus were collected from two commercial abattoirs in South Australia over an 18 month period from February 1998. Toes were examined from a total of 20 declawed emus. Each of the three toes was assessed from one foot of 14 of the emus. To assess any differences in the histology between the left and right feet, all toes were examined from both feet of a further six emus. The histology of the declawed toes was compared to that of toes from 12 clawed emus. The original intention was to assess the histology of toes from 20 clawed emus. Inadequate numbers of clawed emus could be obtained to meet the required 20 emus. To increase the numbers of control toes, all toes from each foot of 9 clawed emus were examined.

Immediately after slaughter of the emus by electrical stunning and bleeding from the carotid artery, the toes were removed and the distal 6 cm of each toe was fixed by immersion in Zamboni's fixative (Stefanini *et al.*, 1967) for a minimum of three weeks. After fixation each toe stump was cut into 2cm lengths, most of the hard keratin peeled from the toe and the central core of the phalangeal bone excised. To decalcify the remaining bone the tissue segments were immersed in ethylenediaminetetra-acetic acid for 14 to 20 days. Each segment was marked with a coloured thread so that the distal to proximal order for each toe was maintained.

To determine the distribution of any sensory receptors, skeletal muscle, tendons, fat pads, blood vessels and connective tissue in the toe, some segments were processed by routine wax-embedding and 10µm-thick transverse sections collected at 500µm intervals stained with haematoxylin and eosin. Other sections were stained with Verhoeff and van Gieson for differentiation of muscle, elastic and collagen connective tissue. Most segments were processed for the identification of nerve fibres using a triple silver impregnation stain (Gilbert, 1965) on frozen transverse-sections of 60µm-thickness. Histological sections were viewed using an Olympus BH-2 microscope.

Biomechanical measurements

Pressure exerted on the foot pad and toes during walking was estimated by measuring body weight / total surface area of foot pad and toes (kg-mass/cm^2). Measurements were taken from 30 adult clawed and 30 declawed emus of similar age, with an estimated weight of 45kg. It was anticipated that any redistribution in weight on the foot pads and toes between the declawed and clawed emus would be readily visible by alteration in the pattern of the footprint.

The total surface area of foot pad and toes in contact with the ground was measured by placing a two-inch-thick layer of coarse red bricklayer's sand onto a hard surface. The emus were coaxed to walk across the surface leaving an imprint in the sand. Trial studies with adult emus have shown that this produces clear sharply defined imprints. Each imprint was traced by overlaying a clear acetate sheet and outlining each depression with a marking pen. For each footprint, the traces were transposed onto 80 GSM weighted paper, and cut-outs of each trace then pooled for each foot print and weighed. The total surface area in contact with the ground for each foot was calculated by comparing the weight of each footprint trace to the weight of 10cm^2 of the 80 GSM paper.

Video recordings of gait

Gait was assessed from video recordings taken at the emu farms at Keith and at Waikerie. The gait of adult emus, declawed at day-old, was compared with similar aged adult emus that have not been declawed. A total of 20 clawed and another 20 declawed emus were recorded walking and assessed by slow motion playback. Gait of the emus was then compared with the footprint / body weight measurements. Recordings were made at the time of taking the footprint impressions.

Statistical analysis

Analysis of variance with repeated measures on one of the factors (left versus right foot) was used within an SPSS statistical package (Release 6.1.3) to analyse the footprint data. The program was used to test the effects of declawing and left versus right foot on the total amount of foot pad and toes in contact with the ground.

Animal ethics

Approval for these studies was given by the animal ethics committees of Flinders University, and the Department of Primary Industries and Resources South Australia and the University of Adelaide. All procedures complied with the "Australian Code of Practice for the care and use of animals for scientific purposes" (Australian Agricultural Council, 1990) and the "Australian Model Code of Practice for the Welfare of Animals. Domestic Poultry" (Standing Committee on Agriculture and Resource Management, 1995).

3.4 Results

Histology

Clawed toes of control emus

No differences were observed in the histology of the toes from any of the control emus. Although the larger diameter of the middle toe in cross-section made it readily distinguishable from the first and third toes, the pattern of the histological features was similar to the other toes. Similarly no histological differences were found between the toes of the left and right feet.

Tissue types, sensory receptors, blood vessels and nerve bundles were clearly identified using the haematoxylin and eosin and Verhoeff and van Gieson stains. The epidermis consisted of two distinct layers, a thick stratum germinativum and a dense corneum. Differences were observed in the dermal-epidermal junction between the dorsal and ventral margins of the toes. Dermal papillae measuring 2 to 3mm in depth were well developed in the ventral region of the toe. As the papillae extended along the lateral edges towards the dorsal surface of the toe, they became more numerous and decreased in height to 500µm. The papillae were absent at the dorsal margin where the keratin had become dense to form scales.

The dermis consisted of dense irregular collagen and elastic fibres that encapsulated the bone of the distal and third phalanges. Herbst corpuscles were observed in the dermis close to the lateral margins of the dorsal scales of all toes. The dermis was well supplied with blood vessels, these were particularly numerous in the dorso-lateral and ventral dermis.

An extensive mass of chondroid-like tissue was present in the ventral dermis. This cartilage-like tissue contained abundant elastic fibres. Lack of staining with post-fixation of frozen sections with 0.5% osmium tetroxide confirmed that this tissue was not adipose.

Silver staining confirmed the distribution and size of nerve bundles observed with conventional staining and revealed many numerous small nerve bundles within the adipose tissue of the ventral sub-dermis. Nerve bundles mostly accompanied the larger blood vessels. These neurovascular bundles were most frequently found in the dorsal-lateral region of the dermis and in the ventral dermis beneath the dermal papillae. Within nerve bundles, fibres were aligned parallel to one another. Nerves were rarely observed near the dermal-epidermal junction. Intra-medullary nerves were present in the distal and third phalangeal bones.

Declawed toes - general tissue organisation

The declawed toes had completely healed. The hard outer keratin and thick underlying germinativum of the epidermis had grown over the distal stump to enclose the original cut surface. Six of the total 78 declawed toes examined revealed a rudimentary claw measuring 0.5 to 1cm in length from its origin at the dorsal surface of the toe. In contrast, claws of the control emus measured approximately 3.5cms in length.

Histological examination revealed that the distribution and amount of connective tissue was similar to that in the clawed toes. The epidermis was a similar thickness to that of the clawed toes. Herbst corpuscles were frequently observed in all declawed toes. As with the clawed intact toes, these sensory receptors were found in the dorsal-lateral dermis immediately beneath the dorsal scales. The chondroid tissue was present in the dermis, but was less extensive than that in the distal phalanx of the clawed toes.

There was no evidence of an inflammatory response in the tissue of the declawed toes; lymphocyte aggregations were absent and eosinophils and mast cells rarely observed.

Blood vessels were numerous throughout the toe, with large neurovascular bundles in the dorso-lateral and ventral dermal regions. The distribution of nerves in the declawed toes was comparable to that in the intact toe. Peripheral nerves were organised either as either small fascicles or into large nerve bundles. Axons were aligned within all fascicles and nerve bundles as parallel arrays. Nerves were never observed penetrating beyond the dermal–epidermal junction.

Declawed toes - microneuromas

Microneuromas were observed in toes of six declawed emus**.** Four of the emus had microneuromas in two or more, but never all, toes. Microneuromas were found in a total of twelve of the 78 declawed toes. These were confined to the distal 2cm segment of each toe. None of the toes displayed large extensive chaotic nerve tangles. All microneuromas presented as small multiple nerve fascicles, each fascicle measuring approximately 60µm in diameter. The microneuromas formed small focal aggregations within the lateral-dorsal dermis. Axons within the fascicles were aligned parallel to one-another in a similar manner to axons within the nerve fascicles innervating the clawed toes. The microneuromas ranged from 720µm to 1400µm in diameter.

Biomechanical measurements

Footprint analyses

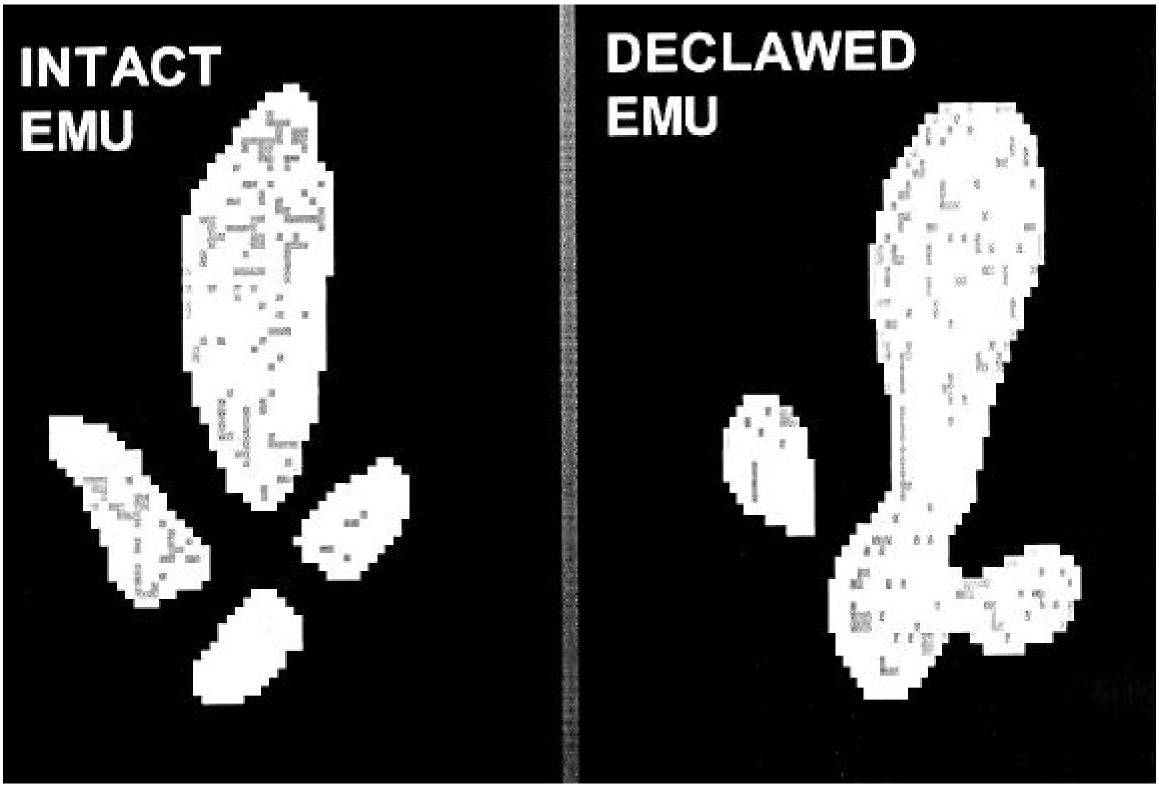
The footprint pattern was different in the clawed emus compared to that of the declawed emus (Figure 3.1). Although declawing had decreased the overall size of the foot, the footprint was significantly larger in the declawed emus compared to that of the clawed emus ($p=0.02$, Figure 3.2, Table 3.1). No significant differences were found in the weight distribution between the right and left feet ($p=0.54$). There was no significant interaction between the claw and foot demonstrating that the difference between the clawed and declawed emus was similar for either the right or left foot ($p=0.42$).

The clawed emus exerted significantly greater pressure on the foot pad and toes during walking compared to the declawed emus ($p=0.02$; Table 3.2, Figure 3.3). The actual forces generated during walking were not addressed as measurement of the temporal distribution of pressure for each footprint was not measured in these studies.

Video footage of gait of declawed emus

Video analyses suggest that declawing alters the gait of the emus. Slow motion replay of the video recordings revealed that during walking the majority of clawed emus always placed the distal phalanx of the middle toe first on the ground. The final "push-off" during walking was also made by the distal phalanx of the middle toe. In contrast the declawed emus appeared to place most of the foot on the ground at the one time without any apparent "push-off" from the middle toe.

Figure 3.1   Footprints made in the sand during walking



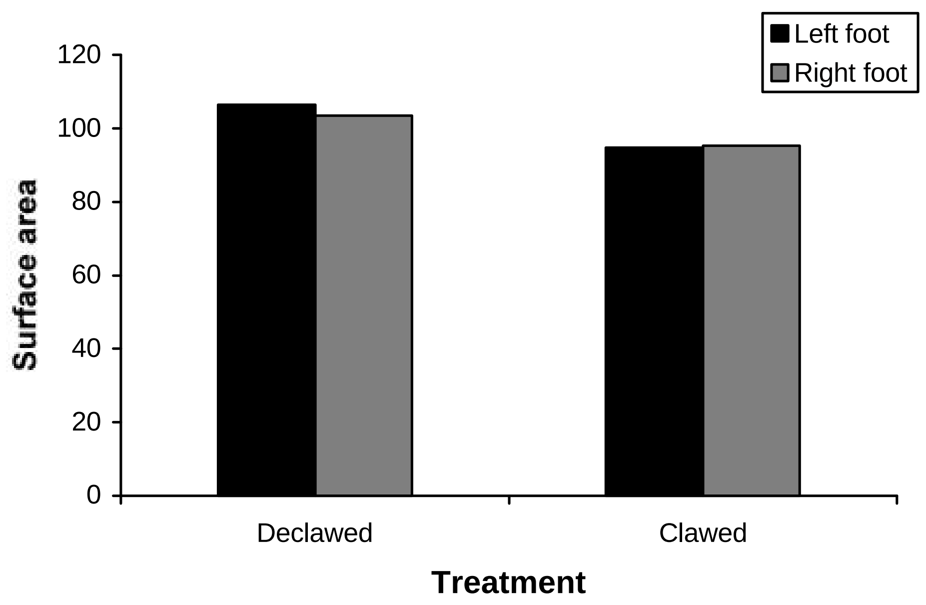
A computer reconstruction showing footprint patterns. The footprint of the intact clawed emu consists of four discrete areas in contact with the sand. In contrast the imprint made by the declawed foot consists of two discrete regions. In this case the imprint of the middle toe has become continuous with the foot pad.

Table 3.1 Total surface area of foot pad and toes in contact with the ground during walking (cm^2)

Treatment and foot	Mean	SD	Co-efficient of variation
Declawed			
left (30)	106.5	20.2	19%
right (30)	103.5	16.6	16%
Clawed			
left (30)	94.8	17.7	19%
right (30)	95.2	16.7	18%

Values in brackets are numbers of emus
Declawed vs clawed P=0.02
Left vs right foot P=0.54
Claw by foot interaction P=0.42

Figure 3.2 Effect of declawing on surface area of foot pad and toes in contact with the ground during walking (cm^2)



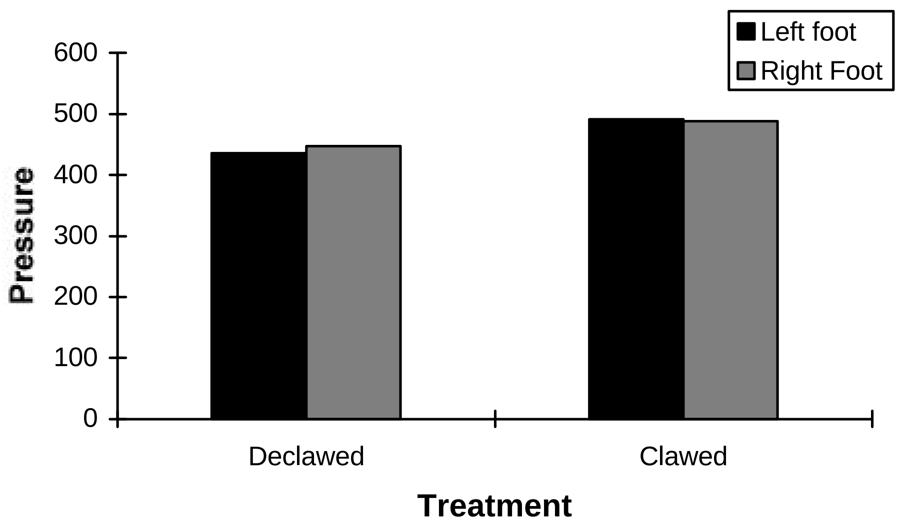
Values are given as means

Table 3.2 Pressure exerted on foot pad and toes during walking (grams per cm^2)

Treatment and foot	Mean	SD	Co-efficient of variation
Declawed			
left (30)	436.0	75.3	17%
right (30)	447.5	84.0	19%
Clawed			
left (30)	491.5	96.2	20%
right (30)	488.2	94.3	19%

Numbers in brackets are numbers of emus
Declawed vs clawed P=0.02
Left vs right foot P=0.67
Claw by foot interaction P=0.448

Figure 3.3 Effect of declawing on pressure exerted on foot pad and toes during walking (grams per cm^2)



Values are shown as means

3.5 Discussion

Histopathology

The histological features in the clawed toes confirm the previous work on the microanatomy of the emu toe (Lunam, 1997). The microscopic structure of the emu toe was found to be similar to that of the toe of domestic fowl (Lucas and Stettenheim, 1972); both species having similar distributions of scales, corpuscles, blood vessels, chondroid tissue, nerves and dermal papillae. The papillae were more prominent in the emu than in the domestic fowl (unpublished observations). Absence of an inflammatory response in the declawed toes indicates that the tissue had completely healed.

Sensory receptors were present in the dermis just beneath the scales on the dorsal surface of the declawed toes. This suggests that the toes have maintained their sensory innervation and can respond to touch and pressure as the clawed emus.

An interesting feature is the chondroid-like tissue immediately beneath the tendon of the flexor muscle in the distal phalanges. This is also present as a thin band of tissue in toes of the domestic fowl (Lucas and Stettenheim, 1972). The function of this cartilage-like tissue is unknown. Numerous elastic fibres within its matrix suggest that it may function as elastic cartilage, providing both flexibility and support to the emu toe; the extensive development of this tissue in the emu being an adaptation to the extreme weight bearing of the toes. Additional cushioning provided by the deep dermal papillae in the ventral region of the toes. As the chondroid-like tissue is most developed in the distal phalanges, it is tempting to speculate that the distal phalanges bear much of the pressure exerted on the toes during walking and running. Thus removal of the distal phalanges with declawing would be expected to alter the weight bearing ability of the toes resulting in redistribution of pressure exerted on the toes and foot pad.

Neuroma development

The process of neuroma development is well documented (Devor and Rappaport, 1990). Following severing, the nerves will regenerate. The regenerating axons sprout into the damaged area. Eventually the nerve sprouts are resorbed by the tissue. Occasionally, the excess nerve sprouts are not resorbed and they may persist as either small foci of nerve bundles (microneuromas), or they may form extensive neuromal masses, consisting of chaotic tangles of nerves. It is the extensive chaotic tangles that can spontaneously discharge, causing permanent reorganisation of the nerve pathways connecting the spinal cord and brain (Devor, 1989). These abnormal discharges and restructured neural pathways can lead to persistent long-term pain. A well-recognised example of this phenomenon is phantom limb pain that may persist in human amputees many years after removal of the limb (Jensen and Rasmussen, 1994).

No extensive neuromas were found in any of the sections through the declawed toes. Small focal microneuromas were however, present in a small percentage of the declawed toes.

These findings are similar to that of Gentle and Hunter (1988) who reported small foci of neuromas in broiler-breeder birds that had their hallux partially amputated at hatch. As was the case with the declawed emu toes, none of the broiler birds developed large extensive neuromas. However in contrast with the present study, in which only a small percentage of emus developed microneuromas, all declawed toes of the broiler birds had small focal neuromas.

The development of neuromas in emus may be dependent on the amount of tissue removed. This may reflect a threshold amount of tissue that can be removed, beyond which axon sprouts cannot be resorbed, resulting in neuromas. This would explain why all broiler chicks developed microneuromas after removal of greater than 50% of the hallux, compared to conservative removal of the distal phalanges of the emu chicks. In support of this, the risk of persistent traumatic neuromas developing after partial amputation of the beak of domestic fowl is significantly reduced if a conservative amount of beak is removed at hatch (Lunam *et al.,* 1996).

Individual emus may have different susceptibilities to neuroma formation. Indeed, individual variability to traumatic-neuromas is found in the beaks of domestic fowl after trimming (Lunam *et al.*, 1996) and is a common phenomenon in humans after peripheral nerve injury (Jensen and Rasmussen, 1994). Thus neuroma development in emus may well be a multifactorial phenomenon, dependent on the age at which declawing is performed and the amount of tissue removed, superimposed on an individual ability for tissue repair during the healing process.

The absence of large extensive neuromas suggests that the declawed emus are unlikely to suffer persistent chronic pain. Furthermore the absence of inflammation and the complete healing of the toes suggest that the emus do not suffer acute pain when pressure is exerted on the foot pad and toes. These results indicate that conservative declawing of emu chicks, leaving part of the distal phalanx intact, when conducted at hatch using a hot-blade de-beaker, does not result in extensive trauma-induced neuromas that persist to adulthood. This data indicates that in adult emus, chronic pain associated with persistent traumatic neuromas is an unlikely consequence of declawing.

Gait

Individual variation in the size of the footprint between left and right feet was greater for the declawed emus compared to the clawed birds. Although this difference was not statistically significant, it does suggest that a variable amount of tissue was removed during declawing. This would explain the development of rudimentary claws in some of the emus, the incomplete removal of the distal phalangeal bone resulting in partial regrowth of the claw.

Following declawing the emus become more flat-footed as the total area of the footprints significantly increased compared to that of clawed emus. The increased area of the footprint presumably accommodates the reduction in length of the declawed toes, by extending the area of the toes in contact with the ground. The altered pattern of the footprints after declawing and the videotape footage confirmed the notion that the declawed emus were more flat-footed than the clawed emus.

The expected alteration in gait would redistribute the pressure placed on each foot during walking. As all emus were of approximately the same weight, a consequence of the declawed emus having the largest footprints, was that they exerted significantly less pressure on the foot pad and toes compared to the clawed emus. It was beyond the scope of this project to measure the differential pressure across the footprint. Thus it was not possible to discern the exact differences in pressure exerted during walking between the clawed and declawed emus.

Removal of the chondroid tissue in the distal phalanges, the lack of inflammation, and the absence of extensive traumatic neuromas, discussed above, suggests that the alteration in gait after declawing is a response to a shift in the weight bearing capacity of the toes, rather than as a result of pain inflicted on the toes during walking.

4. EFFECT OF DECLAWING ON BEHAVIOUR OF EMUS

4.1 Summary

The behaviour of declawed emus in a farm environment subject has not been described despite the importance of declawing to the husbandry and welfare of the emu. This study tested the hypothesis that declawing of emus at hatch causes chronic pain, which persist throughout the life of the bird resulting in permanent changes in the locomotor and general behaviour of emus.

One group of 40 emus was declawed on the day of hatch by removing the distal phalangeal joint using a Lyon beak-trimming machine. Another group of 40 emus not declawed were used as the control group. Declawed emus one year of age were allocated to a paddock 250 m x 125 m, while the control emus were placed in an adjoining paddock of the same dimensions. One hour video records of individual emus from each treatment were made from 08:00 and 17:00 h over 2 periods; firstly when food and water was available and secondly during a stress period when food and water was not available after being withdrawn over night.

Inactive, ingestive, posture change, grooming, aggressive and locomotor behaviours were monitored from the video records. There was no behavioural evidence to indicate that declawed emus had a loss of locomotor ability or to suggest declawed emus were suffering from severe chronic pain. To the contrary declawed emus engaged in significantly more bouts and time of the searching behaviour (walking through the paddock with head lowered). Furthermore declawed emus engaged in less stereotype pacing and pecking indicating they were under less stress and not as frustrated as the control birds which were more aggressive.

Modelling analyses revealed that pecking behaviour of emus was most closely related to foraging behaviour. Birds subject to pecking attacks demonstrated high levels of stereotype behaviour presumably to cope with the increased aggression.

The behavioural evidence in this study would suggest that declawing does not compromise the locomotor ability of emus and has the benefit of improving social structure in emu flocks by reducing stereotype behaviour and aggression.

4.2 Introduction

Declawing is a husbandry practice that could result in long term pain for emus. Zimmerman (1986) reports that chronic pain in other species could modify specific walking behaviours including social behaviour. Chronic pain is observed in orthopaedic disease and in some cases following peripheral injury (Gentle, 1992). It could be inferred that tissue and bone damage resulting from declawing could result in persistent pain with the emu engaging in protective guarding behaviour and other pain coping behaviours. For example in heavy breeds of poultry with arthritic complaints, loss of locomotor function is common (Thorp, 1994). Animals with this condition are unwilling to stand or walk and there is evidence of one legged standing and limping as the bird attempts to cope with the pain. In less painful arthritic conditions animals are observed to change their posture frequently.

The behaviour studies reported in this study were undertaken to examine the following:

- Comparison of locomotor and general behaviours of declawed and non declawed yearling emus in a farm environment.
- Regression analysis to determine models for aggressive and defensive behaviour in emus.
- The influence of environmental temperature and feed restriction on emu behaviour.

4.3 Materials and Methods

Location

The behaviour study was carried out at Southern Emu a commercial emu farm 15 km east of Waikerie in the Riverland of South Australia from 2-21 January, 1998.

Emus

One group of emus was declawed on the day of hatch by removing the distal phalangeal joint using a Lyon beak-trimming machine. Another group of emus were the controls and were not declawed. Birds were brooded and reared apart prior to the experiment.

Enclosures

Four weeks prior to the trial 40 declawed emus one year-of-age were allocated to a paddock 250 m x 125 m, while a control group of 40 emus was placed in an adjoining paddock of the same dimension. The paddocks were predominantly bare earth with some patches of pasture. Both groups of birds had visual contact with each other. The wire and post fencing reduced physical contact between the groups. Limited shelter was available to the emus from trees. The birds were provided with oats supplemented with a mineral mix delivered daily, usually between 08:00 and 10:00 h. Approximately 1 kg of food was available to each bird from one feeder. Drinking water was provided *ad libitum* from a single trough drinker in each paddock.

Observations

Two weeks prior to the behaviour study, a 5 m high scaffold of floor dimensions 6 m x 3 m with a canvas canopy was installed in an adjacent paddock to provide a good vantage point for filming the emus in both paddocks. The birds were given two weeks to adjust to the presence of humans and the scaffold. Four cameras were mounted on the scaffold; two cameras recorded an overall view of emus in each paddock and the other 2 cameras were used for tracking of individual birds. Camera was linked to a video recorder and a remote control unit housed in a caravan near the scaffold.

The legs and upper body of 30 emus from each treatment were spayed with non-toxic paint to aid identification of birds. One hour video records of 30 individual emus from each treatment were made from 08:00 and 17:00 h over two periods; firstly when food and water was available and secondly during a stress period when food and water was not available after being withdrawn overnight. A field view of all the emus was recorded over the same time period as a back up to the individual tracking of emu behaviour. Environmental temperature at the time of producing the videotape was recorded classed as hot when $>30^{0}$C, warm when 25-30^{0}C, mild when 20-25^{0}C and cool when $<20^{0}$C.

Behaviours

For individual emus, behaviours were monitored from the videotapes. These included both timed and discrete behaviours. Two separate bouts of behaviour were recorded if they were separated by a pause of at least 5 seconds or more. The following inactive, ingestive, posture changes, grooming, aggressive and locomotor behaviours were recorded on each emu using the methodology described by Lehner (1996).

Definition of emu behaviours

Inactive
Sit down: Sitting with legs folded under the body
Sitting up: Sitting on knees
Stand: Standing with head raised

Ingestive
Forage: Pecking at the ground and vegetation while standing, walking, sitting up or sitting down. The head may be raised for less than 5 seconds.
Eat: Eating grain as supplied in food troughs or in the immediate area where grain was scattered. The head may be raised for less than 5 seconds.
Drink: Drinking from water trough. The head may be raised for less than 5 seconds.
Eliminate: Excretion of faecal and urinary waste.

Change Position
Step: Any change in position less than 5 seconds that occurred while the bird was standing.
Shift sit: A shift in position while sitting in either position.
Stand up: Standing up from either sitting position.

Grooming and other behaviours
Preening: Using the beak to preen feathers on any part of its body.
Head scratch: Using one of its feet to scratch its head.
Head shake: Shaking its head while walking, standing or in either sitting position.
Stretch: Stretching the body and neck, usually followed by a body shake. Excludes defensive or offensive stretching.
Exhibition: Walking or standing with neck feathers flared out.
Fence Peck: Pecking at the fence wire or post.
Head through fence: Poking the head through the fence while standing or pacing.

Aggressive behaviours
Run chase: Running at another bird.
Run away: Running from another bird.
Give thrusts: Any action that threatens another bird, including run chase.
Receive thrusts: Any threatening action that the bird receives, including those that make it run away.
Peck: When the bird pecks at another bird.
Pecked: When the bird is pecked by another bird.
Step push: Any change in position from a standing position resulting from a push by another bird.

Locomotor
Search: Walking through paddock (other than area within 1.5 m of the fence) with head lowered.
Search pace: Walking parallel to and within 1.5 m of the fence with head lowered.
Walk: Walking through paddock (other than area within 1.5 m of the fence) with head raised.
Pace: Walking parallel to and within 1.5 m of the fence with head raised.
Run: Running through paddock (other than area within 1.5 m of the fence).
Run pace: Running parallel to, and within 1.5 m of the fence.

Anecdotal incidents

During the filming period various incidents occurred which gave a vivid illustration of the interesting behaviours exhibited by the emus. The anecdotes are described in the discussion.

Statistical analysis

For the purposes of this study, each animal was considered as a replicate. The behaviour data was analysed by General Linear Model procedure within the SAS statistical procedure (SAS, 1988). The program was used to test the effect of declawing, feed restriction and environmental temperature on locomotor, exploratory, inactive, social, ingestive and aggressive behaviours. Duncan's multiple range test was used to separate means when significant main effects were detected by the analysis of variance. The Stepwise Regression procedure in SAS was used to gain an insight into the relative strengths of the relationships between aggressive behaviours and other behaviours.

Animal ethics

The animal ethics committees of the Department of Primary Industries and Resources South Australia and University of Adelaide approved these behaviour studies. All procedures complied with the "Australian Code of Practice for the care and use of animals for scientific purposes" (Australian Agricultural Council, 1995).

4.4 Results

Behaviour

The means for the behaviour variables were expressed as number of incidences of the activity for discrete events. For continuing events, the bouts and time (sec) involved in the behaviour over the 60 min observation period were determined.

Effect of declawing on behaviour

Inactive behaviours

There was no significant differences between the declawed and control emus in inactive behaviours (Table 4.1). The exception to this was the declawed emus which engaged in fewer bouts ($P<0.05$) of standing. There was, however, no difference between the treatments in standing time per bout with declawed emus spending 34 sec/bout and the control emus 36 sec/bout.

Ingestive behaviours

There was no significant difference in ingestive behaviours of the declawed and control group (Table 4.1). There was a non significant trend ($P=0.11$) for the control group to engage in more frequent bouts of eating with less eating time/bout.

Posture change behaviours

There was no significant differences in the number of changes in posture made by declawed emus compared to the control group (Table 4.2).

Grooming and other behaviours

There was no significant difference in the grooming behaviours (Table 4.2) of the treatment groups. The control group engaged in a greater incidence of the stereotype behaviour which involved poking their heads through the fence into the neighbouring paddock and back again on a repetitive basis.

Aggressive and defensive behaviours

Control emus were subject to a significantly higher ($P<0.05$) incidence of the step pushing behaviour. In addition there was a trend for control emus (relative to the declawed emus) to give more thrusts, to peck more at other emus and to be pecked more by other emus (Table 4.3).

Locomotor Behaviours

The declawed emus engaged in significantly ($P<0.05$) more bouts and time of searching compared to control emus (Table 4.4). In contrast the control emus were involved in significantly more ($P<0.05$) bouts of pacing and spent more time pacing relative to the declawed emus.

Effect of feed and water restriction on emu behaviour

Inactive behaviours

Emus that were subject to feed and water withdrawal had significantly fewer ($P<0.05$) bouts of sitting compared to the control group but there was no difference between the treatments in time spent sitting or standing (Table 4.1).

Ingestive behaviours

Time spent foraging and incidence of eliminative behaviours were significantly lower for emus deprived of food and water (Table 4.1).

Posture change behaviours

Emus not subject to the stress of feed and water withdrawal engaged in more bouts of shifting while in the sitting position but there was no difference between the treatment groups in other posture change behaviours (Table 4.2).

Grooming and other behaviours

When emus were subject to the stress of food withdrawal there was a reduction in the bouts and time spent preening including a reduction in head scratches relative to the fully fed emus (Table 4.2). There was no difference between the treatments in other stereotype and display behaviours.

Aggressive and defensive behaviours

Overall there was no major significant differences in aggressive behaviours between the fed and starved groups of emus. There was however a significant increase in both the incidence of run chase bouts and emus receiving thrusts associated with the stress period (Table 4.3).

Locomotor behaviours

The starved emus spent more time ($P<0.05$) walking and there was a significant increase in pacing bouts and time spent pacing compared to the control emus (Table 4.4).

Effect of environmental temperature on emu behaviour

Inactive behaviours

Under hot conditions there was a significant increase in the time emus spent sitting, matched by a significant decline in time spent standing. In contrast under cool conditions emus spent more time standing and less time sitting (Table 4.1)

Ingestive behaviours

During cool periods emus engaged in significantly more bouts of eating and spent more time drinking than emus did during the hotter periods (Table 4.1).

Posture change behaviours

There was no differences in posture change behaviours that could be attributed to environmental temperature (Table 4.2).

Grooming and other behaviours

As environmental temperature increased there was a significant decline in bouts and time spent preening and incidence of head scratching (Table 4.2).

Aggressive and defensive behaviours

Overall there was no major differences in aggressive behaviours that could be attribute to environmental temperature (Table 4.3).

Locomotor Behaviour

As environmental temperature increase there was a reduction in bouts of walking and running time. Time spent pacing increased as the environmental temperature increased (Table 4.4).

Interactions

No biologically important 2 or 3 way interactions were observed in emu behaviour for the main effects of declawing, feed restriction or environmental temperature

Table 4.1 Effect of declawing, feed restriction and environmental temperature on bouts, time (seconds/hour) and incidence of emus involved in inactive and ingestive behaviours

DECLAWING				FEED RESTRICTION			ENVIRONMENTAL TEMPERATURE				
Variable	**De-claw**	**Control**	**l.s.d.**	**No feed**	**Feed**	**l.s.d.**	**Cool**	**Mild**	**Warm**	**Hot**	**l.s.d.**
Inactive											
Sitdown B	0.7	0.7	Ns	0.4a	0.9b	0.4	0.8	0.7	0.7	0.6	Ns
Sitdown T	681	429	Ns	462	652	Ns	475	480	584	636	Ns
Situp B	1.7	1.3	Ns	1.2a	1.9b	0.6	1.4	1.2	1.5	1.8	Ns
Situp T	492	308	Ns	377	428	Ns	184b	322b	313b	708a	306
Stand B	31.2a	39.9b	7.8	37.7	33.2	Ns	41.4	41.3	34.6	28.5	Ns
Stand T	1148	1387	Ns	1118	1394	Ns	1917a	1205b	1258b	1048b	440
Ingestive											
Forage B	11.4	10.7	Ns	10.2	11.9	Ns	4.4	13.3	12.8	5.6	Ns
Forage T	44	20	Ns	14a	50b	35	13	23	27	63	Ns
Eat B	38	81	Ns	0a	111b	58	141a	53.7ab	54.6ab	33.5b	90
Eat T	363	293	Ns	0a	364b	62	386	393	373	184	Ns
Drink B	0.8	1.5	Ns	0a	2.2b	0.8	1.6	1.3	1.4	0.4	Ns
Drink T	17	29	Ns	0a	43b	15	48a	23b	22b	12b	24
Eliminate	0.4	0.5	Ns	0.3a	0.7b	0.2	0.6	0.6	0.6	0.5	Ns
Forage sit	1.7	1.2	Ns	0.8	1.9	0.9	0.5	1.7	1.1	2.0	Ns

(Means within rows within comparison followed by the same letter are not significantly different at P=0.05, l.s.d.=least significant difference, Ns=not significant, B=Bouts, T=Time in secs)

Table 4.2 Effect of declawing, feed restriction and environmental temperature on bouts, time (seconds/hour) and incidence of emus involved in changes in posture, grooming and other behaviours

DECLAWING				FEED RESTRICTION			ENVIRONMENTAL TEMPERATURE				
Variable	**Declaw**	**Control**	**l.s.d.**	**No feed**	**Feed**	**l.s.d.**	**Cool**	**Mild**	**Warm**	**Hot**	**l.s.d.**
Change Posture											
Step	11.3	12.8	Ns	12.3	11.7	Ns	13.8	11.7	13.0	10.4	Ns
Shift while sitting	1.1	2.0	Ns	0.9a	2.2b	1.0	1.3	2.0	1.2	2.0	Ns
Stand up	1.1	0.9	Ns	0.9	1.0	Ns	0.8	0.7	1.0	1.3	Ns
Groom and other behaviour											
Preen B	15.1	15.1	Ns	10.2a	19.6b	3.5	26.7a	19.5b	13.8c	8.3d	5.5
Preen T	105	97	Ns	56a	143b	26	231a	125b	86bc	49c	40
Head scratch	0.6	0.2	Ns	0.2a	0.6b	0.3	1.3a	0.1b	0.5b	0.3b	0.5
Head shake	3.2	4.2	Ns	3.2	4.1	Ns	4.5	3.5	4.1	3.0	Ns
Stretch	0.5	0.9	Ns	0.4	0.9	Ns	1.3	0.7	0.6	0.5	Ns
Exhibit B	0.9	0.6	Ns	0.7	0.8	Ns	0.9	1.2	0.8	0.3	Ns
Exhibit T	28	11	Ns	23	17	Ns	17	28	24	9	Ns
Fence Peck	74	18	Ns	8	82	Ns	73	32	78	5	Ns
Head thro Fence	0.3a	6.7b	5.6	5.7	1.3	Ns	2.7	9.8	1.4	0.8	Ns

(Means within rows within comparison followed by the same letter are not significantly different at P=0.05, l.s.d.=least significant difference, Ns=not significant, B= Bouts, T=time in secs)

Table 4.3 Effect of declawing, feed restriction and environmental temperature on bouts, time (seconds/hour) and incidence of emus involved in aggressive and defensive behaviours

DECLAWING				FEED RESTRICTION			ENVIRONMENTAL TEMPERATURE				
Variable	**Declaw**	**Control**	**l.s.d.**	**No feed**	**Feed**	**l.s.d.**	**Cool**	**Mild**	**Warm**	**Hot**	**l.s.d**
Aggressive Behaviour											
Run Chase B	0.8	0.7	Ns	1.3a	0.3b	0.9	0.5	0.3	0.7	1.3	Ns
Run Chase T	5	4	Ns	7	1	Ns	2	2	5	6	Ns
Run away B	1.2	1.0	Ns	1.4	0.9	Ns	1.4	1.3	1.2	0.8	Ns
Run away T	6	6	Ns	8	4	Ns	8	7	6	5	Ns
Give thrusts	1.2	1.7	Ns	2.1	0.8	Ns	0.7	1.1	1.5	2.0	Ns
Receive Thrusts	2.0	2.1	Ns	2.7a	1.4b	0.9	1.7	2.5	2.0	1.8	Ns
Peck	1.4	1.9	Ns	1.1	2.3	Ns	2.1	0.9	1.3	2.9	Ns
Pecked	0.6	1.0	Ns	0.8	0.8	Ns	0.6	1.1	0.9	0.4	Ns
Step push	0.7a	2.0b	1.1	1.3	1.3	Ns	1.4	1.7	1.2	0.9	Ns

(Means within rows within comparison followed by the same letter are not significantly different at P=0.05, l.s.d.=least significant difference, Ns=not significant, B =Bouts, T=Time in secs)

Table 4.4 Effect of declawing, feed restriction and environmental temperature on bouts, time (seconds/hour) and incidence of emus involved in locomotor behaviours over 1 hour

	DECLAWING			FEED RESTRICTION			ENVIRONMENTAL TEMPERATURE				
Variable	**De-claw**	**Control**	**l.s.d.**	**No feed**	**Feed**	**l.s.d.**	**Cool**	**Mild**	**Warm**	**Hot**	**l.s.d**
Loco Motory											
Search B	8.1a	2.8b	2.2	4.6	6.5	Ns	7.8	5.3	5.9	4.4	Ns
Search T	172a	39b	53	99	117	Ns	125	104	109	102	Ns
Search Pace B	4.2	5.4	Ns	5.7	3.9	Ns	3.5	4.8	6.4	2.7	Ns
Search Pace T	56	89	Ns	53	94	Ns	35	66	109	38	Ns
Walk B	9.8	8.8	Ns	9.3	9.3	Ns	12.3a	6.5b	11.2ab	7.8ab	5.0
Walk T	216	147	Ns	223a	146b	74	175	121	208	121	Ns
Pace B	13.9a	29.4b	8.3	254.a	16.6b	8.3	16.9	27.2	19.8	18.1	Ns
Pace T	344	788	302	762a	372b	302	232b	823a	470ab	585ab	474
Run B	0.2	0.1	Ns	0.2	0.1	Ns	0.2	0.1	0.2	0.2	Ns
Run T	2	3	Ns	3	3	Ns	10a	0b	1b	4ab	6
Run Pace B	0.2	0.1	Ns	0.3a	0b	0.2	0.1	0.2	0.1	0.3	Ns
Run Pace T	2	1	Ns	2	0	Ns	0.5	0.9	1.0	1.7	Ns

(Means within rows within comparison followed by the same letter are not significantly different at P=0.05, l.s.d.=least significant difference, Ns=not significant, B=Bouts, T=Time in secs)

The stepwise regression procedure

Because of the overall lack of significant change in emu behaviour associated with the declawing treatment it was decided to pool the behaviour data and apply the stepwise procedure to find which of all the other independent behaviour variables could be included in a model for the aggressive and defensive behaviours; pecking, being pecked, giving head thrusts and receiving head thrusts. The stepwise first finds the single variable model which produces the largest R^2 statistic. For each of the other independent variables, stepwise calculates an F statistic reflecting the variables contribution to the model, were it to be included. The variable with the highest F value is added to the model provided the probability associated with the F value is greater than 5%. After a variable is added stepwise looks at all the variables already included in the model. Any variable not producing a partial F-statistic at the 5% significance level is then deleted from the model. Variables are added to the model until none produces an F value of the required probability until the variable deleted is the last variable added.

Stepwise procedure for dependent variable giving pecks

All other variables measured (including pecked, receiving and giving head thrusts) in this study were included as independent variables for this analysis. The following variables were selected in order of importance for their association with emus giving pecks. The first 5 variables selected were able to explain 42% of the variation associated with giving pecks.

Variable	**Correlation with giving pecks**	$\mathbf{R^2}$
Forage bouts	Positive	0.29
Sit down time	Positive	0.35
Time foraging while sitting	Positive	0.39
Stretch	Positive	0.41
Preen bouts	Positive	0.42

Stepwise procedure for dependent variable of being pecked

All other variables measured in this study were included as independent variables for this analysis. The following variables were selected in order of importance for their association with emus being pecked. The first 5 variables selected were able to explain 27% of the variation associated with emus being pecked.

Variable	**Correlation with being pecked**	$\mathbf{R^2}$
Receive thrusts	Positive	0.11
Fence peck	Positive	0.16
Step push	Positive	0.21
Exhibition time	Positive	0.24
Head shake	Positive	0.27

Stepwise procedure for dependent variable receiving thrusts

All other variables measured in this study were included as independent variables for this analysis. The following variables were selected in order of importance for their association with emus receiving thrusts. The first 5 variables selected were able to explain 67% of the variation associated with emus receiving thrusts from other emus.

Variable	**Correlation with receiving thrusts**	R^2
Run away bouts	Positive	0.29
Giving thrusts	Positive	0.35
Run chase bouts	Positive	0.39
Pacing time	Positive	0.41
Pecking	Positive	0.42

Stepwise procedure for dependent variable giving thrusts

All other variables measured in this study were included as independent variables for this analysis. The following variables were selected in order of importance for their association with emus giving thrusts. The first 5 variable selected were able to explain 88% of the variation associated with emus giving thrusts.

Variable	**Correlation with giving thrusts**	R^2
Run chase bouts	Positive	0.82
Receive thrusts	Positive	0.85
Run away bouts	Positive	0.86
Pecked	Positive	0.87
Pecking	Positive	0.88

4.5 Discussion

Declawing and inactivity

If the emus were suffering severe chronic pain there would be evidence that declawed emus were more inactive compared to control emus and unwilling to stand or walk. No behavioural evidence based on inactivity variables could be found to suggest the emus were suffering from chronic pain. Furthermore there was no evidence of one legged standing or limping.

Declawing and locomotor ability

If emus were suffering from severe chronic pain, the toe stumps would feel sore resulting in a reduction in locomotor ability. There was no behavioural evidence to indicate any decline in locomotor function. In fact declawed emus engaged in more bouts and time involved in searching compared to control birds suggesting the declawed birds were showing no discomfort from chronic pain.

Declawed emus also engaged in less stereotype pacing compared to the controls. Pacing is generally considered to be a frustration behaviour observed in confined and restricted animals which are not provided the full opportunity to perform their natural behaviour patterns (Hinde, 1970; Duncan and Wood-Gush, 1972). The frustration leads to the redirection or substitution with behavioural stereotypes (Rushen, 1984 and 1985; Odeberg, 1987).

For example, stereotypic pacing in hens is associated with the lack of nest boxes (Duncan, 1970) or restriction of feed (Duncan and Wood-Gush, 1972). It has been suggested that stereotypes could be a positive mechanism by which the animal maintains itself within optimal physiological and psychological limits (Fraser and Broom, 1990) and hence a normal central nervous system response (Ridley and Baker, 1982). There is also empirical evidence to link stereotypes with coping, although it is not clear if stereotypes themselves are the source of coping (Mason, 1991).

In the case of the control emus (not declawed) they may be engaging in more stereotype pacing as a mechanism to cope with the stress of being in a threatening social environment where they fear attack from emus with the intact claws. It was also observed that control animals engaged in the a greater incidence of poking their heads through the fence while they were pacing. Emus may have analogous behaviour to poultry and ostriches (McKeegan *et al*. 1997) as it is well known that with increased levels of frustration the behavioural changes observed include increased displacement, stereotype pacing and increased aggression by dominant birds (Duncan and Wood-Gush, 1972).

Declawing and changes in posture

In less painful arthritic conditions animals are observed to change their posture more frequently in an attempt to achieve relief from the discomfort. For instance if the emus were in pain they would tend to be restless when both in the standing or the sitting position. This normally would lead to more frequent changes from the standing to the sitting position and vice versa. No evidence could be found in these studies that the declawed emus engaged in more posture changes compared to the controls as a result of feeling discomfort.

Declawing and aggressive behaviour

Control emus gave more aggressive threats compared to declawed emus. These threats comprised thrusts toward other emus and pushing them away. There was also a trend for control emus to exhibit an increased incidence of other aggressive behaviours. The increased frustration in control emus demonstrated by the increase in stereotype behaviours (pacing and head through fence behaviour) is known to lead to an increase in aggression in other species. Declawed emus showed no difference in their ingestive and grooming behaviours compared to the controls providing further evidence that the practice of declawing does not have a major influence on emu behaviour.

Behaviour models for aggressive and defensive behaviour in emus

Birds giving pecks

The stepwise regression analysis revealed that emus which give pecks to other emus have a tendency to engage in more bouts and time involved in foraging. In poultry feather pecking is an abnormal behaviour which often results in extensive damage to the plumage of birds (Hughes and Michie, 1982). It is usually a problem associated with the confinement of animals which is a dramatic change in the bird's original habitat. Some scientists believe feather pecking to be a social order failure as for example the confinement enforced in emus under current farming practices may lead to intensive social interaction and more agonistic acts.

Wennrich (1995) has other views, stating feather pecking is comparable to food pecking rather than aggressiveness. A number of investigators agree (Blokhuis, 1986 and 1989; Blokhuis and Arkes, 1984 and Braastad, 1990) and have confirmed the relationship of feather pecking with ground pecking and foraging behaviour. Ground pecking stimuli has been used to alleviate the feather pecking problem. Other investigators (Vestergaard and Limburg, 1993; Vestergaard, 1994) associate feather pecking with dust bathing behaviour and the provision of attractive stimuli like sand and peat has reduced feather pecking. Martin (1989) suggests that providing both ground pecking stimuli and sand will control feather pecking.

Birds spend most of their time in beak related activities (Hughes and Grigor, 1996) and when there is very little choice in activities there would be more time for feather pecking. Foraging involves both searching and consumption and the behavioural instinct to fetch food could be satisfied by ground pecking (Martin, 1984 and Sherwin, 1985).

The current studies have demonstrated that pecking behaviour in emus is closely related to foraging behaviour. Domestic poultry which are able to engage in foraging activities tend to have reduced levels of feather pecking. In contrast, emus confined in paddocks, perhaps were not rewarded when foraging the bare paddocks leading to frustration and an increase in aggressive pecking behaviour. It should be noted that foraging sources could differ in the incentive value for pecking motivation (Baum, 1991) and for dust bathing (Petherick and Duncan, 1989). Providing the right forage material may reduce the pecking problems (Blokhuis, 1992).

Birds being pecked

Birds being pecked were those emus that also had a high incidence of step pushing at other animals, receiving thrusts and a tendency to engage in stereotype behaviours (fence pecking and head shaking). It is considered that reduction of fear in birds is reflected in adaptive or displacement behaviour. In this study of emus head shaking and fence pecking were the significant displacement behaviours associated with birds subject to pecking attacks. Head shaking has been referred to as a fear coping mechanism and may be a symptom of being 'better off' (Duncan, 1970 and Mauldin and Siegel, 1979). The behaviour is prominent in domestic poultry (Webster and Hurnick, 1990). Head shaking in emus also coincided with the exhibition behaviour which in itself could attract aggressive pecking by other birds.

Emus receiving and giving thrusts

Emus receiving thrusts tended to be those birds which also engaged in the aggressive behaviours of giving thrusts, pecking and running at other emus. It was clear from the data that emus under threat also spent more time pacing which is a stereotype behaviour suggesting frustration. Similarly emus giving thrusts were also those birds which pecked and chased other birds but also received thrusts and ran away following the encounters.

Effect of feed and water withdrawal on behaviour

Withdrawal of feed resulted in an increase in aggressive behaviours and birds were more restless. Birds spent more time walking and also engaged in more bouts and time spent pacing. During periods of starvation emus would be more likely to suffer damage to the skin from aggressive behaviours. It is recommended birds have food available at all times**.**

Effect of environmental temperature on behaviour

Under hot conditions emus spent more time sitting, less time walking but there was an increase in stereotype pacing. There was a decline in grooming behaviours. Grooming ensures the feather condition is maintained to assist in insulation against the cold. During hot weather birds would be saving energy by reducing preening as there is a reduced need to keep their feathers in a condition to provide the maximum insulation. Emus did most of their drinking when the environmental temperature was cool associated with the increased feeding time during this period. It was expected that emus would spend more time drinking when it was hot. The drinking water for emus was provided in water troughs that were not shaded. The water was very warm and may be aversive for emus to drink. Keeping drinking water cool for emus in hot weather is recommended.

Anecdotes associated with the emu behaviour studies

(Reported by Mark Bradley and David Palmer)

'The game'

On arriving at the farm one day a number of declawed birds were gathered along the fence line like spectators, watching the emus in the breeder paddock tossing a small plant. The scene resembled a game a group of kids would play in the park. Sometime later the declawed birds in their own paddock were also observed pecking at and tossing a plant. Other birds gathered and they all started to play the game they were previously were involved in only as spectators.

'This water trough is mine'

A bird was observed strolling towards the drink trough, but hesitated when it noticed another bird already near the tank in a stalking position. The approaching bird moved on with caution towards the water trough. The bird guarding the trough stretched forward and charged at the approaching bird, which turned very quickly, rushed away for a few steps and then settled back into a casual walk. The charging bird stopped suddenly, looked at the offending bird with its head cocked watching as the other bird strolled away. The bird guarding the water trough never really thought it was going to allow this other bird to have a drink. Meanwhile the bird chased from the water trough strolled towards a tree where it rested.

'Keep out of this corner'

One day a bird was noticed taking up residence in one corner of the paddock that boarded the breeder's paddock and the control group. Throughout the day this bird fiercely protected this area. Any bird coming near was charged and kicked if it came close. While some birds were able to stand within a metre or two, others were not so lucky and would be charged as they came within 3-4 metres. The next day for some reason this corner of the paddock was not being fiercely protected and the bird, which was previously keeping all the other emus out, was not seen.

'Proud or stubborn'

A bird was pacing along the fence, minding its own business, when a larger emu standing in its path near the fence struck a proud statue like pose. The approaching smaller bird paused then decided two can play this game and mirrored the larger bird's pose. They stood eyeball to eyeball not a blink or a murmur from each. After a while the encroaching smaller bird made an initial move and stepped around the larger bird, but then hesitated as if it thought 'why should I step around you?' and stepped back near the fence line. The larger bird refused to move. The smaller bird made up its mind and charged ahead. The larger bird refused to budge as the smaller bird barged between the larger bird and the fence, presumably causing damage to its skin.

'Feather pecker guarding the feed bin'

A bird moved toward the feed bin and started eating. Another bird approached from behind and also started to eat. They paused; eye balled each other for a moment then both continued to eat. After a while the bird, which had commenced eating first, stopped feeding and stood upright as a third bird approached the feed trough. It rushed at the approaching bird kicking up at the bird with both legs forcing the encroaching emu from the area. After the attack the bird, which did the kicking, walked away and commenced foraging and searching and occasionally preening itself. It searched on casually moving toward a bird sitting on its own. It stood over it for a while inspecting its back, then began pecking at the feathers on its side and rear end. The bird being pecked remained motionless in the sitting position. The feather pecker eventually stopped pecking and stood motionless over the bird for over 2 minutes. Eventually the bird, which was being pecked, started to forage and the aggressive bird finally walked off searching and foraging.

‘Conflict at the water trough’
A bird approached the water trough at the same time as another bird was also moving toward the water trough. On arriving at the waterer one bird walked around the trough with the other bird first following and then rushing at the bird in front. The threatened bird rushed away in escape while the offending bird eased back and retreated to the water trough. The chased bird began to forage some straw near two other birds, which were sitting on the straw. The previously attacked bird approached one of the birds that was sitting and pecked it on the middle of the back. The bird jumped up and rushed off while the bird, which had done the pecking, sat on its knees and began foraging the straw.

‘The Fence Pecker’
A bird stood and pecked at the fence for about 15 minutes, then it sat down and continued to peck the fence, until a neighbouring bird from the breeders paddock gave threat, rushing and pecking at it. At different times while the bird was pecking the fence, birds from the same paddock approached and would stand nearby watching or even moving closer to look at bird pecking. Some birds would try to stand between the fence and the bird but the bird just kept on pecking until another attack came from the bird in the breeder’s paddock. When attacked by the breeder the pecker hesitantly walked away. A brief moment later however the pecker returned to the fence but the breeder stepped forward to threaten it again and forced it away. As the pecker wandered toward the water trough it stopped and preened. Another bird was drinking at the water trough so the pecker approached with caution, walking in a wide ark around the other side. The drinking bird stopped to watch the pecker for a while then continued drinking allowing the pecker to drink. After sometime the pecker moved to the feed trough and started to eat but then returned to the fence and commenced pecking again. The fence pecker attracted the attention of a bird in the same paddock, which stood nearby for some time. One of the breeders from the neighbouring paddock approached the birds and gave threat, sticking its head through the fence, trying to peck both birds before rushing at the fence pecker. Both threatened birds retreated briefly. After a while when it was clear the fence pecker returned and continued to peck the fence. Some time later another bird from the breeder’s paddock approached the fence pecker and stood watching a while before poking its head through the fence and pecking the fence pecker several times on the back. The pecker stopped for a short time, looked at the bird that had pecked it then returned to fence pecking.

‘Get out of the way’
A group of birds stood at the fence looking into the neighbouring paddock. A bird wandered over and stood behind for a while. It was unable to get a front row seat and so it lowered its head to knee level, moved closer in and pecked at a bird in front of it under the tail. The pecked bird lifted its head in surprise and stepped to the left leaving a gap into which the aggressive bird immediately stepped. The other birds shuffled around for a moment before settling. The displaced bird moved off and walked a full circle around behind the aggressive

bird and moved in on its other side. Suddenly the displaced bird pushed at the bird which taken its position knocking it off balance and out of the way.

‘Curious neighbours’
A bird was foraging near the fence when another bird from the neighbouring paddock approached. The bird stopped foraging and watched the neighbour approach for a moment then paced on as the approaching bird stopped in front of it. The neighbouring bird paused a short while then followed, watching the pacing bird closely as it started to forage again. The neighbouring bird then stuck its head through the fence and pecked the ground in front of the foraging bird. The bird stopped foraging looked at the neighbour and paced off. The neighbour followed in a mirror image for a while until finally the bird started to forage again. The neighbouring bird then paced on and they parted company.

‘Exhibiting to the neighbours’
A bird was pacing along the fence occasionally foraging and pausing due to the presence of another bird that was also pacing or standing. They looked at each other for a moment then continued on their own way. After a while one of the birds strutted off, watching the birds in the neighbouring paddock and went into exhibition mode, puffing it’s neck feathers out and thrusting it’s chest forward. A bird in the neighbouring paddock rushed from behind towards the fence, as the bird continued to puff out its feathers fully and strut away from the fence. As the birds nearby in the same paddock move off, there was a brief encounter with one of them as they passed by. The exhibiting bird relaxed, turned and strolled back to the fence and paused. Once again the assertive bird rushed in, put its head through the fence, giving threat. The bird leaned away from the threat, turned and walked off. The attacking bird withdrew its head and rushed off along the fence line.

‘Head through Fence’
As a bird was pacing along the fence bordering the breeder’s paddock, it frequently put its head through the fence as though the breeder’s paddock was its own. After nearly 20 minutes of this persistent behaviour standing with its head through the fence, one of the breeders approached it and pecked it assertively on the side of the neck, just below the head. The pecked bird withdrew its head in and walked off to the fence bordering another paddock where it continued the pacing and pausing, poking its head through the fence into the next paddock.

‘Sparring bird’
A bird stood tall and proud scanning the horizon, when suddenly its head dived parallel to the ground with its neck fully stretched. It stepped to face its target and rushed off, but stopped dead without reaching the target. It then stood tall, turned slightly right and walked a few paces. It stopped, scanned the horizon again, the turned back to move to where it came from. The same bird spent some time sparring with other birds. In one situation, after chasing another bird, it rushed up to a bird standing by the fence and lashed out at it, kicking it until the other bird ran off. Then it stood restless for a while before walking off across the paddock.

‘Wet Droppings’

A bird was noted pacing and walking restlessly around the paddock. It approached the food trough on numerous occasions, attempted to eat but withdrew. It tried some foraging and then a brief drink, but appeared to be not interested. Later it was observed to have very wet droppings.

'Play time'
A bird was foraging when one by one other birds approached and they foraged together. One of the birds became interested in something another bird had and became pushy. A scuffle broke out as the other birds approached to see 2 emus continually tossing a small stone.

'Don't mind where I get a scratch'
While one bird was preening, another bird approached and stood nearby. It then bent its head and rubbed the top of its head in the bend of the preening bird's neck.

'Tangled in the fence'
In the control paddock the birds were spread out, some pacing, others walking, foraging or searching. Along the fence line a few birds from each paddock were pacing. A little tension between some birds developed and a chase was initiated down the fence line. A number of other birds were spooked by the flight and ran along the fence with the others. The bird at the front of the group decided to turn and run back around the approaching birds. A bird turned towards the fence and tried to run around the bird coming behind, so as to avoid being confronted. In doing so one of its legs went through the wire fence and the bird crashed to the ground. The bird's leg became entangled in the fence. It tried to get free but just remained trapped thrashing in the dirt. Birds came from every corner of both paddocks attracted by the thrashing of the entangled emu. The concentration of birds under these circumstances caused many minor scuffles, birds chasing and pecking and in some cases kicking aggressively at each other. While all the scuffles were occurring, we come down from our viewing platform and release the tangled bird.

'The mischievous emus'
While setting up the paddocks for the emus, Geoff Leane told us he put a feed silo containing tons of grain into the paddock. The silo had a schutte with a sliding arm to control the flow of grain when being dispensed. One morning when Geoff went to check the birds, he discovered the emus had managed to pull open the slide on the silo draining 4 tonne of grain into the paddock. He put a wing nut into the slide to prevent this from re-occurring. This was effective only for a few days. The birds pecked at the wing nut, unscrewed it and released all the grain from the silo for a second time. The solution was to use flat screws to secure the slide.

'Pulled the pin on ball float valve'
One day on arriving at the paddock, Geoff Leane told us that he noticed the paddock was a wash with water and he immediately thought it was a burst pipe. On closer inspection he found that the emus had pulled the pin on the ball shut off valve.

'Confusion in the paddocks'

While standing by the fence a bird is threatened by 2 birds running toward it along the fence. The threatened bird responds by standing tall, stretching its neck and flaring the neck feathers. As the birds pass, the threatened bird turns and gives chase. The rushing stirs a pacing bird in the neighbouring paddock to run pace and other birds join in. As the birds in the neighbouring paddock stop running, a brief confusion occurred and one bird charges the others pushing/kicking some into the fence as they tried to pass. Just after impact with the fence the original threatened bird stopped dead, turned, paused a moment with its neck feathers still flared, looked at what happened at the fence and then proceeded to pace back.

'Copy cats'
To enter the emu paddocks one was required to unravel a chain used to secure the gates. The noise of the chain being removed and then replaced was not passed unnoticed by the breeders who were always present as people entered and closed the gates. A sound recording was made of the noises of the emus in the vicinity of the gate. It was discovered that the emus in their own characteristic tone were copying the sound the chain made as it was released and then secured on the gate.

5. IMPLICATIONS

This work has contributed significantly to the Emu Industry by establishing declawing as a creditable practice. Declawing will avert losses of $5,000,000 annually to the Industry by reducing the amount of scarring on the skins from wounds inflicted during aggressive behaviours. Reducing skin damage is essential for the production of A-grade skins of export quality demanded by the world market.

Declawing of the emus markedly improves the safety of handlers, particularly during transport and at the time of slaughter.

Data generated from this study indicates that declawing improves the well-being of the emus by promoting social interaction during rearing and by reducing aggressive behaviours thereby preventing the emus from inflicting injury upon themselves.

6. RECOMMENDATIONS

It is recommended emus be declawed according to the procedure published by the Western Australian Department of Agriculture. That is, emus are declawed soon after hatch using a hot blade beak-trimming machine, leaving part of the distal phalanx intact.

Declawing by this method will minimise any risk of both acute and chronic pain resulting from tissue and nerve damage. Declawing will reduce aggression and stereotype behaviours which can contribute to social stress and skin damage in emus

- To minimise the aggressive interactions between birds it is recommended that:
  - Emus be provided with enough feeding space and drinking space to enable all birds to eat and drink at the same time.
  - Feeders and drinkers should be located well away from fences to reduce the potential of emus running into fences as they escape from conflicts while eating or drinking.
  - The keeping of emus in adjoining paddocks increases the potential for conflicts, skin damage and entrapment in fences.
  - Stereotype behaviours in farmed emus could be minimised by enriching the paddock environment. This could be achieved by providing more forage, novel objects for the birds to peck and sandy areas for dust bathing.
  - The high correlation of giving thrusts to other aggressive behaviours would indicate this variable could be used as a selection parameter in breeding programs to reduce aggression in emus.
- Traditional fencing may need to replaced with materials that prevent entrapment and conflicts between neighbouring stock to reduce damage to the skin.
- Strategies should be employed to keep drinking water cool during summer. These include regular flushing of water trough, keeping incoming water lines out of direct sunlight, insulating water lines and ensuring water storage tanks are well shaded.

Further research required

- Determination of the load bearing of the foot pad and toes of the emus by measuring pressure differences across the footprints during walking and running, with respect to time: assess the effects of declawing on these parameters.
- Influence of environmental enrichment, feeding and drinking space and social groupings on aggressive behaviour and productivity of farmed emus.
- The influence of fencing type on behaviour and productivity of emus in adjoining paddocks.
- Selection for reduced aggression in flocks based on behavioural indices.

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