final report

Project code: B.FLT.0236

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Date published: 22 March 2018

PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 1961
NORTH SYDNEY NSW 2059

Feedlot acclimation study

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

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Abstract

Acclimation is a process of controlled human interaction with cattle that builds on the principles of low-stress stock handling, which is a work practice that has seen interest in grazing production systems, especially weaning management. In feedlots, proponents of acclimation suggest that adaptation and adjustment to the feedlot environment will be enhanced by these methods. Acclimation is held to better manage the psychological stressors associated with the abrupt introduction to a highly mechanised, highly human populated, production system with unfamiliar diet and sources of feed and water. Additionally, the socialisation stress for newly placed feeders as a consequence of commingling with strange pen mates is thought to be reduced by Acclimation.
To date, evidence for the benefits of acclimation in the feedlot industry has been intuitive, but anecdotal. A review of scientific literature (Cusack, 2013) concluded there were inadequate robust, controlled studies to support putative effects of acclimation in feedlot cattle. Therefore, the feedlot industry requested a fully replicated scientific assessment of the process, and this was undertaken at five large scale commercial sites. The main aim of the project was to determine if there are any health, welfare, or production benefits of acclimation in feedlot cattle.

Executive summary

Background

During the last decade, there has been some interest generated, particularly in the North American feedlot industry, of a work practice and process coined “Acclimation” which built on the principles of low-stress stock handling. As is the case in Australia, low-stress stock handling had seen application in pastoral settings for mustering and yard work; especially for yard weaning and tailing out management as an adjunct to this practice.

The main purpose of low-stress stock handling in pastoral environments and acclimation in feedlots is similar – to train cattle to be confident and without fear of human interaction, while also facilitating an expeditious and seamless adaptation to their new environment, be it temporary or permanent. Proponents of these methods will also cite the superior workability of cattle trained with these principles, and a safer and more satisfying work environment for staff and personnel handling the cattle.

The Australian feedlot industry recognised that intuitively, acclimation appeared to have merit as a work practice if it could deliver these proposed benefits and align with good stockperson principles that typically feedlot operators wish to consistently employ. The issue remained however, that any evidence of the proposed benefits was anecdotal. Also, a literature review commissioned by Meat & Livestock Australia (Cusack, 2013) determined that suitably controlled studies demonstrating any effect in feedlot cattle were not available.

There is no strict prescriptive formula of techniques to achieve the aims of acclimation, and different cattle groups will have varying speeds of progress to the desired behavioural end-points based on numerous factors, including genetics, temperament, and phenotypic factors such as handling management, weaning and production / growing methods pre-feedlot.

Objectives

The objectives of the project were to:

1. Establish the performance and financial benefits and costs associated with implementation of an acclimation program through:
    a. Quantification of the improvements in animal welfare, performance and animal health outcomes for feedlot cattle that undergo acclimation programs.
    b. Recording and quantification of all operational cost and work practice changes associated with acclimation activities.
2. Develop a comprehensive, objective and repeatable methodology that industry operators can utilise for the implementation of an acclimation program.

Methodology

The project was run at five (5) large scale commercial feedlot sites so that the acclimation treatment could be tested against standard, conventional procedures employed by staff in all aspects of livestock management, and, that sufficient cattle were available to fill the experimental design across multiple market categories and cattle types. Ten (10) treatment pairs (acclimation v control) were inducted at each site to ensure sufficient replication was achieved for meaningful statistical analysis. The experimental design sought to remove bias by randomly allocating project cattle to a treatment or control pen with blocking for origin, cattle type, and purchase method.

The project utilised a recognised industry expert in cattle handling, familiar with acclimation concepts, to deliver training and minimum competency assessment to the participating livestock personnel at the five commercial feedlot trial sites. The competency assessment was both practical and theoretical. In consultation with the principal investigator, the acclimation trainer developed a structured acclimation schedule (treatment) that was replicated across the five sites.

A suite of animal health, production, and carcase performance data were collected, on an individual animal basis. Cognisant of previous studies' consideration of temperament, this project also collected chute scoring elements at induction on all enrolments into the treatment and control pens. Additionally, an adaptation of the stress surveillance employed in habitat management of wildlife, whereby cortisol metabolites in faeces are measured to establish stress levels, was utilised to address a deficiency in physiological stress markers identified in previous studies.

Results

The project captured a total of 9533 conventional control cattle and 9518 acclimation treatment cattle across the 50 pen replicates and 5 feedlot sites. Enrolments occurred from January 2015 to May 2017. There was an equal distribution of sex in the study cattle and treatment group, and induction weights ranged between 300kg – 500kg as feeders entered largely short-fed and mid-fed programs typical of the Australian lot feeding industry.

No significant effects of acclimation were detected in health or on-feedlot production metrics, carcass attributes or faecal cortisol variables in this project.

- There were no differences in pull rates, for any cause(s), or rate of death loss and reject salvage between acclimation treatment cattle and standard controls.
- For exit live weights, carcass weights, average daily growth (gain) (ADG) rates and feed conversion efficiencies (FCE), differences between means for treated cattle relative to control cattle were small, 95% confidence intervals relatively narrow, and p-values high.

The livestock staff surveyed at the completion of the project indicated they could appreciate positive behavioural indicators in acclimated cattle and that acclimation was a very useful skillset that they saw as highly valuable to any personnel working with cattle, and that it added to their own personal job satisfaction. They also supported applying an acclimation schedule only to select groups of incoming cattle based on a risk assessment of temperament, breed, sourcing location and high transit stress.

Benefit to industry

For the first time, industry has definitive data on the benefits of acclimation under Australian conditions. There was no direct, positive return on investment for acclimation in this project, in that the extra human resources in terms of staff hours spent on acclimation did not return benefits in feedlot cattle health, production or carcase attributes, over standard feedlot work practice.

While the project researchers recommend the use of low-stress stock handling techniques for all instances of cattle handling, the application of the formalised acclimation schedule outlined in this report may only be warranted in select groups of at-risk cattle.

Future research opportunities

The novel approach to chute temperament testing of cattle, remote surveillance of feedlot production pens by solar powered video cameras, and the use of a non-invasive physiological stress monitor via faecal cortisol metabolites have future research application. The video footage captured in home pens during this trial is a resource that could be utilised in future research, such as animal welfare science, and the database generated from this project has immense capacity for analysis to further investigate the (extra to acclimation) interactions between all the health, production and carcass variables collected.

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1 Background

The Australian feedlot industry and its operators were familiar with the North American feedlot industry's experiences with acclimation and of domestic practitioners championing its cause in feedlot and pastoral settings. Industry conferences and workshops at feedlot sites by these practitioners have presented a range of cattle handling techniques, grouped as acclimation, which involve human handlers working cattle within their home production pens, moving cattle out of their home production pens into lanes and returning, and through handling facilities. Concepts of controlled pressure-response-reward handling, the power of body position and movement as opposed to generating noise or using goads, initiating lead movement in a group, and steering towards no-pressure areas, flight zone appreciation etc, form some – not all – of the basis of skills required for low-stress stock handling and acclimation . The Australian feedlot industry had some familiarity with these concepts and wanted to examine whether acclimation applied to new feeders would confer any benefits. The significance to the feedlot industry included the possibility that a non-invasive, non-pharmaceutical, structured work practice that enriched livestock staff job satisfaction and aligned positively with good quality assurance and workplace health and safety of feedlot operations, might also deliver animal health, welfare, and production benefits to feedlot cattle concurrently.

Before this project, evidence for any benefit to feedlot cattle subject to an acclimation process was anecdotal. Additionally, a literature review (Cusack, 2013) concluded there were inadequate robust, controlled studies to support putative effects of acclimation in feedlot cattle. This literature search revealed that acclimation has been proposed as a procedure to improve temperament (Noffsinger and Locatelli, 2004), but the procedure of acclimation is inadequately defined. Other studies had determined that calmer temperament cattle, as measured by flight speed, agitation when confined in a crush, or agitation when isolated in a pen with a human handler, were associated with significant positive effects in feedlot cattle on dry matter intake (Nkrumah et al., 2007; Café et al., 2011), and average daily gain (Voisinet et al., 1997; Fell et al., 1999; Petherick et al., 2002; Hoppe et al., 2010; Café et al., 2011; Turner et al., 2011). However, calm temperament cattle – as measured by the above methods – demonstrated no effect on bovine respiratory disease morbidity, mortality, or post-mortem lung lesions (Reinhardt et al., 2009), but with a positive effect on total mortality (Reinhardt et al., 2009). Published work on a handling method through a processing facility (Cooke et al., 2009*a*, 2009*b*; Cooke et al., 2012; Francisco et al., 2012) demonstrated improved temperament, as measured by temperament score and plasma cortisol concentration (Francisco et al., 2012), exit velocity and plasma concentration of cortisol and haptoglobin (Cooke et al., 2012), and crush score and plasma cortisol concentration (Cooke et al., 2012). However, while this handling method may have produced one of the aims of acclimation in that improved temperament (as objectively measured) was achieved, it resulted in decreased average daily gain (ADG; $P < 0.01$) and gain:feed (G:F; $P = 0.03$) corresponding with decreased dry matter intake (DMI; $P = 0.07$) in *Bos taurus* steers placed in commercial Oregon (USA) feedlots.

Against this backdrop, the Australian feedlot industry determined that a fully replicated scientific assessment of the process of acclimation should be undertaken to discover any possible benefits to feedlot cattle, in particular any benefits to animal health, welfare, and production. In concert with, and cognisant of, some of the recommendations in the Cusack (2013) literature review, the project objectives sought to include the development of a comprehensive, objective, and repeatable methodology of applying acclimation to feedlot cattle and examining for effects.

2 Project objectives

The project objectives can be summarised as follows;

- Development of a comprehensive, objective, and repeatable methodology of applying acclimation to feedlot cattle.
- Random allocation to pen with blocking for origin, cattle type, and purchase method.
- Recognition of pen as the unit of interest due to acclimation being a pen-based intervention.
- Allocation of appropriate controls with allowance for pen as a potential confounder.
- Appropriate replication of treatments and control to ensure statistical validity of results.
- Inclusion of objective measurement of the effectiveness of the acclimation method in improving cattle temperament, in producing calm and settled behaviour in cattle, constructive responsiveness to human handlers, enhancing adaptation to the feedlot environment, and any health and performance benefits.
- Collection of data on animal health, production, and carcase performance in project cattle.
- Comparison of animal health, production and faecal cortisol variables between acclimated treatment cattle and existing feedlot management control cattle.
- Quantification of all labour inputs and determination of any efficiency or cost-benefit gained through implementation of acclimation.
- Documentation and maintenance of existing feedlot management and handling regimes across control treatments for the duration of the study.

3 Methodology

3.1 Animal ethics approvals

This project was approved by the Queensland Department of Agriculture, Fisheries and Forestry Ethics Committee; reference numbers SA 2014/12/494 and SA 2017/02/593.

3.2 Feedlots

The acclimation project was a controlled trial conducted within five (5) commercial feedlots from January 2015 to May 2017. The number of replicates of paired treatment and control pens were ten (10) per site, resulting in twenty (20) pens utilised per participating feedlot for the duration of the study. Across the fifty (50) total replicates for the entire study, just under 20,000 head of cattle were enrolled and monitored in the study. Replicates were "blocked" by source, market category and cattle types such that incoming source cattle were systematically allocated evenly to treatment and control groups within the incoming sources. Procurement of feeders into the trial sites were through channels of saleyard purchase, direct consignment and from backgrounding operations. The market categories and feeding programs of the enrolments included short-fed bullocks (100 – 120 days fed), trade domestic (70 days fed), and European Union (120 days fed). Cattle types across these programs included British, Euro, cross-bred British, *Bos indicus* and cross-bred *B. indicus*.

3.3 Induction

The commercial feedlot sites received new arrival cattle per their normal operational process(es) and inducted into lots / pens as normal, however the study design required that an acclimation replicate of treatment and control pens both be filled in less than three (3) days. If incoming source cattle numbers appeared to be able to fulfil this requirement, a trained project team member would visit the site and conduct a temperament scoring exercise (see scoring elements below in appendix 9.1.3) through the induction chute for all the treatment and control enrolments. The chute temperament scoring exercise was also captured by video footage as described in the appendix below so that re-examination post-induction could be conducted if required, and, a novel technique of calculating chute exit velocity using frame speeds of the video captured exiting from the chute of each enrolment was also applied. As such, a baseline temperament score, consisting of ten (10) total elements, five (5) of which were direct behavioural elements on a categorical scale, four (4) were operational elements and one (1) was the objective measure of exit velocity was established for each enrolment into the trial.

3.4 Acclimation schedule

An acclimation schedule which outlined the acclimation workings that were to be applied to the treatment pen catered for all the encountered feeding programs at each of the trial sites. The acclimation schedule also detailed the days during the feeding period that faecal samples were to be taken for the cortisol metabolite monitoring of both the treatment and control pens. The acclimation schedule is available below in Appendix 9.1.2.

A recognised industry expert practitioner of acclimation had conducted workshops with each participating feedlot site preceding the trial starting proper. From these workshops, competency tested (theory and practical) livestock staff were selected from each site for an initial set of practice pens for acclimation working and then the selected livestock staff were then further examined for competency before the first trial pens were enrolled. The acclimation trainer returned to each site halfway through the set of completed replicates to validate the required skillsets were still maintained and all elements of the acclimation schedule were being adhered to. Additionally, the project leaders visiting the acclimation trial sites also verified minimum standards were being maintained. Further, project leaders and the acclimation trainer had access for remote viewing of the video monitoring being captured of the treatment and control pens of enrolled replicates.

3.5 Data collection

Initially, the study design required, in addition to replicate pens being filled no later than three days, full-time video monitoring of treatment pen and concurrently control pen. This did limit the rate of enrolment of pen replicates. At each feedlot site, at least five (5) x replicates have been captured by video monitoring with footage stored for subsequent review and analysis in addition to the monitoring function served during the experimental phase of the trial. The acclimation schedule commenced the day after the last enrolments were inducted into the pens due to time spent filling the treatment and control pens with trial enrolments, ensuring that video cameras were mounted, functional, and transmitting to the local base station, external drive, and to the dedicated website for live remote viewing. For the control pens, all feedlot operations were conducted as normal without acclimation treatment except for the faecal sample monitoring to evaluate cortisol metabolite levels to compare against the acclimation treatment pen. Faecal samples were collected at the equivalent date and time for the treatment and control pens under a structured protocol.

Carcase and MSA data were collected electronically from the processors by Management for Technologies through their existing data management arrangements with the individual feedlots.

The acclimation process is outlined in Appendix 9.1.1 and describes the activities performed during acclimation workings per the schedule applied to the treatment pens. Examples of trained personnel recording acclimation sessions during the experiment are presented alongside the acclimation schedule in Appendix 9.1.2.

3.6 Summary

The project methodology has been developed to:

1. Ensure repeatability and consistency of results by engaging with the proposed five feedlots and a total of approximately 20,000 head comprising a range of sources, cattle types, and days on feed.
2. Determine cause and effect relationships by analysing data from assessing at least 28 individual and lot health and performance parameters, from induction through to chiller assessment.
3. Measure the quantitative impacts of acclimation by splitting each lot/pen into control and experimental groups.
4. Determine acclimation measurement variability based on the split of vendors / origin sources equally into control and experimental groups. This will show the differences in acclimation outcomes by vendor/ origin source types.
5. Ensure robustness of study and negating potential bias by conducting the study across five (5) feedlot sites with independent assessors while conducting centralised data analysis.
6. Quantify the costs and operational benefits, if any, by recording all operational cost and work practice changes associated with acclimation activities.
7. Ensure study adoption and post study continuation of positive animal welfare outcomes due to education and training of feedlot management and operational personnel in acclimation methods.

Other proposed measurements, utilising video monitoring footage from the experimental treatment and control pens, included calculations of flight zone for both acclimation and non-acclimation groups at specific days on feed periods / experimental stages, preferably to an equivalent stimulus such as faecal cortisol sampling. Also, calculations of flight speed and flight zone during defined points of the acclimation schedule and target behavioural indicators using the moving and still video footage were proposed.

Active participation and support by the feedlot sites was achieved through compensation of costs associated with disruption to normal work practices by the acclimation study.

The statistical methods utilised to analyse effects of acclimation are outlined in the Results section below.

4 Results

4.1 Summary

A controlled trial was conducted to assess the effects of acclimation in feedlot cattle. Within each of five commercial feedlots, from January 2015 to May 2017, ten cohorts of incoming cattle were selected, where a cohort could consist of cattle from one or multiple sources. As each cohort was inducted, half of the cattle were systematically allocated to a treatment group or lot and the remaining half allocated to a control lot. Each lot was then housed in a separate pen for the study period. In total, 9,518 treated cattle were enrolled across the 50 treatment lots and 9,533 control cattle were enrolled across the 50 control lots (19,051 cattle in total). All cattle in the fifty treatment lots received the acclimation treatment. Other than this, treated and control lots were managed in the same way as non-study lots. At induction, nine chute variables were recorded for each animal; these described various animal behaviours during induction and aspects of the induction process.

No significant effects of acclimation were detected, in this project the null hypothesis was proved.

In total, 0.6% of treated animals and 0.7% of control animal died while on feed. Reasons for death were similar in treated and control cattle. During their time on feed, 20% of treated animals and 19% of control animals were pulled at least once. The most common reasons for first pull were BRD, “buller” syndrome, foot problems and observation. Reasons for first pull were similar in treated and control cattle, as were cumulative incidences of being pulled for any reason. Cumulative incidences of being pulled for BRD, being a buller, foot problems and observation were also similar in treated and control cattle.

For exit live weights, carcass weights, average daily growth (gain) (ADG) rates and feed conversion efficiencies (FCE), differences between means for treated cattle relative to control cattle were small, 95% confidence intervals relatively narrow, and p-values high. These results indicate that, if these variables are affected by acclimation, any such effects are small. For evaluating ADG rate, the project investigators proposed an additional measure to standard industry reporting where ADG is typically calculated based on assigning starting weight to the purchase (pay) or induction weight and finishing weight to the feedlot exit (weighbridge) weight. A summary of average daily gain (ADG) measures is listed below, with the proposed “ADG-M” metric outlined;

- **ADG-T**: Average Daily Gain “Truck” whereby exit weight as recorded on feedlot weighbridge is used as finishing weight
- **ADG-L**: Average Daily Gain “Liveweight” whereby individual liveweight is approximated by dead bar scale in the abattoir, just post knocking, and is used as finishing weight
- **ADG-C**: Average Daily Gain “Carcase” whereby feedlot exit weight is calculated from the known Hot Standard Carcase Weight measured in abattoir, using a fixed yield of 55% to standardise
- **ADG-M**: Average Daily Gain “Meat” whereby induction weight is utilised as the starting weight and carcase weight is the finishing weight. The induction weight is adjusted by a fixed yield of 55% (as opposed to carcase weight) in order to minimise calculation error

Intuitively, the "ADG-L" is the best surrogate of actual individual liveweight (immediately pre-slaughter) as this weight is taken just after knocking and bleeding in the abattoir. A "dead bar" scale to capture this weight is not available in all abattoirs however.

Definitions of market reject and grading fail were developed to describe animals whose carcasses did not attain market values. Of treated and control cattle, 1.5% and 1.4%, respectively, were market rejects, and 2.8% and 2.3%, respectively, were grading fails.

Carcass attributes (P8 fat depth, eye muscle area, MSA index, marbling score and meat colour) did not vary significantly between treated and control cattle. Results indicated that, for P8 fat depth, eye muscle area, and MSA index, if these variables are affected by acclimation, any such effects are, at most, modest.

Feed delivered and consumption per head were compared over time between treated and control cattle at lot level. Consumption up to day 50 were similar in treated and control lots and means did not differ significantly between treated and control lots. Both treated and control lots plateaued evenly from day 50 to close out.

Faecal cortisol concentrations were measured on multiple days in all 20 lots (10 pen pair replicates) from one feedlot. On each sampling day, 8 to 11 faecal pats were sampled and mean faecal cortisol concentration calculated. Concentrations decreased rapidly from day 1 in a curvilinear fashion. Concentrations were similar in treated and control lots.

It was possible that the effects of acclimation varied between subgroups of cattle. To explore this, some factors that may have potentially interacted with acclimation were assessed. Effects on average daily gain *meat* (ADG-M), being pulled (for any reason and by reason) and MSA index were assessed. Most p-values were high, thus providing no support of the hypothesis that the effect of acclimation varies between the respective subsets of cattle.

Chute score variables were not closely correlated. If misclassification errors were minimal when allocating chute scores, these results indicate that these various chute scores are largely describing different attributes of the animal. For a subset of study cattle from one feedlot, using video footage, average velocities were calculated for each animal as they moved the 1.5 metres from the crush release to when their head aligned with the start of the gate. Some preliminary analyses of velocity were performed. There was considerable overlap in velocities for cattle with various chute exit scores, indicating that chute exit score is not a close surrogate for exit velocity. There was also considerable overlap in velocities for cattle with various values for other chute score variables.

Potential determinants (other than acclimation) of being pulled for any reason, being pulled for BRD, average daily growth rate – meat and MSA index were also assessed using multivariable models.

The hazard of being pulled for any reason varied markedly by feedlot, and with dentition (animals with 1 to 4 permanent incisors were less likely to be pulled than those with no permanent incisors). The hazard of being pulled also varied with chute entry score (animals with scores of 2 or 3 were less likely to be pulled than those with scores of 1) and with chute exit score (animals with scores of 2 or higher were at less risk than those with scores of 1). Cattle from saleyards had the highest risk of being pulled, those in cohorts formed with cattle from 2 to 10 property identification codes (PICs) had the next highest risk, and those in cohorts formed from 1 PIC had the lowest risk.

The hazard of being pulled for BRD also varied markedly by feedlot, and with dentition (animals with 1 to 4 permanent incisors were less likely to be pulled than those with no permanent incisors). Cattle from saleyards had the highest risk of being pulled for BRD, those in cohorts formed with cattle from 2 to 10 PICs had the next highest risk, and those in cohorts formed from 1 PIC had the lowest risk.

ADG-M varied markedly by feedlot, with two of the five feedlots having considerably higher growth rates. ADG-M varied with induction weight (higher in those heavier at induction), sex (higher in males), and dentition (higher in animals with no permanent incisors compared to those with 1 or more permanent incisors). Estimated effects of chute entry and vocal scores were small. Relative to cattle in cohorts formed with cattle from only 1 PIC, cattle in cohorts formed with cattle from 2 to 10 PICs had higher average daily growth rates – meat, as did those from saleyards.

MSA index varied markedly by feedlot. MSA index also varied with ADG-M and induction weight (higher in those with higher ADG-M, and in those that were heavier at induction), sex (higher in females), and dentition (higher in animals with no permanent incisors compared to those with 1 or more permanent incisors).

Six chute score variables were also associated with MSA index. Mean MSA index values were highest in cattle with chute entry scores of 1 (relative to ≥2), chute resist scores of 2 to 5 (relative to 1), chute vocal scores of 1 (relative to 2 or 3), chute faecal scores of 4 (relative to 1), and chute exit scores of 1 (relative to 3 to 5), and in cattle whose horns were not tipped. However, some of the estimated effects of chute score variables were relatively small (changes of 0.1 to 0.3 units relative to the reference group).

4.2 Statistical methods

Statistical analyses were performed using Stata (version 15, StataCorp, College Station, Texas, USA).

Binary variables (transferred, died, market reject, grade fail, non-performer, meat colour score) were compared between treated and control cattle using logistic regression with lot fitted as a random effect and treatment and feedlot fitted as fixed effects. Stata's -xtlogit- command was used.

Times to first pull were calculated as first pull date minus induction date. Times were compared between treated and control cattle using competing risks survival analysis. Under usual survival analysis, records for individuals not experiencing the event of interest are right-censored at the last date they were observed with the implicit assumption that those individuals could have subsequently experienced the event at some future date after their study observation period ended. In contrast, competing risks regression is appropriate if individuals not experiencing the event of interest are no longer at risk of experienced that event. For example, cattle not pulled by date of exit can no longer be pulled. Thus, exiting is considered a competing risk, preventing cattle not yet pulled from being pulled. Competing risks regression models were fitted using Stata's -stcrreg- command. Robust standard errors that accounted for correlations between cattle within lots were used. Treatment and feedlot were fitted as fixed effects.

For analyses of times to first pull for any reason, exiting and death in the feedlot were treated as competing risks. Cattle not pulled whose exit status was recorded as transfer were right-censored on their transfer date. Cattle whose first pull reason was recorded as 'Return home' were excluded from these analyses.

Times to first pull for each of the most common specific reasons for first pull (BRD, buller, foot problems, and observation) were also analysed. For each of these analyses, being first pulled for any other reason, exiting and death in the feedlot were treated as competing risks. Cattle not pulled whose exit status was recorded as transfer were right-censored on their transfer date. Cattle whose first pull reason was recorded as 'Return home' were excluded from these analyses, as were cattle whose reasons for first pull were 'no pull code' or 'unknown'.

Numbers of pulls per animal were compared between treated and control cattle using a Poisson model, with lot fitted as a random effect and treatment and feedlot fitted as fixed effects. Stata's -xtpoisson- command was used. Cattle whose first pull reason was recorded as 'Return home' were excluded from this analysis. The exponentiated coefficient for treatment was interpreted as the ratio of the arithmetic mean number of pulls per animal for treated cattle relative to control cattle.

For continuous data (exit weights, average daily gains, feed conversion efficiencies, P8 fat depth, eye muscle area and MSA index), means were compared between treated and control cattle using linear regression with lot fitted as a random effect, and treatment and feedlot fitted as fixed effects. Stata's -xtreg- command was used, with the maximum likelihood random effects estimator. For analyses of exit weights, average daily gains, and feed conversion efficiencies, induction weight and days on feed were fitted as additional covariates. These analyses of MSA index values treat those data as continuous (interval) i.e. there is an implicit assumption that each unit increase in MSA index has the same underlying meaning over the range of index values observed in the study data. It is unclear whether this assumption is valid.

Distributions of the ordinal variable, marbling score, were compared between treated and control cattle using proportional odds regression models with treatment and feedlot fitted. Stata's -ologit- command was used, with robust standard errors that accounted for correlations between cattle within lots. The proportional odds assumption was assessed using the Brant test of the parallel regression assumption, calculated using Stata's -brant- command after fitting treatment but not feedlot.

Interactions between treatment and other factors (i.e. effects of treatments in various subsets of animals) were assessed using the same statistical models were used as described above, but with interaction terms with treatment category (i.e. treated or control) fitted. For some potential interacting factors, some levels were collapsed to simplify the model. For average daily gain *meat* (ADG-M) and MSA index, the joint significance of the interaction terms was assessed using likelihood ratio tests, while for being pulled (for any reason and by reason), joint Wald tests were used.

Amounts of feed offered to each lot each day per head were compared with the lot-day as the unit of analysis. Feedlot was fitted as a fixed effect and linear and quadratic terms for time were fitted as feed offered increases from day 1 in a curvilinear fashion, with increases in daily feed offered initially large but becoming progressively smaller with time. Stata's -mixed- command was used, with lot fitted as a random effect. Errors were assumed to have a first order autoregressive correlation structure. Maximum likelihood estimation was used.

In addition, total amounts of feed up to day 50 were compared between treated and control lots. The lot was the unit of analysis. Linear regression models were used with treatment and feedlot fitted as fixed effects. Stata's -regress- command was used.

Faecal cortisol concentrations were compared using means of values from the 8 to 11 faecal pats collected from the lot on the same day. Thus, for all analyses, the unit of analysis was at the lot-day level. Within cohorts, treatment, and control lots had been sampled on the same day; this pairing of samplings was accounted for in the statistical analyses. Feedlot was fitted as a fixed effect and linear and quadratic terms for time on feed were fitted as concentrations decreased rapidly from day 1 in a curvilinear fashion, with decreases initially large but becoming progressively smaller with time. Concentrations were compared between treated and control lots using Stata's -mixed- command, with lot-day clustered within pair which, in turn, was clustered within lot which, in turn, was clustered within cohort. Maximum likelihood estimation was used.

Statistical methods for additional analyses are described below, in conjunction with the results of those analyses.

4.3 Numbers enrolled

Numbers of cattle enrolled are summarised in Table 1. Ten cohorts (each consisting of one treated lot and one matched control lot) were enrolled in each of 5 feedlots. In total, 19,051 cattle were enrolled, 9,533 in control lots and 9,518 in treated lots.

Within the 50 cohorts, treated and control lots had the same number of cattle or 1 animal different other than 3 cohorts (feedlot 24: 4 more in one control lot; feedlot 24: 2 less in one control lot; feedlot 26: 11 more in one cohort).

In total, 397 animals were listed twice (396 from the first cohort enrolled from feedlot 26, 1 animal from feedlot 4; within each of these animals, one record had induction date and weight recorded). These duplicated records were excluded.

Table 1. Numbers of cattle enrolled

Feedlot	No. cattle			No. cattle in treated lots	
	Control cattle	Treated cattle	Pooled	Median	Range
4	2,184	2,183	4,367	227	190 to 235
22	2,639	2,636	5,275	265	244 to 278
24	2,158	2,154	4,312	231.5	167 to 257
26	1,679	1,670	3,349	181.5	61 to 219
28	873	875	1,748	87	70 to 100
Pooled	9,533	9,518	19,051	208	61 to 219

4.4 Description of enrolled cattle

Induction date was recorded for 98% of cattle (18,692/19,051). Cattle were inducted between January 2015 and May 2017 (Figure 1).

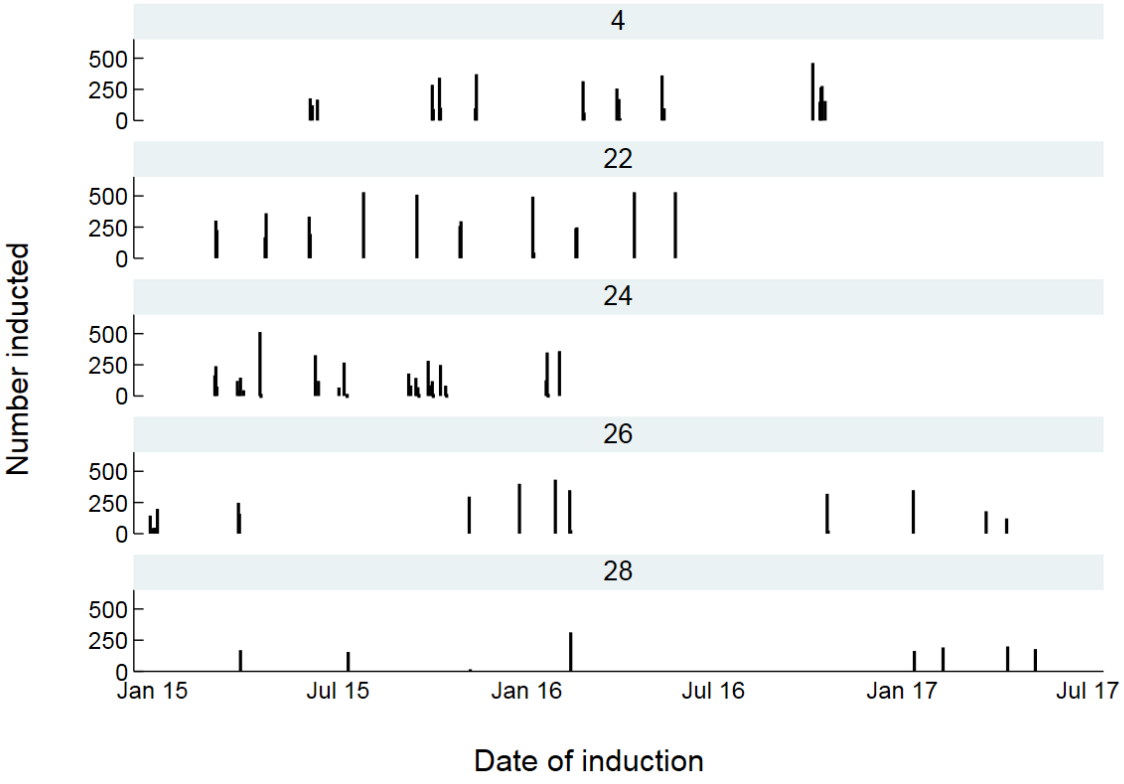

Figure 1. Distributions of study cattle by date of induction (month and year) and feedlot. (Feedlot identification numbers were 4, 22, 24, 26, and 28.)

Sexes of study cattle are shown in Table 2, and induction weights are shown in Figure 2.

Table 2. Distribution of study cattle by sex and treatment group

Sex	Control cattle		Treated cattle	
Female	3,106	32.6%	3,117	32.8%
Male	6,419	67.4%	6,392	67.2%
Sex not recorded	8		9	
Pooled	9,533	100.0%	9,518	100.0%

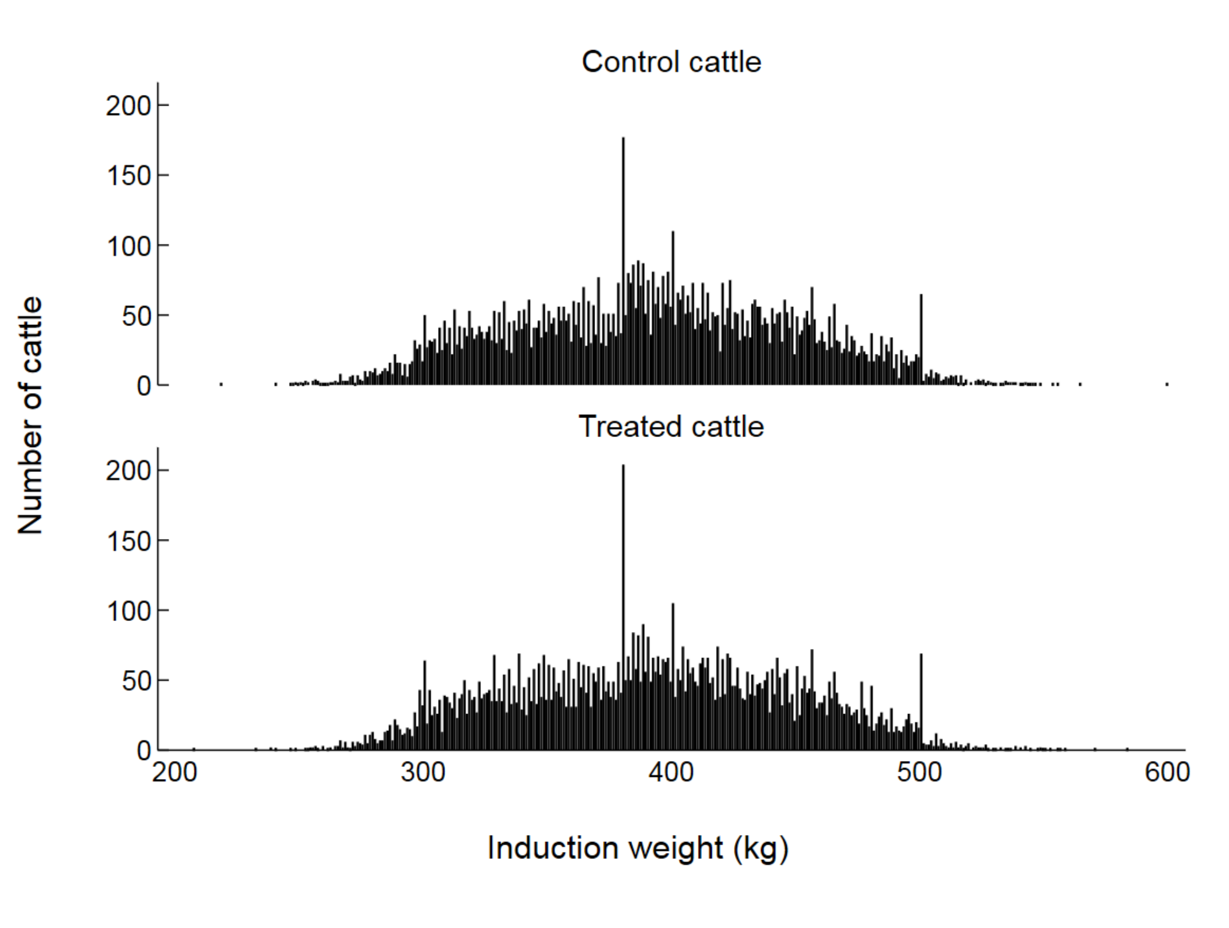

Figure 2. Distributions of induction weights of study cattle by treatment group.

The peaks in induction weights at exactly 380 kg, 400 kg and 500 kg were largely due to 486 (11%) of the 4,367 animals from feedlot 4 (3% of all study animals). These animals were spread across all 20 lots from that feedlot and constituted between 2% and 31% of animals in those lots. These cattle had average daily growth rates of meat within the same ranges as other cattle in their lots (Figure 3). Reasons for the unexpectedly large numbers of cattle with these values were not ascertained. However, as average daily growth rates *meat* (ADG-M) for these cattle were similar to those from other cattle in their lot, it was likely that their true induction weights were moderately close to these recorded values. As induction weights are subject to other important sources of variation including gut fill, errors in induction weights in these animals was probably minor relative to other sources of variation. For these reasons, and because these cattle constituted minorities of cattle in their lots, these cattle were retained in analyses.

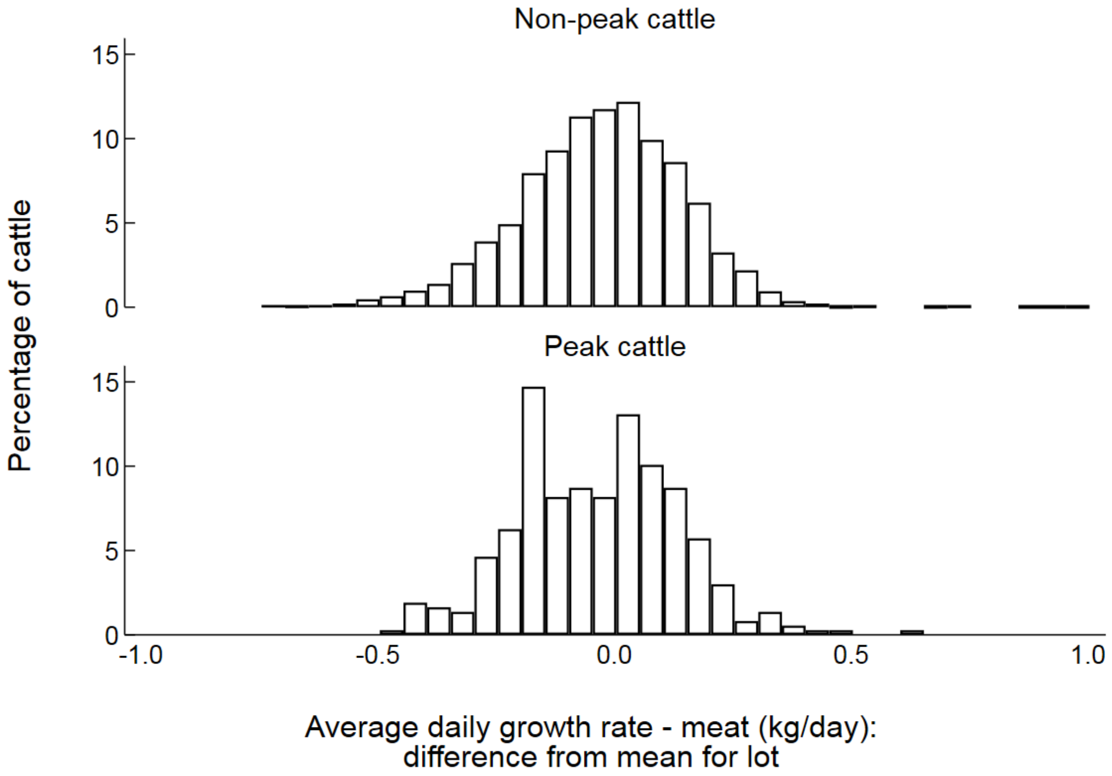

Figure 3. Distributions of differences in average daily growth rates *meat* (ADG-M) between study cattle with induction weights of exactly 380 kg, 400 kg, and 500 kg from feedlot 4 ("peak") and other cattle from that feedlot ("non-peak"). Cattle with differences <-1 kg/day (5 non-peak cattle) and >1 kg/day (34 non-peak cattle; 2 peak cattle) were excluded from this graph.

Distributions of study cattle by chute variables are shown in Table 3. Two vocal and two exit scores, on time score were invalid values (all >5) and all were deleted. For jigger used, only values of 1 (not used), 4 (used once) or 5 (used more than once) were valid. However, 6 animals were recorded as having values of 2 or 3. These invalid values were deleted. For the variable, horns tipped, only values of 1 (not tipped) or 5 (tipped) were valid. However, 512 animals were recorded as having values of 2, 3 or 4. These consisted of 2 animals from feedlot 22, both of whose horn scores were deleted, and all 510 animals in one cohort from feedlot 24 (cohort 100039). As it was possible that horn tip data had been transposed with other chute variables for these animals, no chute variables were used from these 510 animals. For all chute score variables, scores were right-skewed with the majority of cattle having low to moderate scores and a minority having high scores. For chute entry, resist and exit scores, the mode score was 2; for all other variables, the mode score was 1. Faecal scores of 3 were allowed even though that category was not specifically described as these scores presumably represented a gradation between the adjoining categories.

Table 3. Distributions of study cattle by chute variables and treatment group

Chute variable	Control cattle		Treated cattle	
Entry				
1	3,649	39.5%	3,521	38.1%
2	4,326	46.8%	4,364	47.3%
3	1,130	12.2%	1,206	13.1%
4	114	1.2%	127	1.4%
5	22	0.2%	17	0.2%
Not recorded	35		30	
Cohort 100039	257		253	
Pooled	9,533	100.0%	9,518	100.0%
Catch				
1	8,635	93.4%	8,638	93.5%
2	393	4.3%	407	4.4%
3	71	0.8%	50	0.5%
4	4	0.0%	6	0.1%
5	138	1.5%	134	1.5%
Not recorded	35		30	
Cohort 100039	257		253	
Pooled	9,533	100.0%	9,518	100.0%
Resist				
1	2,848	30.8%	2,778	30.1%
2	3,370	36.5%	3,325	36.0%
3	2,508	27.1%	2,555	27.7%
4	456	4.9%	507	5.5%
5	59	0.6%	70	0.8%
Not recorded	35		30	
Cohort 100039	257		253	
Pooled	9,533	100.0%	9,518	100.0%
Vocal				
1	4,834	52.3%	4,749	51.4%
2	1,859	20.1%	1,864	20.2%
3	1,696	18.4%	1,672	18.1%
4	744	8.1%	825	8.9%
5	108	1.2%	123	1.3%
Not recorded or invalid value	35		32	
Cohort 100039	257		253	
Pooled	9,533	100.0%	9,518	100.0%
Faecal				
1	7,824	84.7%	7,843	84.9%
2	947	10.2%	924	10.0%

3	116	1.3%	127	1.4%
4	120	1.3%	108	1.2%
5	234	2.5%	233	2.5%
Not recorded	35		30	
Cohort 100039	257		253	
Pooled	9,533	100.0%	9,518	100.0%
Exit				
1	591	6.4%	573	6.2%
2	3,951	42.8%	3,984	43.1%
3	3,595	38.9%	3,549	38.4%
4	893	9.7%	939	10.2%
5	210	2.3%	188	2.0%
Not recorded or invalid value	36		32	
Cohort 100039	257		253	
Pooled	9,533	100.0%	9,518	100.0%
Jigger used				
Not used	9,092	98.4%	9,092	98.5%
Used once	30	0.3%	34	0.4%
Used more than once	116	1.3%	107	1.2%
Not recorded or invalid value	38		32	
Cohort 100039	257		253	
Pooled	9,533	100.0%	9,518	100.0%
Horns tipped				
No	9,089	98.4%	9,113	98.7%
Yes	150	1.6%	122	1.3%
Not recorded or invalid value	37		30	
Cohort 100039	257		253	
Pooled	9,533	100.0%	9,518	100.0%
Time				
1	6,255	67.7%	6,249	67.7%
2	2,449	26.5%	2,415	26.2%
3	379	4.1%	390	4.2%
4	89	1.0%	81	0.9%
5	69	0.7%	100	1.1%
Not recorded or invalid value	35		30	
Cohort 100039	257		253	
Pooled	9,533	100.0%	9,518	100.0%

4.5 Assessment of main effects of treatment

4.5.1 Exit reasons

Distributions of study cattle by exit type are shown in Table 4 and reasons for death are shown in Table 5.

Percentages of cattle having each exit type were similar for treated and control cattle. Transfers occurred in only 2 feedlots (feedlots 4 and 28). Within these feedlots, the odds ratio for being transferred rather than exiting or dying (treated relative to control; adjusted for feedlot) was 0.82 (95% CI 0.42 to 1.62; P=0.573). If the odds ratio was known to be 0.82, this would indicate that the odds of being transferred for treated cattle are 0.82 (or 82%) of the odds of being transferred for control cattle. However, the 95% CI is from 0.42 (odds 58% lower for treated cattle) to 1.62 (odds 62% higher for treated cattle). Thus, these results are also compatible at the 0.05 level (i.e. P<0.05) with no difference in odds (an odds ratio of 1) and also with increased odds in treated cattle. The P-value of 0.573 indicates that the null hypothesis (that there is no difference in odds) cannot be rejected.

The odds ratio for dying in the feedlot rather than exiting (treated relative to control; adjusted for feedlot) was 0.94 (95% CI 0.63 to 1.41; P=0.780).

These results do not support the hypothesis that acclimation affects exit type. However, based on these 95% CIs, these results are compatible with acclimation having quite large adverse or beneficial effects.

Reasons for death were similar for treated and control cattle (Table 5).

Table 4. Distribution of study cattle by exit type and treatment group

Exit type	Control cattle		Treated cattle	
Exit or exit calculated	9,397	98.8%	9,401	98.9%
Dead	66	0.7%	61	0.6%
Transferred	45	0.5%	43	0.5%
Not recorded	25		13	
Pooled	9,533	100.0%	9,518	100.0%

Table 5. Reasons for death by treatment group

Reason	Control cattle		Treated cattle	
Acidosis	1	1.7%	1	1.9%
Bloat	6	10.0%	4	7.4%
BRD	29	48.3%	25	46.3%
Buller	0	0.0%	2	3.7%
Cast	3	5.0%	2	3.7%
Dystocia	2	3.3%	2	3.7%
Injury	6	10.0%	6	11.1%
Liver	1	1.7%	0	0.0%
Septic arthritis	4	6.7%	4	7.4%
Stock adjust	0	0.0%	1	1.9%
Tracheitis	5	8.3%	4	7.4%
Urogenital	1	1.7%	2	3.7%
Other	2	3.3%	1	1.9%
Not recorded	6		7	
Pooled	66	100.0%	61	100.0%

4.5.2 Pulls for any reason

Cumulative incidences of being pulled for any reason were compared between treated and control cattle. For all analyses of incidences of being pulled, pulls where the reason was "Return home" were disregarded. In addition, in one lot (the control lot from cohort 100006 in feedlot 4), after experiencing 2 BRD pulls on 20th April 2016 (when most of the 224 animals had been inducted 9 or 11 days previous) and 13 BRD pulls on the next day, a mass pull was conducted on 22nd April 2016 with 198 further animals pulled for BRD on that date. These 198 animals were excluded before analyses of pulls.

After excluding these 198 animals, 19.0% of control animals (1,769/9,335) and 19.8% (1,882/9,518) of treated animals were pulled at least once. Reasons for first pull are shown in Table 6. The most common reasons for first pull were BRD, being a buller, foot problems and observation. Reasons for first pull were similar in control and treated cattle. Times from induction to first pull could be calculated for 1,752 of the 1,769 pulled control cattle and 1,854 of the 1,882 pulled treated cattle. These are summarised in Figure 4. Cumulative incidences of being pulled for any reason by days from induction to first pull are shown in Figure 5.

The sub hazard ratio for being pulled (treated relative to control; adjusted for feedlot) was 1.04 (95% CI 0.83 to 1.30; P=0.742). This sub hazard ratio refers to the hazard of being first pulled for treated cattle relative to that for control cattle after accounting for competing risks. The hazard is the probability that an animal is first pulled at any particular time point given that the animal has not been pulled up to that time. If there had been a beneficial treatment effect on being pulled, this could have been because of a) a direct effect of treatment making being pulled less likely to occur, b) an indirect effect of treatment making competing events (i.e. exiting or dying in the feedlot) more likely to occur, or c) both.

If the sub hazard ratio was known to be 1.03, this would indicate that the percentage of cattle pulled for any reason is greater for treated cattle than for control cattle. However, the 95% CI is from 0.83 to 1.30. Thus, these results are also compatible at the 0.05 level (i.e. P<0.05) with no effect of treatment (sub hazard ratio of 1) and also with an adverse effect of treatment (i.e. a higher percentage of treated cattle pulled for any reason). The P-value of 0.742 indicates that the null hypothesis (that there is no difference between treated and control cattle) cannot be rejected.

These results do not support the hypothesis that acclimation affects the cumulative incidence of being pulled for any reason. However, based on this 95% CI, these results are compatible with acclimation having quite large adverse or beneficial effects.

Table 6. Reasons for first pull by treatment group

Reason for first pull	Control cattle		Treated cattle	
BRD	1,104	63.1%	1,168	63.1%
Buller	215	12.3%	238	12.9%
Digestive	1	0.1%	9	0.5%
Dystocia	3	0.2%	2	0.1%
Ear	1	0.1%	1	0.1%
Eye	6	0.3%	9	0.5%
Foot	177	10.1%	171	9.2%
Injury	8	0.5%	9	0.5%
Laminitis	0	0.0%	3	0.2%
Neurological	1	0.1%	1	0.1%
Non-eater	10	0.6%	6	0.3%
Observation	148	8.5%	160	8.6%
Reject	2	0.1%	5	0.3%
Urogenital	49	2.8%	47	2.5%
Other	25	1.4%	23	1.2%
Not recorded	19		30	
Pooled	1,769	100.0%	1,882	100.0%

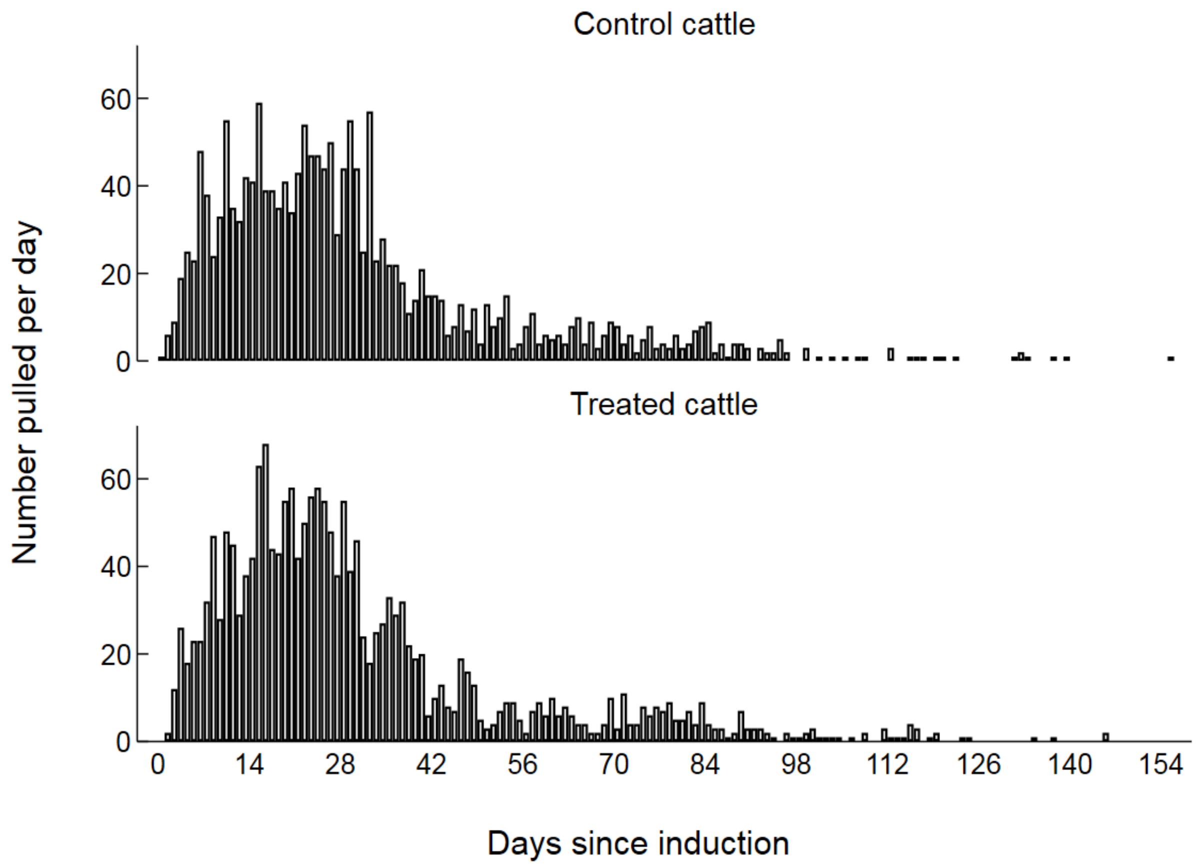

Figure 4. Distributions of times to first pull for 1,752 control cattle and 1,854 treated cattle pulled for any reason.

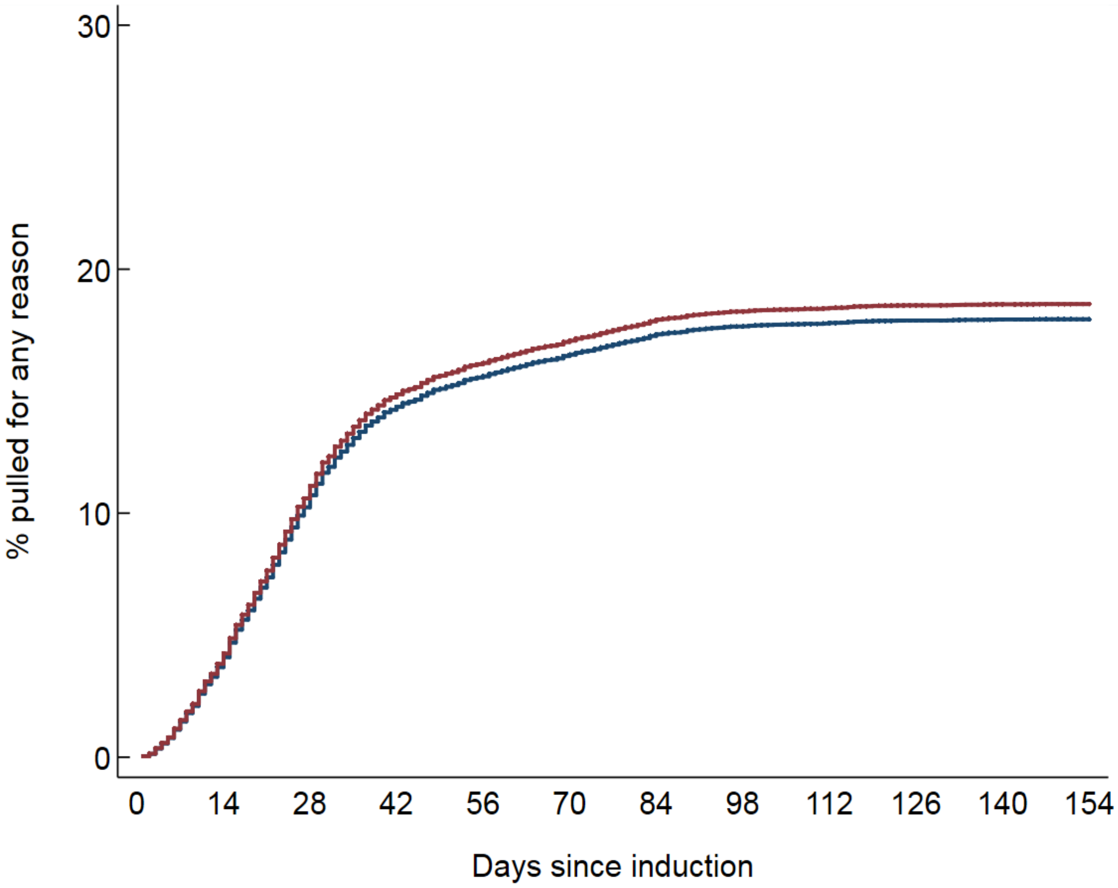

Figure 5. Cumulative incidences (%) of being pulled for any reason by days from induction to first pull for control (blue line) and treated (red line) cattle.

Numbers of pulls for any reason per animal by treatment group are shown in Table 7. The ratio of mean number of pulls per animal (treated relative to control; adjusted for feedlot) was 0.96 (95% CI 0.75 to 1.24; P=0.772). If the ratio of mean number of pulls per animal was known to be 0.96, this would indicate that the mean number of pulls per animal is 4% lower for treated cattle as for control cattle. However, the 95% CI is from 0.75 to 1.24. Thus, these results are also compatible at the 0.05 level (i.e. P<0.05) with less pulls, on average, per animal for treated animals (ratio of 1) and also with more pulls, on average, per animal for treated animals. The P-value of 0.772 indicates that the null hypothesis (that there is no difference between treated and control cattle) cannot be rejected.

Table 7. Numbers of pulls for any reason per animal by treatment group

Number of pulls	Control cattle		Treated cattle	
0	7,747	81.2%	7,811	80.4%
1	978	10.3%	1,064	11.0%
2	404	4.2%	399	4.1%
3	203	2.1%	200	2.1%
4	87	0.9%	96	1.0%
5	46	0.5%	66	0.7%
6	22	0.2%	20	0.2%
7	19	0.2%	21	0.2%
8	15	0.2%	12	0.1%
9	10	0.1%	5	0.1%
10	6	0.1%	19	0.2%
Pooled	9,537	100.0%	9,713	100.0%

4.5.3 First pulls for specific reasons

Cumulative incidences of being pulled for specific reasons were compared between treated and control cattle. Times from induction to first pull where the first pull was for BRD are summarised in Figure 6 and cumulative incidences by days from induction to first pull are shown in Figure 7. The sub hazard ratio (treated relative to control; adjusted for feedlot) was 1.04 (95% CI 0.76 to 1.42; P=0.791).

These results do not support the hypothesis that acclimation affects the cumulative incidence of being pulled for BRD. However, based on this 95% CI, these results are compatible with acclimation having quite large adverse or beneficial effects.

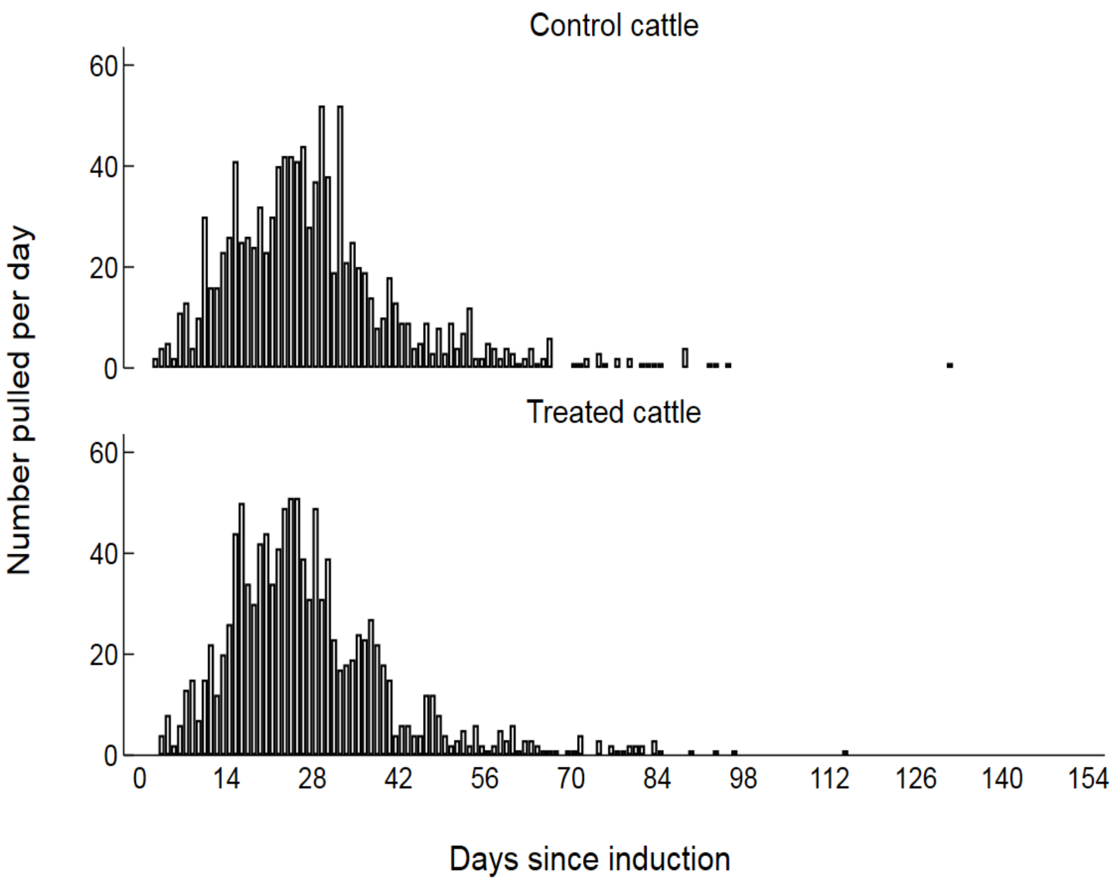

Figure 6. Distributions of days from induction to first pull for 1,090 control cattle and 1,151 treated cattle first pulled for BRD.

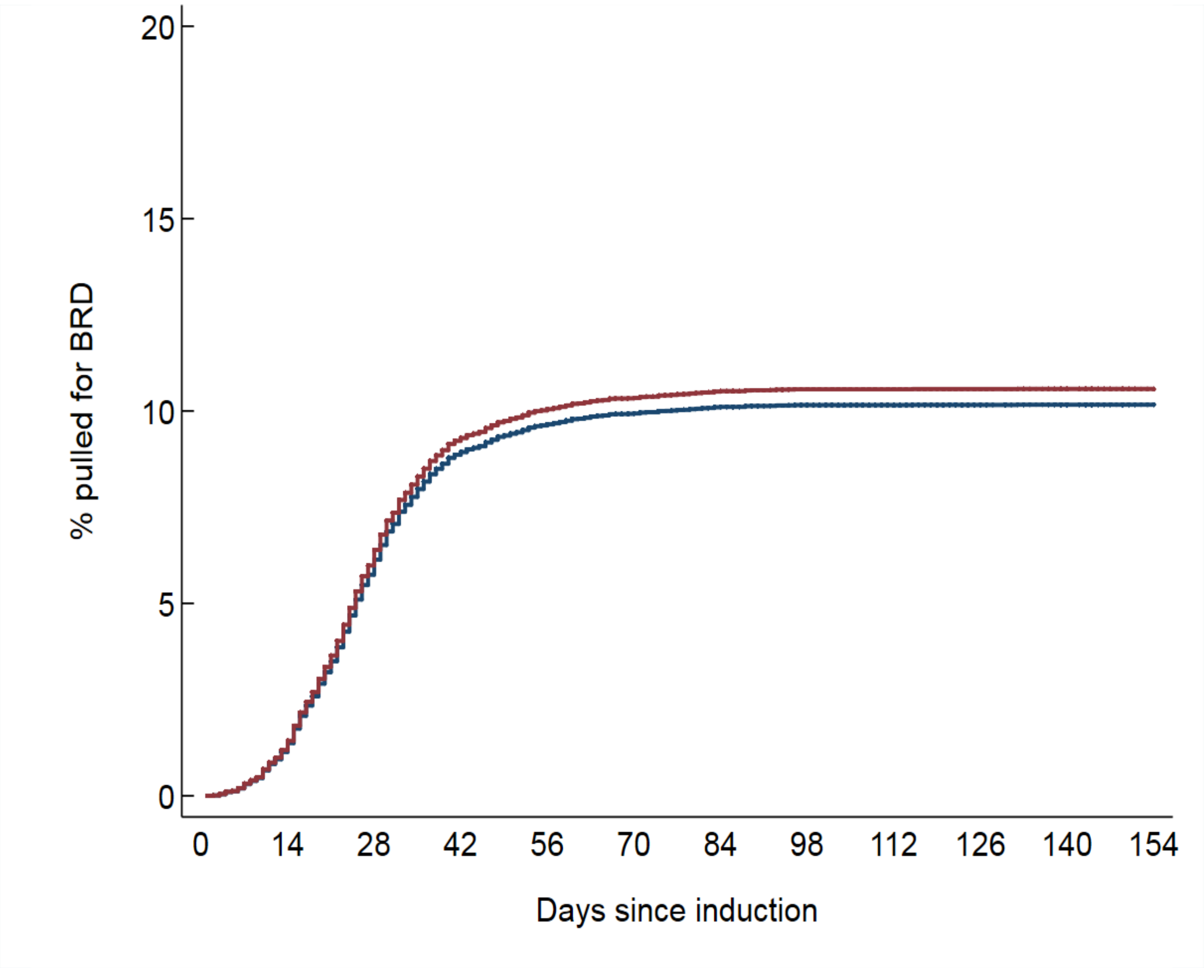

Figure 7. Cumulative incidences (%) of being first pulled where the first pull was for BRD by days since induction for control (blue line) and treated (red line) cattle.

Times from induction to first pull where the first pull was for being a buller are summarised in Figure 8 and cumulative incidences by days from induction to first pull are shown in Figure 9. The sub hazard ratio (treated relative to control; adjusted for feedlot) was 1.08 (95% CI 0.72 to 1.64; P=0.707).

These results do not support the hypothesis that acclimation affects the cumulative incidence of being pulled for being a buller. However, based on this 95% CI, these results are compatible with acclimation having quite large adverse or beneficial effects.

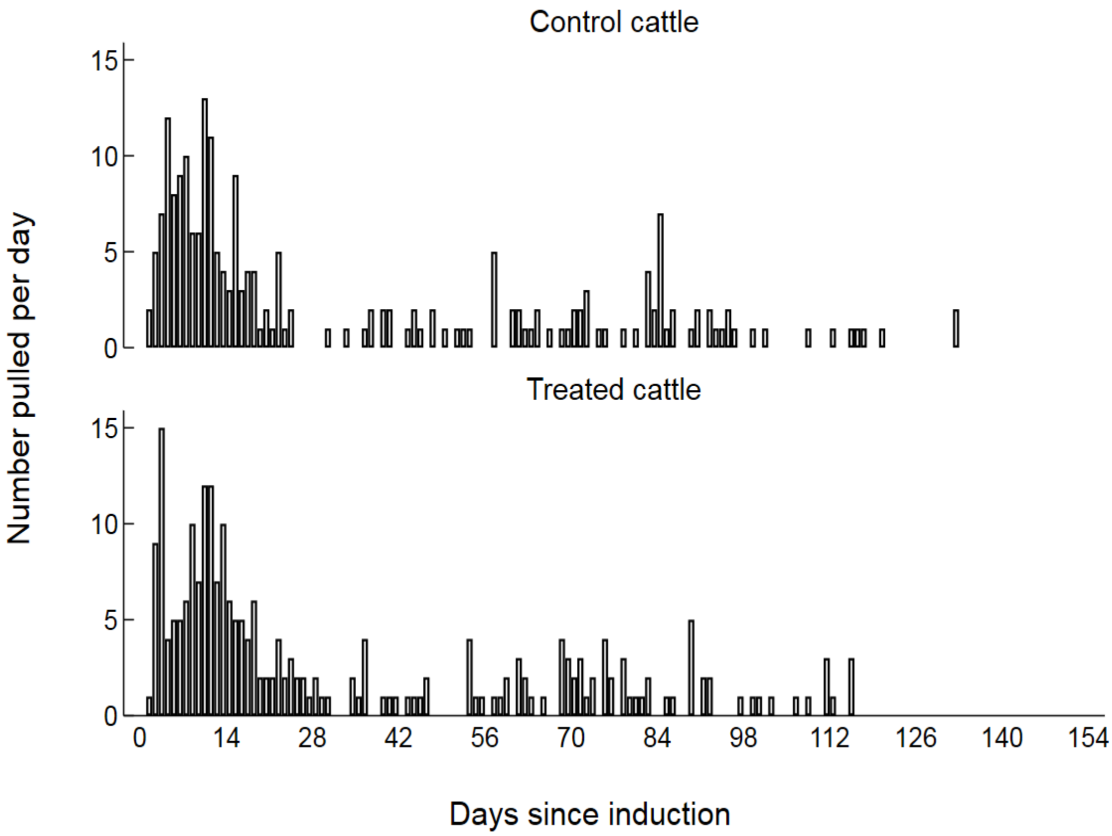

Figure 8. Distributions of days from induction to first pull for 215 control cattle and 238 treated cattle first pulled for being a buller.

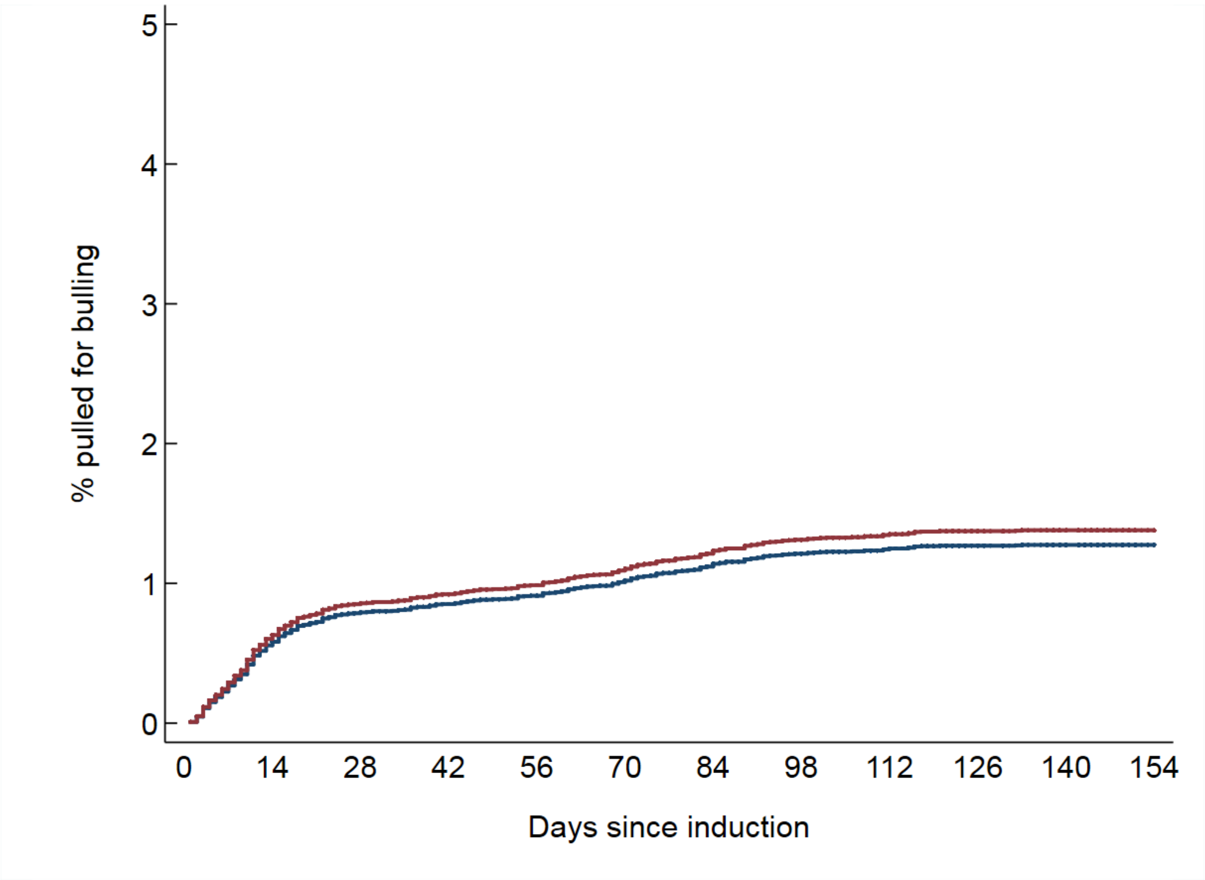

Figure 9. Cumulative incidences (%) of being first pulled where the first pull was for being a buller by days since induction for control (blue line) and treated (red line) cattle.

Times from induction to first pull where the first pull was for foot problems are summarised in Figure 10 and cumulative incidences by days from induction to first pull are shown in Figure 11. The sub hazard ratio (treated relative to control; adjusted for feedlot) was 0.90 (95% CI 0.55 to 1.49; P=0.684).

These results do not support the hypothesis that acclimation affects the cumulative incidence of being pulled for foot problems. However, based on this 95% CI, these results are compatible with acclimation having quite large adverse or beneficial effects.

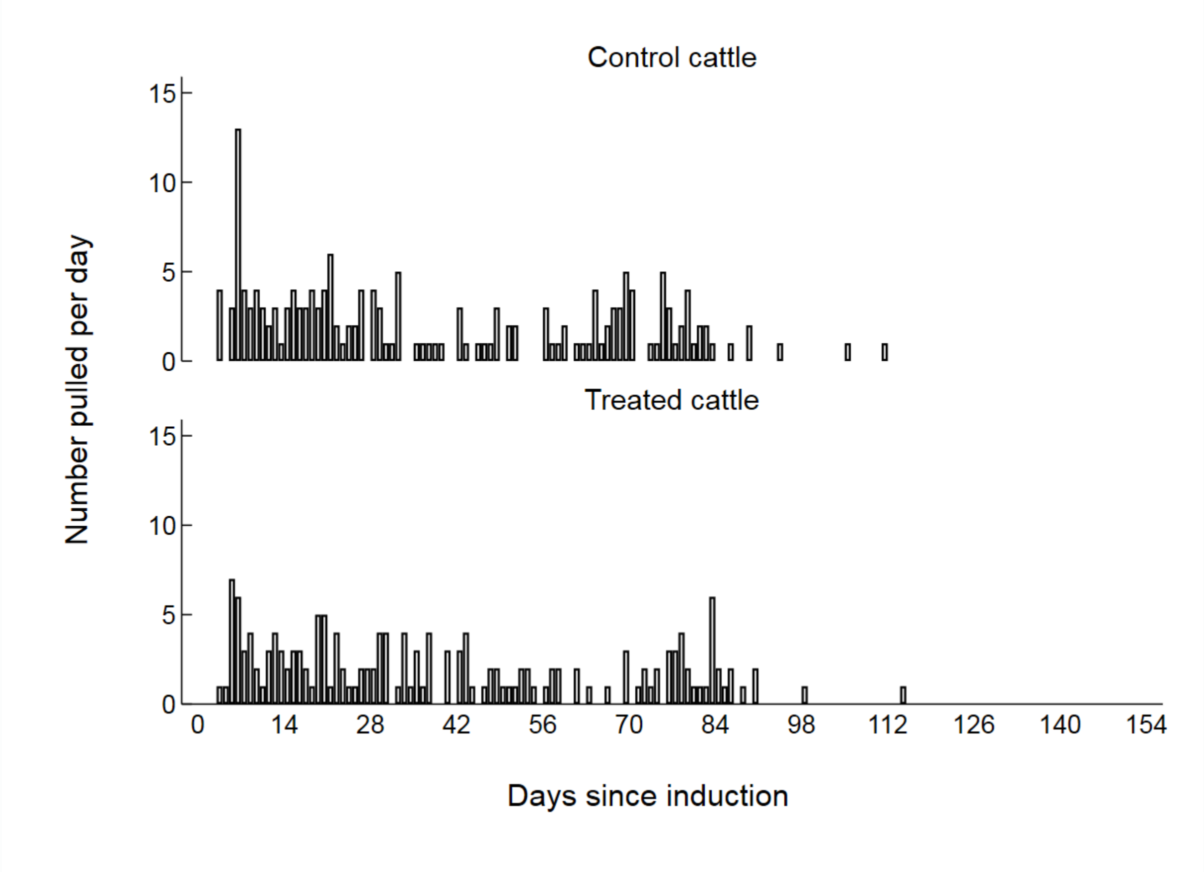

Figure 10. Distributions of days from induction to first pull for 175 control cattle and 166 treated cattle first pulled for foot problems.

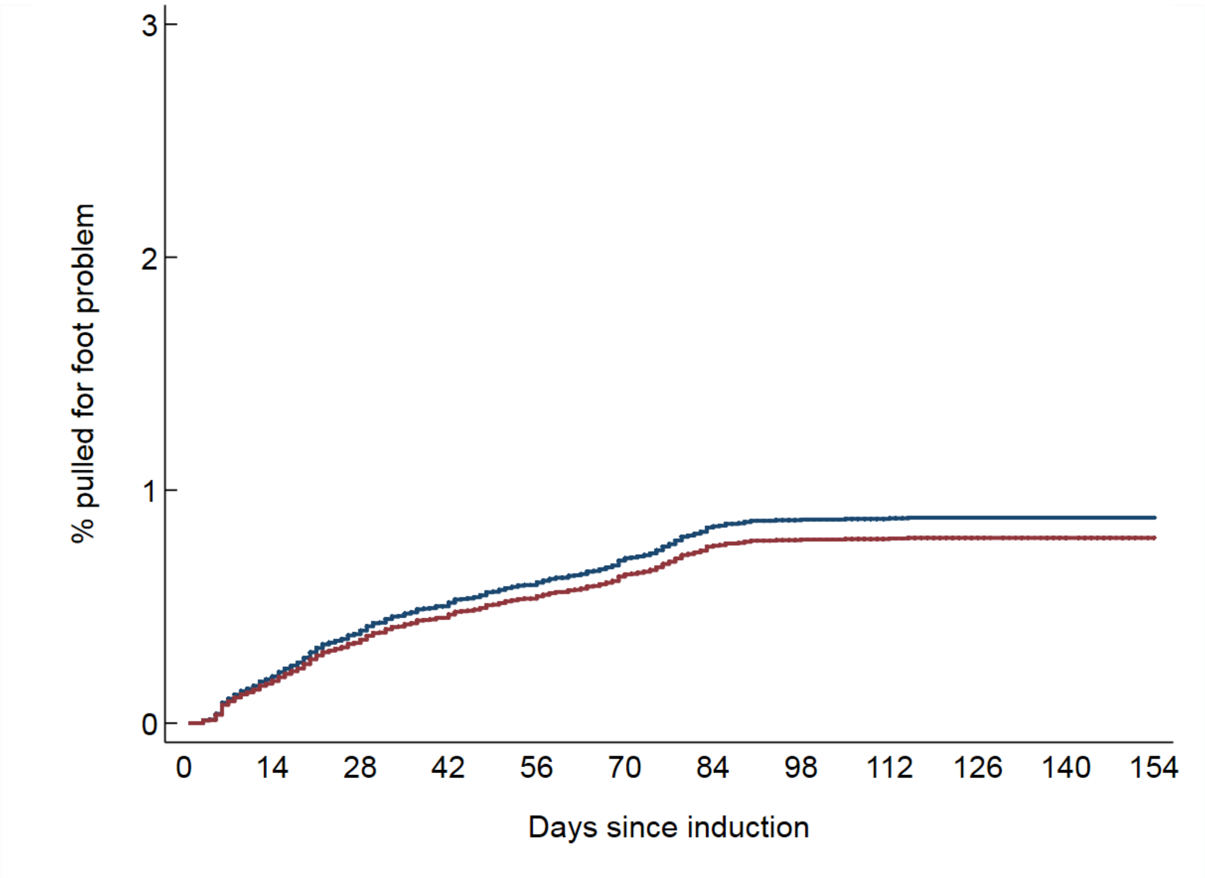

Figure 11. Cumulative incidences (%) of being first pulled where the first pull was for foot problems by days since induction for control (blue line) and treated (red line) cattle.

Times from induction to first pull where the first pull was for observation are summarised in Figure 12 and cumulative incidences by days from induction to first pull are shown in Figure 13. The sub hazard ratio (treated relative to control; adjusted for feedlot) was 1.06 (95% CI 0.71 to 1.60; P=0.773).

These results do not support the hypothesis that acclimation affects the cumulative incidence of being pulled for observation. However, based on this 95% CI, these results are compatible with acclimation having quite large adverse or beneficial effects.

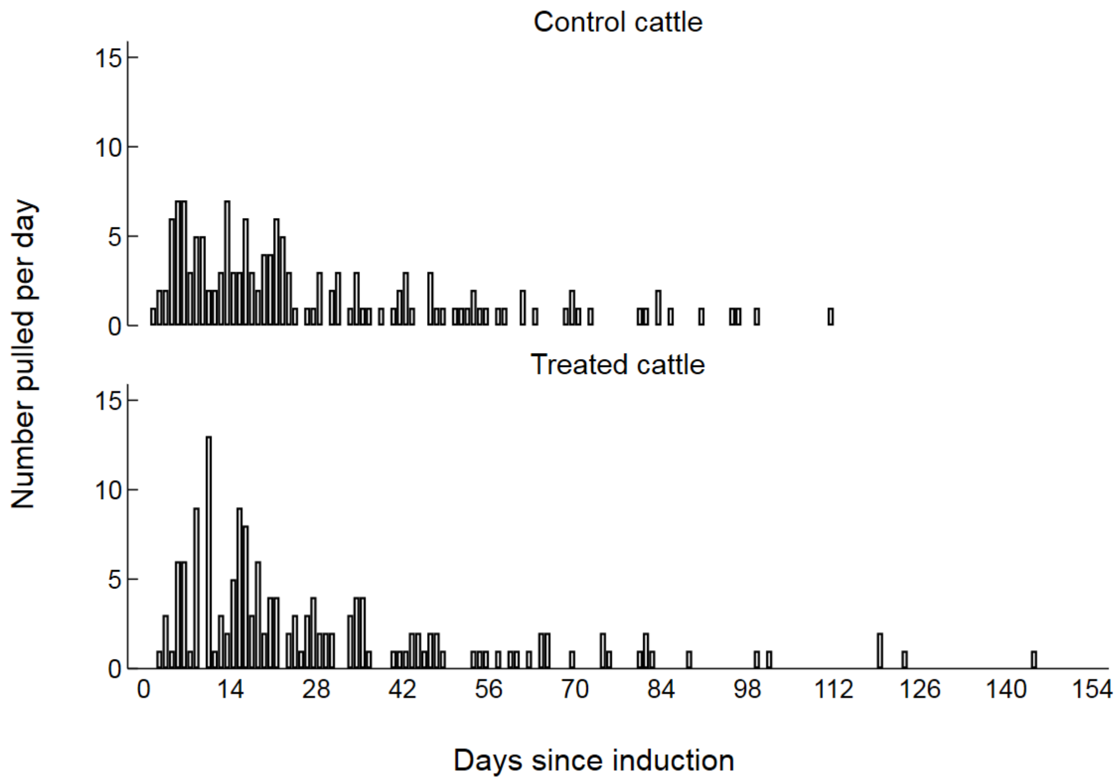

Figure 12. Distributions of days from induction to first pull for 148 control cattle and 157 treated cattle first pulled for *observation*.

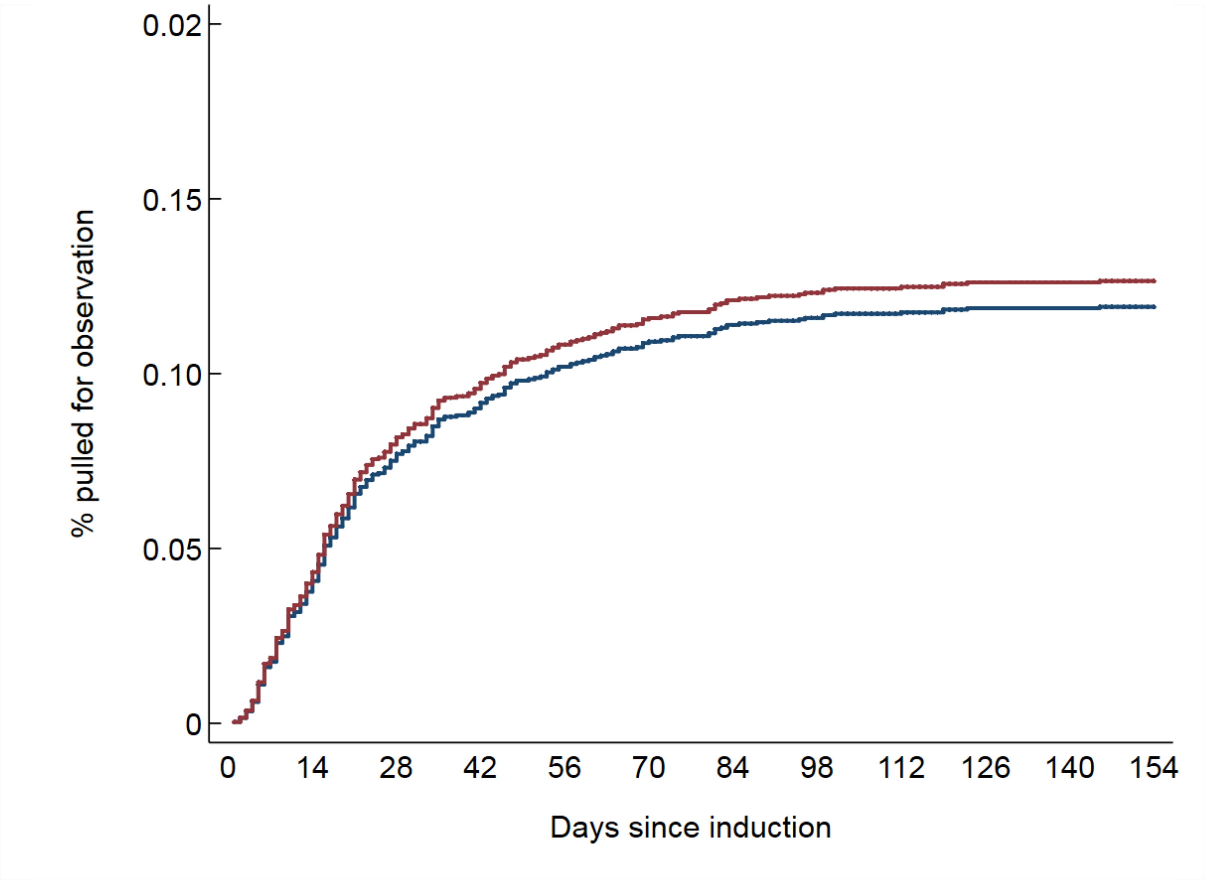

Figure 13. Cumulative incidences (%) of being first pulled where the first pull was for *observation* by days since induction for control (blue line) and treated (red line) cattle.

4.5.4 Exit live weights and carcase weights

Distributions of exit live weights and carcase weights by treatment group are shown in Figures 14 to 19 and Table 8, and results of statistical comparisons are shown in Table 8. Recorded weights less than 278 kg were excluded before analyses as these were likely to be erroneous. These values were only observed for out weight –truck where, of 16,639 cattle with weights recorded, for 0.4% (67) the recorded weight was less than 278 kg.

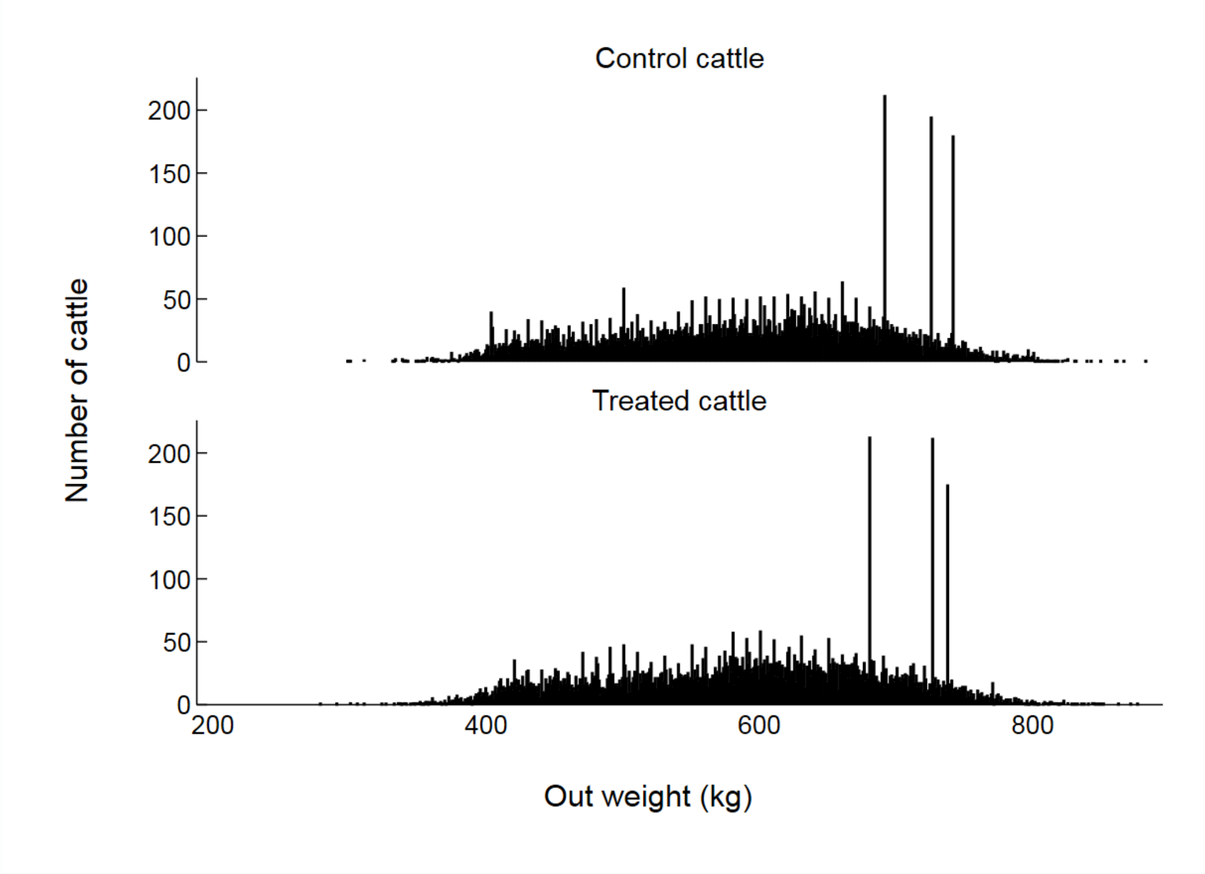

Figure 14. Distributions of out weights for control and treated cattle. Recorded weights <278 kg were excluded before analyses.

The 6 peaks in out weights were all from 6 lots from 3 cohorts from feedlot 4:

- lot 100008T: 179 animals were all recorded as 680.54 kg
- lot 100008C: 188 animals were all recorded as 691.52 kg
- lot 100009T: 159 animals were all recorded as 737.61 kg
- lot 100009C: 167 animals were all recorded as 741.63 kg
- lot 100010T: 197 animals were all recorded as 725.57 kg
- lot 100010C: 182 animals were all recorded as 726.13 kg.

These 1,072 animals constituted the majority (77 to 88%) of animals in those lots. Reasons for the unexpectedly large numbers of cattle with these identical values were not ascertained. Values for out weight truck, average daily growth rate, average daily growth rate truck and feed conversion efficiencies had also been recorded for these cattle. These values were excluded before analyses of those variables. These cattle did not have values recorded for any other exit liveweight or average daily growth rate variables, nor for hot standard carcass weight or carcass attributes.

For exit live weights and carcass weights, differences between means for treated cattle relative to control cattle were small, 95% confidence intervals relatively narrow, and p-values high (Table 8). These results indicate that, if these variables are affected by acclimation, any such effects are small.

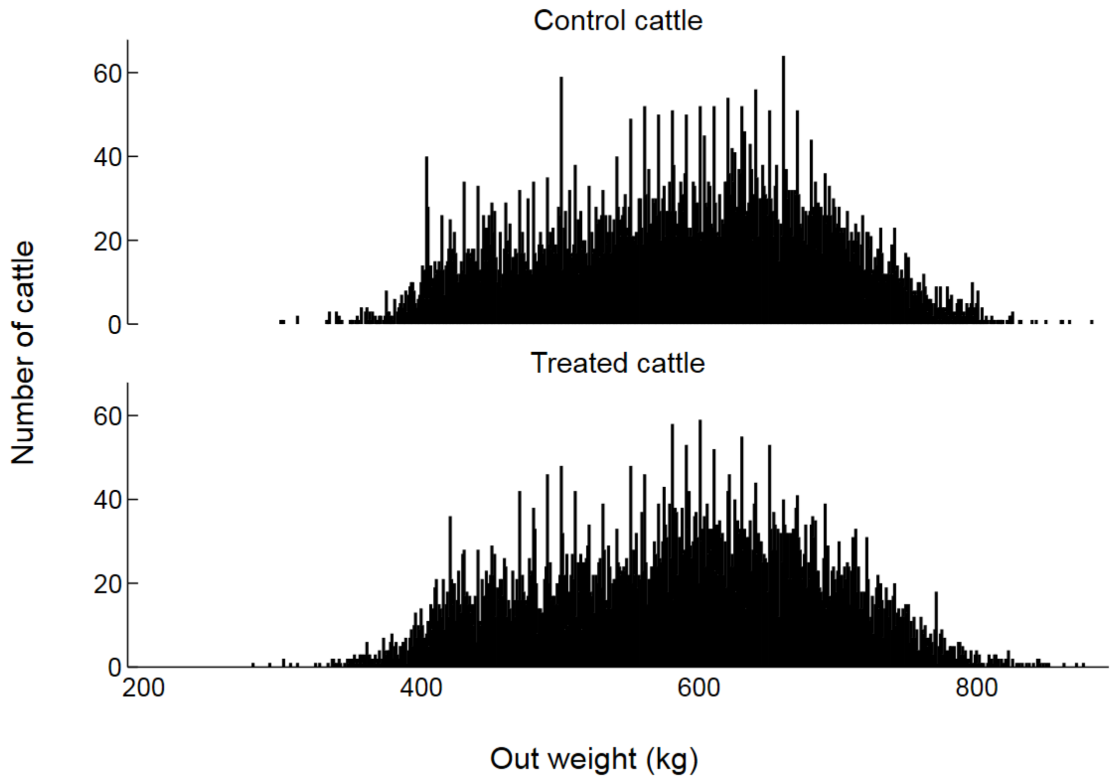

Figure 15. Distributions of out weights for control and treated cattle. Values in the 6 peaks of out weights were excluded before analyses.

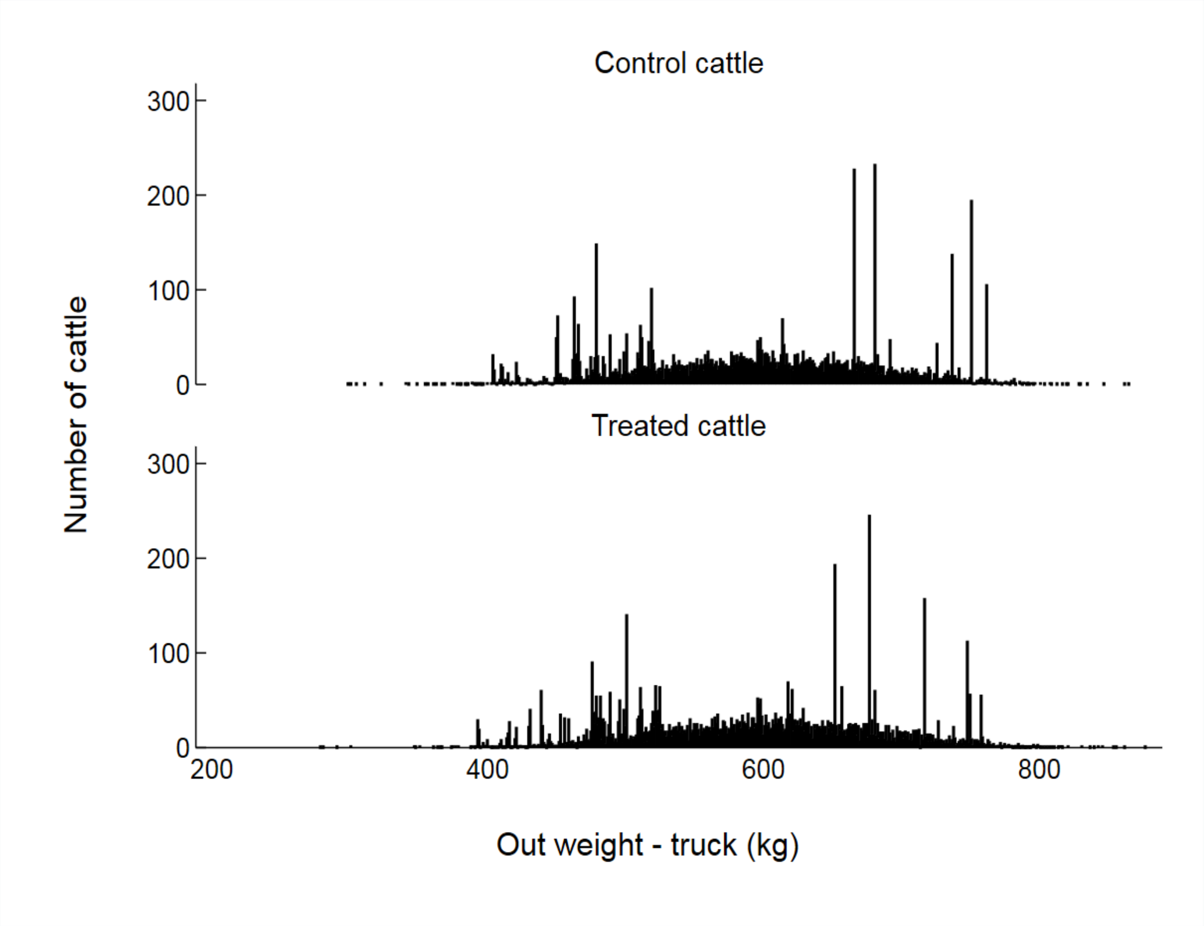

Figure 16. Distributions of out weights from trucks for control and treated cattle. Recorded weights <278 kg were excluded before analyses along with values for cattle whose out weights were in any of the 6 peaks for that variable.

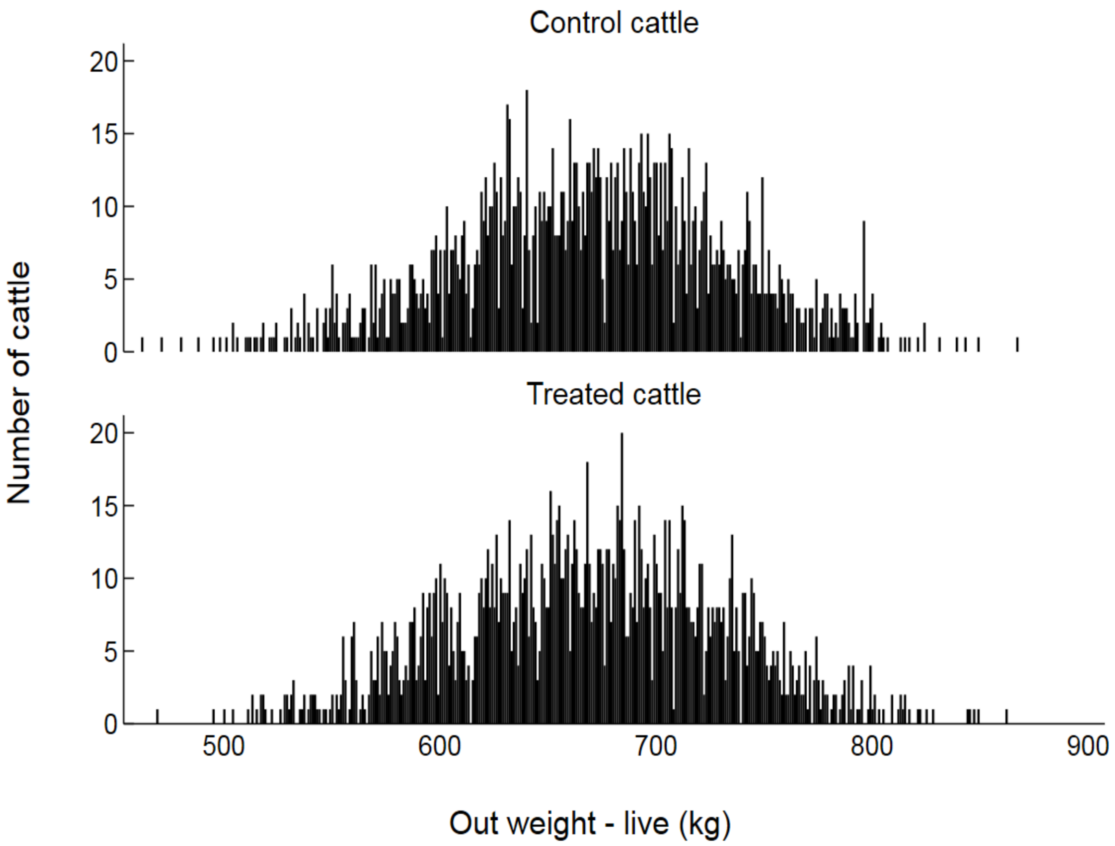

Figure 17. Distributions of out weights from live weights for control and treated cattle.

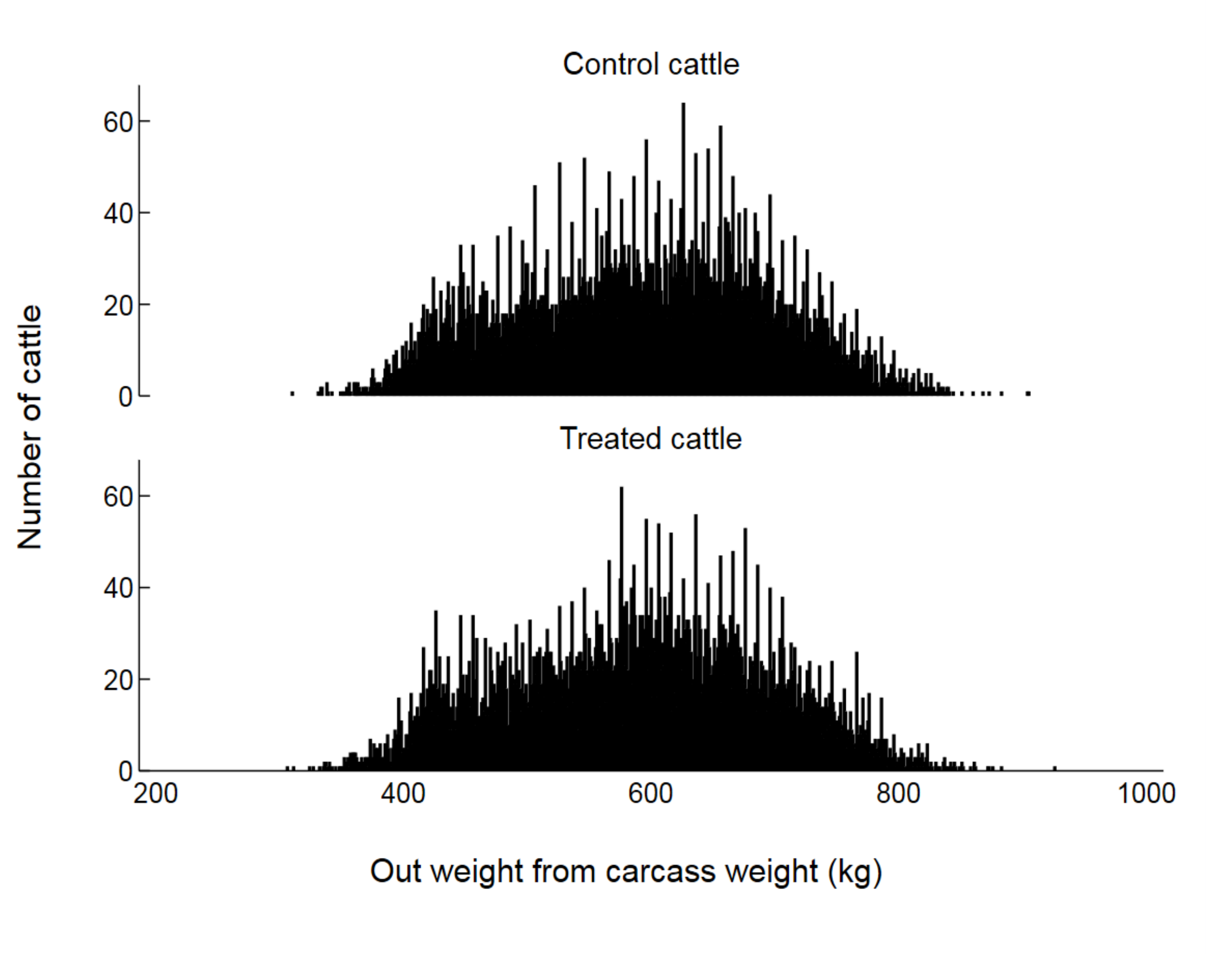

Figure 18. Distributions of out weights calculated from carcass weights for control and treated cattle.

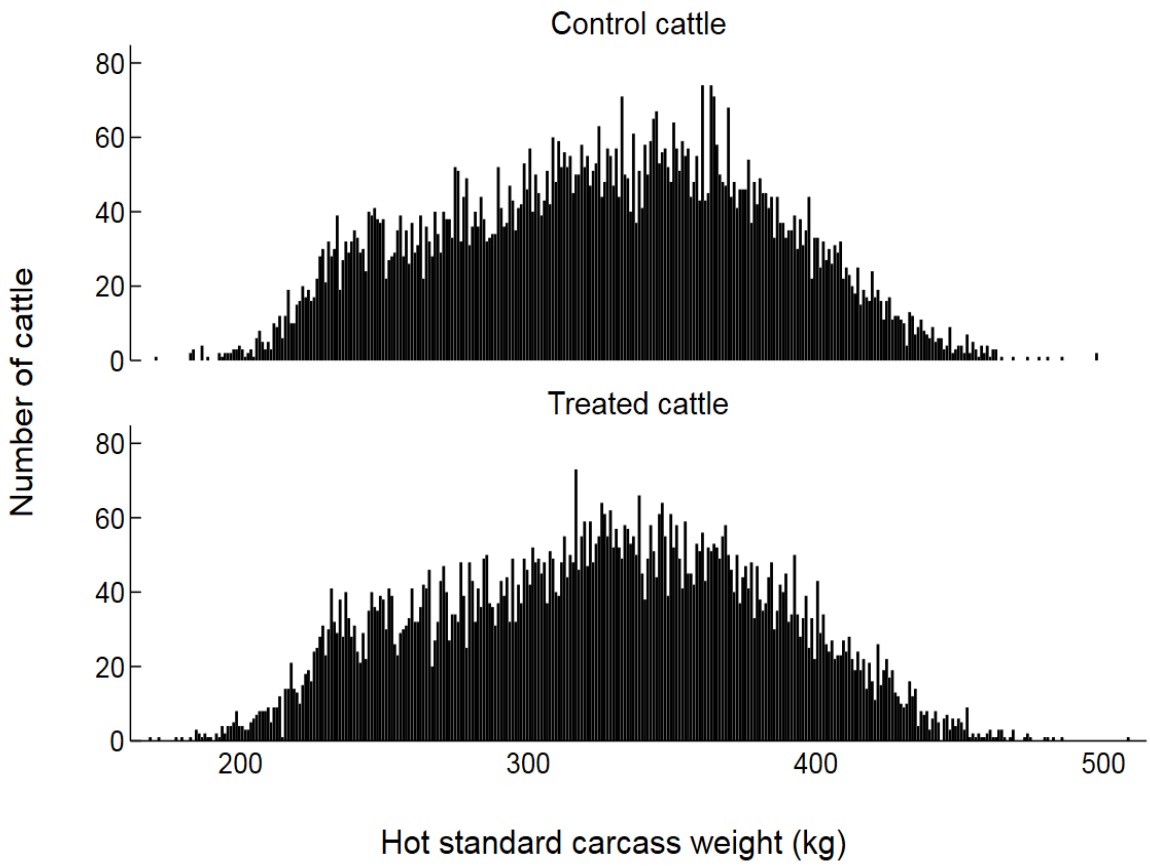

Figure 19. Distributions of hot standard carcass weights for control and treated cattle.

Table 8. Mean weights (kg) and differences between means between treated and control cattle

Variable	Control cattle		Treated cattle		Difference between means[1]	95% CI	P
	No.	Mean (SD)	No.	Mean (SD)			
Out weight[2]	8,860	585.9 (100.2)	8,874	584.8 (101.4)	-1.14	-12.22 to 9.94	0.840
Out weight truck[2,3]	7,715	596.2 (93.4)	7,785	593.8 (93.0)	-0.56	-15.22 to 14.10	0.941
Out weight live	1,703	669.9 (62.3)	1,713	668.5 (61.5)	-0.63	-27.84 to 26.59	0.964
Out weight calculated using hot standard carcass weight with fixed yield	8,586	591.4 (102.8)	8,545	589.1 (104.8)	-1.34	-12.40 to 9.72	0.812
Hot standard carcass weight	8,586	325.3 (56.5)	8,545	324.0 (57.6)	-0.74	-6.82 to 5.35	0.812

[1] Estimated mean for treated cattle minus mean for control cattle, adjusted for feedlot, induction weight and days on feed

[2] Values for cattle whose out weights were in any of the 6 peaks for that variable (Figure 14) were available for these variables but were excluded before analyses

[3] Of the 16,639 cattle with weights recorded, for 0.4% (67), the recorded weight was less than 278 kg; these values were also excluded before analyses of this variable

4.5.5 Average daily growth rates and feed conversion efficiencies

Distributions of average daily growth rates and feed conversion efficiencies by treatment group are shown in Figures 20 to 26, and results of statistical comparisons are shown in Table 9. Average daily liveweight growth rate values less than (i.e. more negative than) -2 kg/day and those greater than 3 kg/day were excluded before analyses, as were average daily meat growth rate values less than (i.e. more negative than) -0.5 kg/day, and those greater than 2.25 kg/day. Feed conversion efficiency values less than 5 kg feed as fed/kg liveweight gain and those greater than 12.5 kg were excluded before analyses, as were feed conversion efficiency values less than 4 kg feed dry matter/kg liveweight gain and those greater than 10 kg. All of these values were excluded because they were likely to have been incorrect.

Numbers and percentages of values that were excluded due to these implausible values were as follows:

- Average daily liveweight growth rate: 0.3% (53/18,805); <-2 n=3; >3 n=50
- Average daily liveweight growth rate calculated from truck weights: 1.2% (201/16,638); <-2 n=70; >3 n=131
- Average daily liveweight growth rate calculated from live weights: 0.9% (155/17,130); <-2 n=0; >3 n=155
- Average daily liveweight growth rate calculated from carcass weights: 0.9% (155/17,130); <-2 n=0; >3 n=155
- Average daily liveweight growth rate - meat: 0.2% (29/17,130); <-0.5 n=1; >2.25 n=28
- Feed conversion efficiency on an as fed basis: 15.5% (2,585/16,635); <5 n=2,239; >12.5 n=346
- Feed conversion efficiency on a dry matter basis: 18.5% (3,076/16,635); <4 n=2,769; >10 n=307

For each of these variables, differences between means for treated cattle relative to control cattle were small, 95% confidence intervals relatively narrow, and p-values high (Table 9). These results indicate that, if these variables are affected by acclimation, any such effects are small.

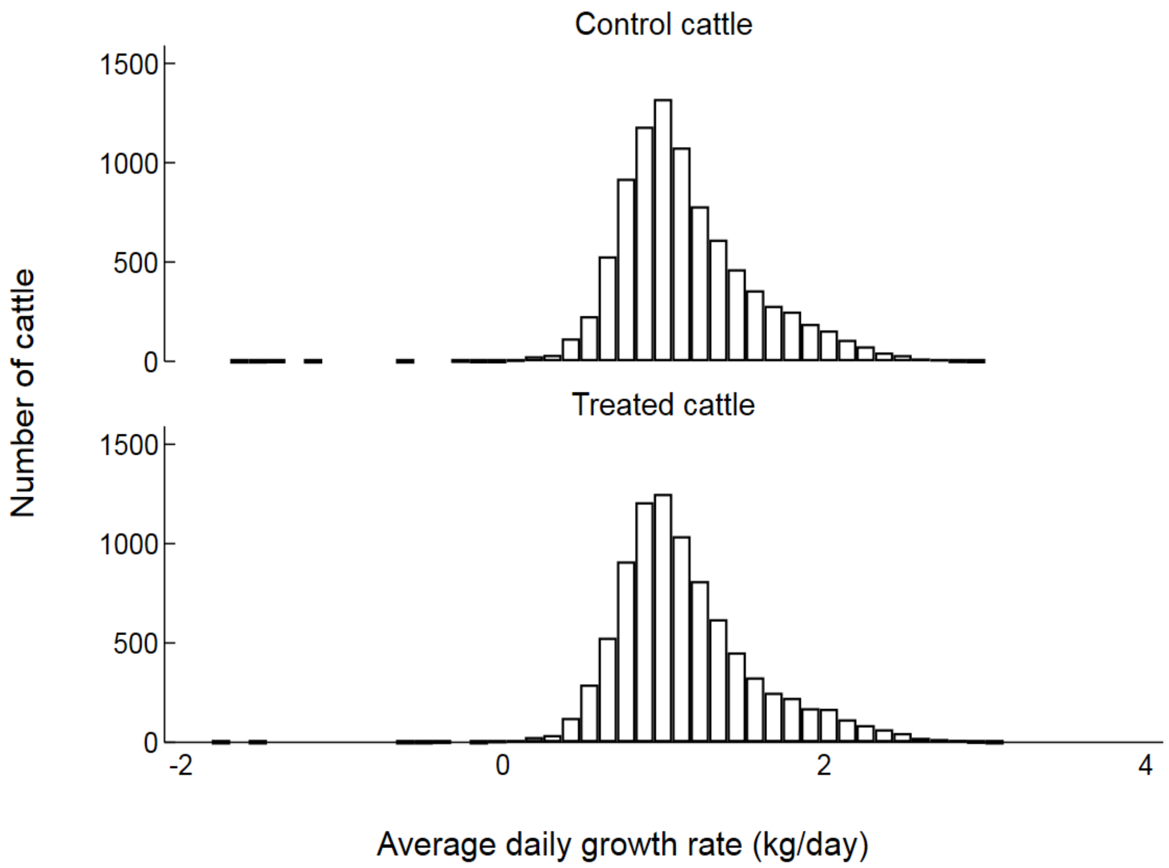

Figure 20. Distributions of average daily growth rates for control and treated cattle. Average daily growth rates weights <-2 kg/day and those >3 kg/day were excluded before analyses along with values for cattle whose out weights were in any of the 6 peaks for that variable.

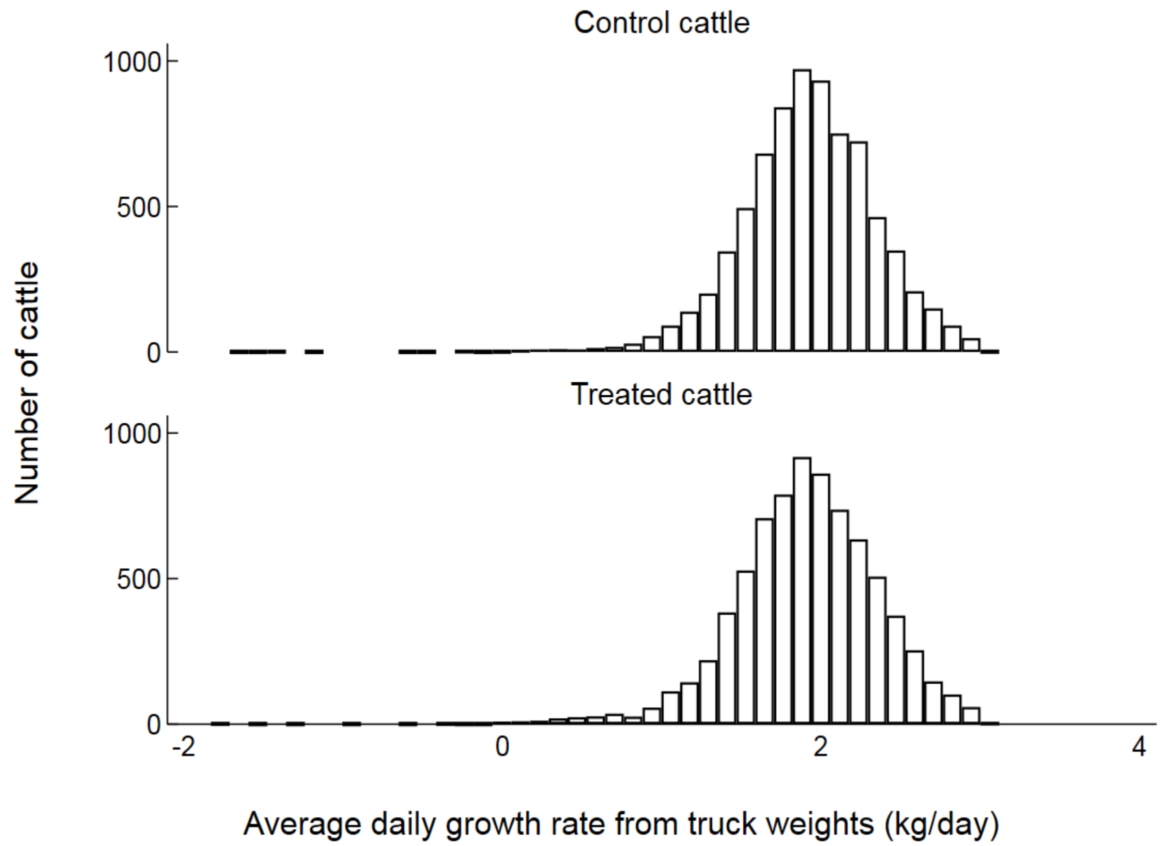

Figure 21. Distributions of average daily growth rates calculated from *truck weights* for control and treated cattle. Average daily growth rates weights <-2 kg/day and those >3 kg/day were excluded before analyses along with values for cattle whose out weights were in any of the 6 peaks for that variable.

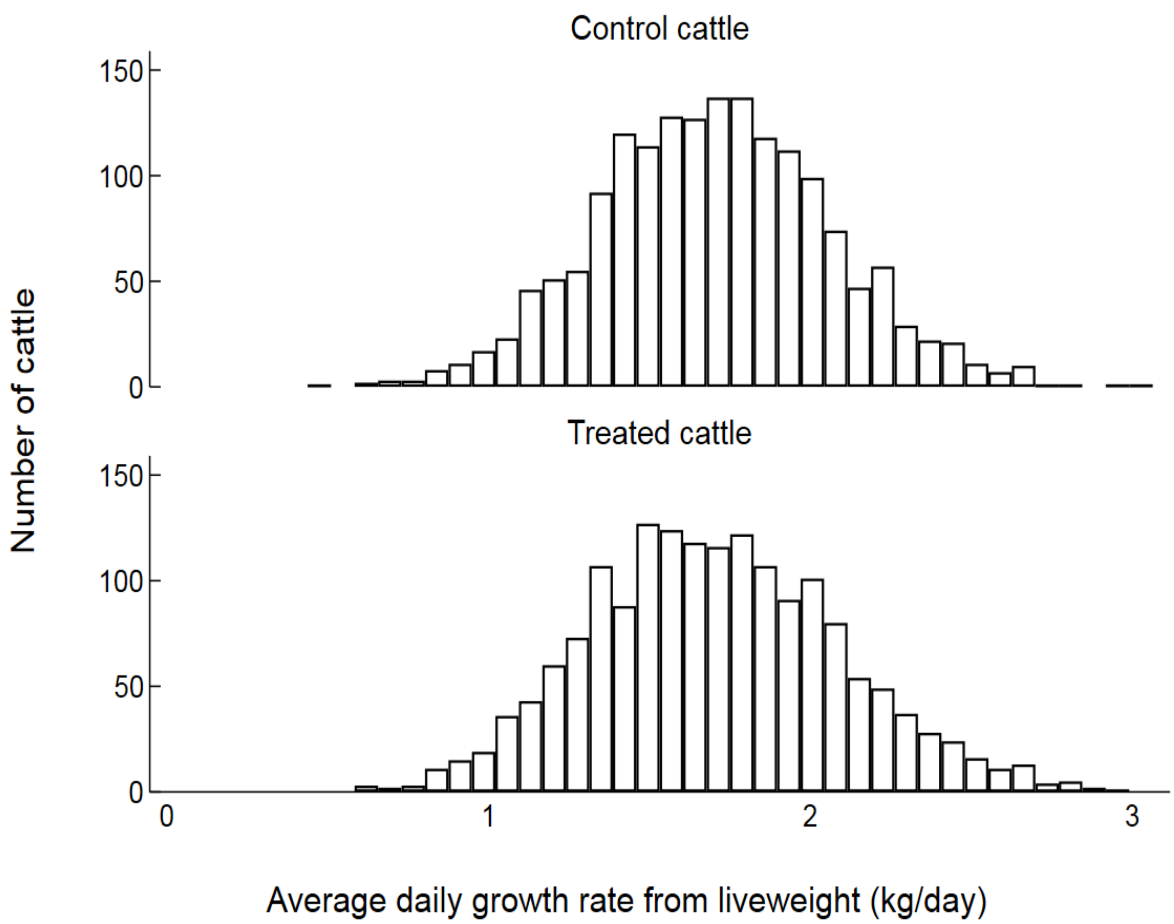

Figure 22. Distributions of average daily growth rates calculated from *live weights* for control and treated cattle. Average daily growth rates weights <-2 kg/day and those >3 kg/day were excluded before analyses.

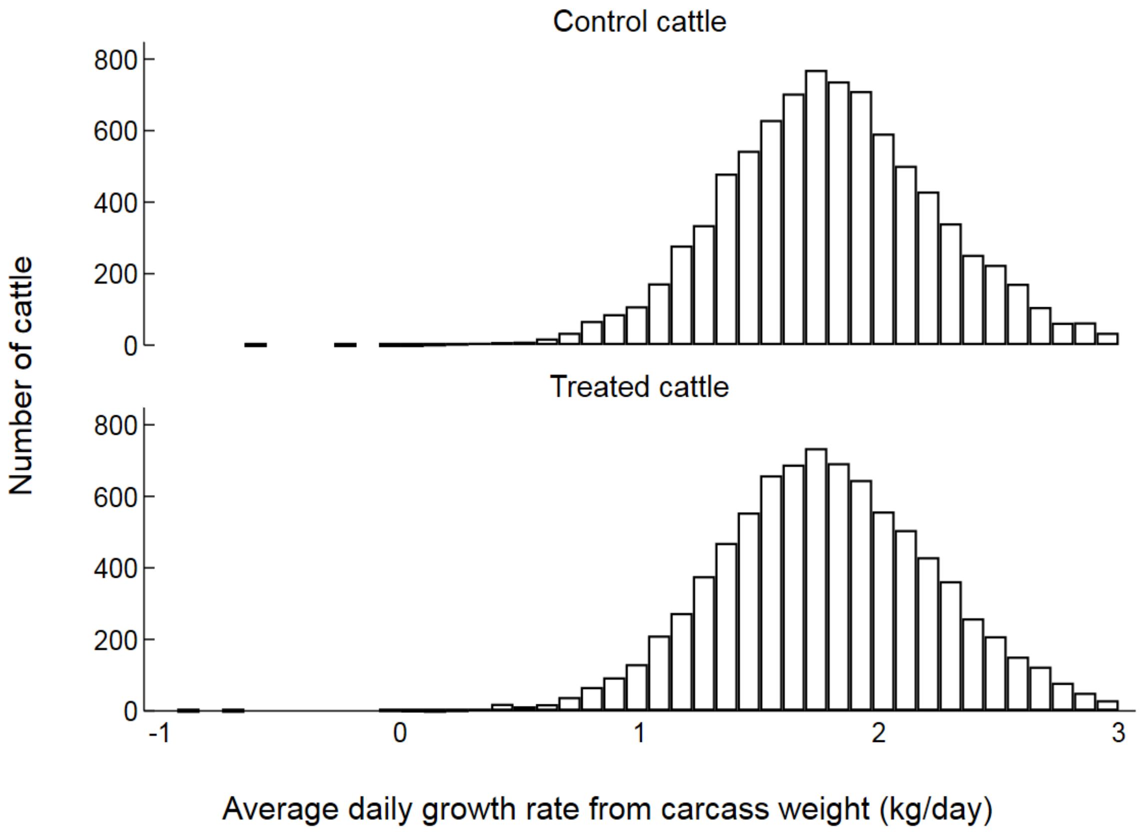

Figure 23. Distributions of average daily growth rates calculated from *carcass weights* for control and treated cattle. Average daily growth rates weights <-2 kg/day and those >3 kg/day were excluded before analyses.

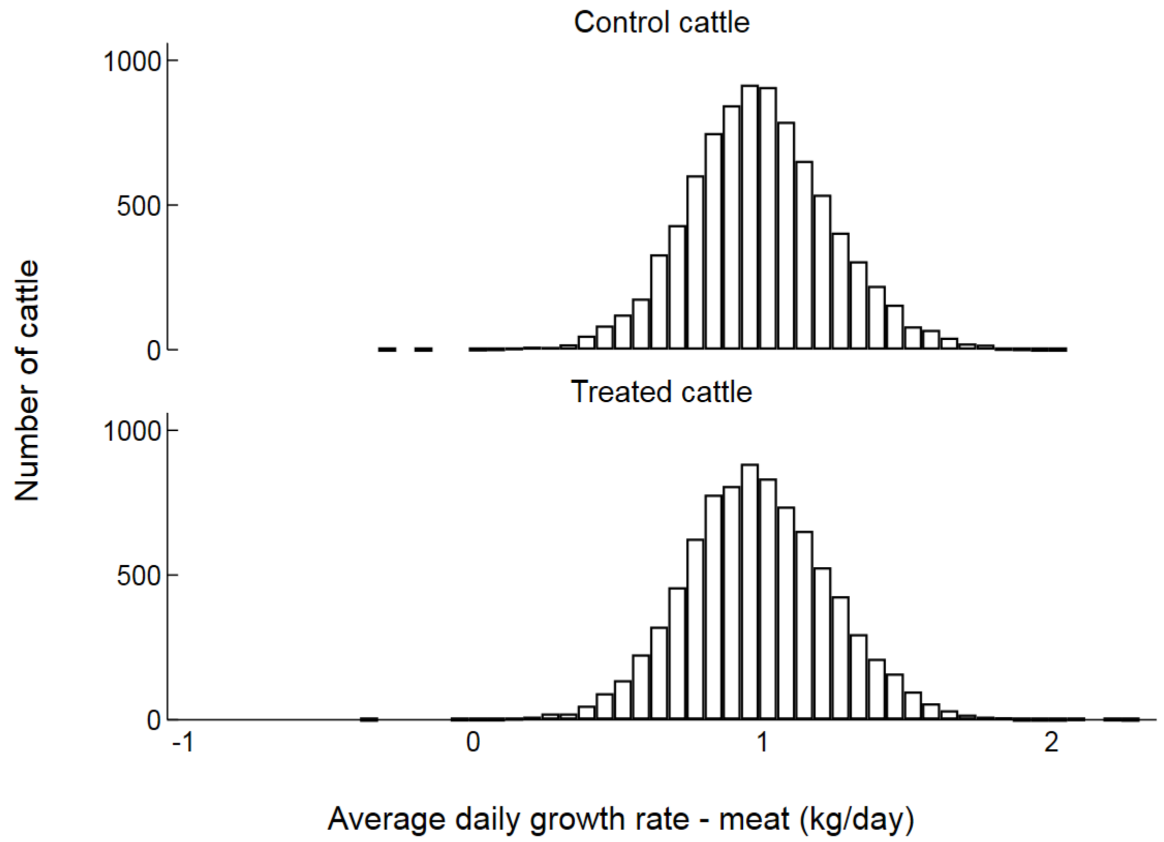

Figure 24. Distributions of average daily *meat* (ADG-M) growth rates for control and treated cattle.

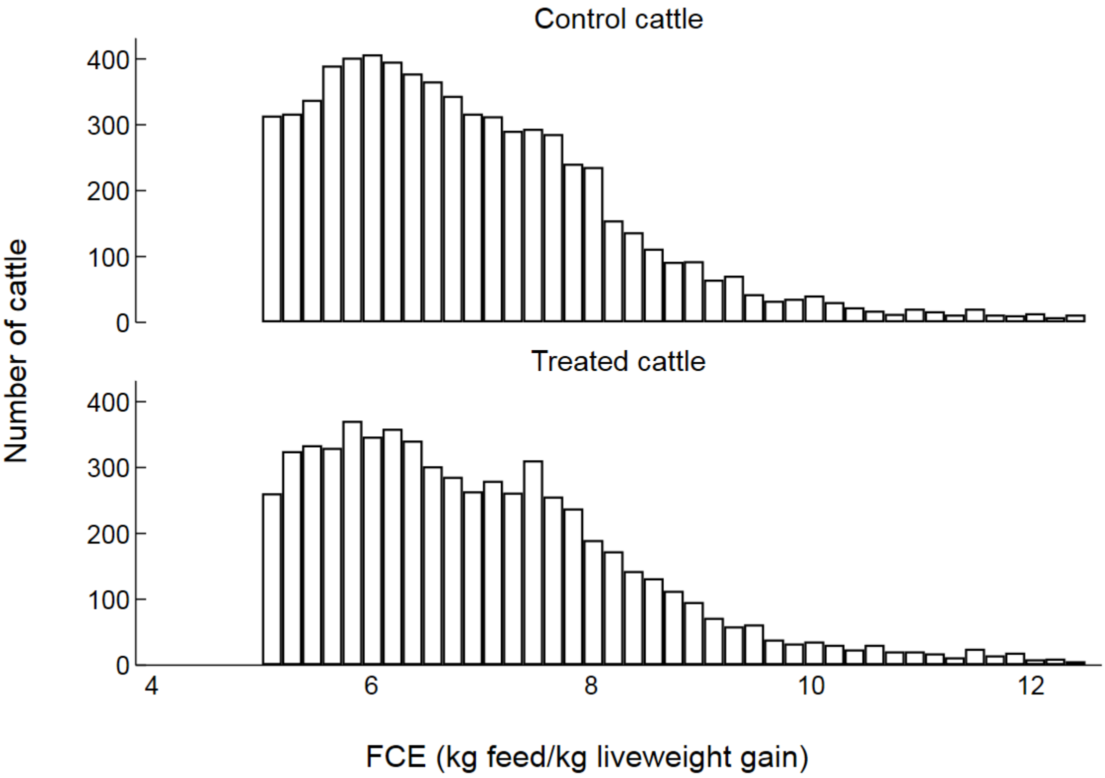

Figure 25. Distributions of feed conversion efficiencies (FCE) for feed as fed for control and treated cattle. Feed conversion efficiencies <5 kg feed/kg liveweight gain and those >12.5 kg feed/kg liveweight gain were excluded before analyses along with values for cattle whose out weights were in any of the 6 peaks for that variable.

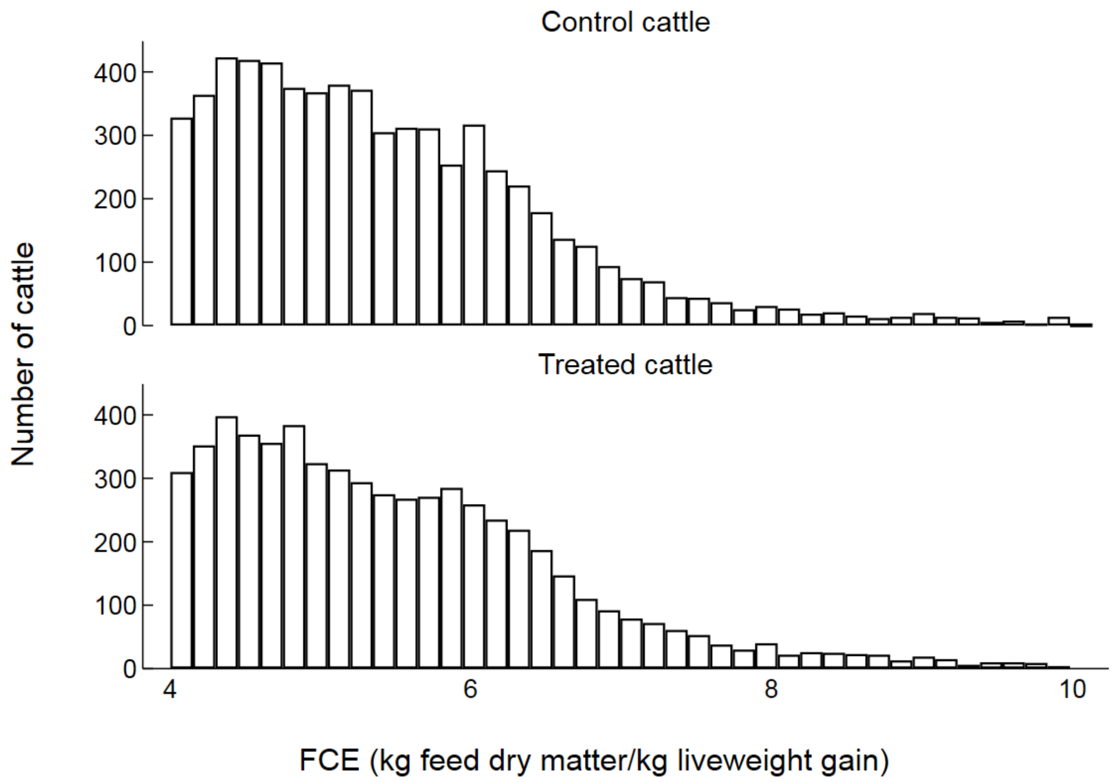

Figure 26. Distributions of feed conversion efficiencies (FCE) for feed dry matter for control and treated cattle. Feed conversion efficiencies <4 kg feed/kg liveweight gain and those >10 kg feed/kg liveweight gain were excluded before analyses along with values for cattle whose out weights were in any of the 6 peaks for that variable.

Table 9. Mean average daily gains (kg/day) and feed conversion efficiencies (kg feed per kg liveweight gain), and differences between means between treated and control cattle

Variable	Control cattle		Treated cattle		Difference between means[1]	95% CI	P
	No.	Mean (SD)	No.	Mean (SD)			
Average daily gain[2,3]	8,840	1.14 (0.42)	8,840	1.14 (0.44)	0.00	-0.10 to 0.11	0.987
Average daily gain *truck*[2,3]	7,651	1.92 (0.43)	7,714	1.90 (0.46)	-0.02	-0.12 to 0.08	0.760
Average daily gain *live*[2]	1,686	1.70 (0.36)	1,690	1.70 (0.39)	0.00	-0.18 to 0.17	0.984
Average daily gain calculated using *hot standard carcass weight with fixed yield*[2]	8,505	1.79 (0.44)	8,470	1.77 (0.45)	-0.01	-0.10 to 0.08	0.815
Average daily gain *meat*[4]	8,573	0.99 (0.25)	8,528	0.98 (0.26)	-0.01	-0.06 to 0.05	0.826
Feed conversion efficiency as fed[3,5]	6,721	6.92 (1.37)	6,257	7.00 (1.43)	0.02	-0.20 to 0.23	0.875
Feed conversion efficiency dry matter[3,6]	6,461	5.45 (1.06)	6,026	5.50 (1.11)	0.03	-0.13 to 0.20	0.698

[1] Estimated mean for treated cattle minus mean for control cattle, adjusted for feedlot, induction weight and days on feed

[2] Values <-2 kg/day and those >3 kg/day were excluded before analyses

[3] Values for cattle whose out weights were in any of the 6 peaks for that variable were available for these variables but were excluded before analyses

[4] Values <-0.5 kg/day and those >2.25 kg/day were excluded before analyses

[5] Values <5 kg feed/kg gain and those >12.5 kg feed/kg gain were excluded before analyses

[6] Values <4 kg feed/kg gain and those >10 kg feed/kg gain were excluded before analyses

Effects of treatment on average daily gain *meat* (ADG-M) were also assessed by defining those cattle whose average daily gain meat was ≤0.4 kg/day as 'non-performers'. The distribution of study cattle by non-performer status and treatment group is shown in Table 10. The odds ratio for being a non-performer (treated relative to control cattle adjusted for feedlot, induction weight and days on feed) was 0.99 (95% CI 0.45 to 2.16; P=0.974).

These results do not support the hypothesis that acclimation affects the risk of an animal being a non-performer. However, based on this 95% CI, these results are compatible with acclimation having quite large adverse or beneficial effects.

Table 10. Distribution of study cattle by non-performer status and treatment group

Non-performer status[1]	**Control cattle**		**Treated cattle**	
No	8,488	99.0%	8,432	98.9%
Yes	85	1.0%	96	1.1%
Average daily gain meat not available or<-0.5 kg/day or >2.25 kg/day	960		990	
Pooled	9,533	100.0%	9,518	100.0%

[1]Yes = average daily gain *meat* ≤0.4 kg/day; no = average daily gain *meat* >0.4 kg/day

4.5.6 Market rejects

Cattle were classified as market rejects where:

a. their normalised health record included either 'Reject' and/or 'Cull' or
b. their dead cause was 'Cull' or
c. their dead cause was 'Reject' or
d. NLIS data indicated the RFID of the animal went to an establishment which was known to always be for reject/pet food or
e. the animal's days on feed in the study lot was less than 15 days or
f. the animal's days on feed in the study lot was less than 75% of the median of the days on feed for the animal's lot.

The distribution of study cattle by market reject status and treatment group is shown in Table 11. The odds ratio for being a market reject (treated relative to control cattle; adjusted for feedlot) was 1.07 (95% CI 0.73 to 1.57; P=0.733).

These results do not support the hypothesis that acclimation affects the risk of an animal being a market reject. However, based on this 95% CI, these results are compatible with acclimation having quite large adverse or beneficial effects.

Table 11. Distribution of study cattle by market reject status and treatment group

Market reject status	**Control cattle**		**Treated cattle**	
No	9,336	98.6%	9,324	98.5%
Yes	137	1.4%	146	1.5%
Data insufficient to classify animal	60		48	
Pooled	9,533	100.0%	9,518	100.0%

Average daily growth rate and average daily growth rate *meat* (ADG-M) were compared between market reject and non-market reject cattle. Mean values for both were lower in market reject cattle (Table 12). However, there was substantial overlap in both between market reject cattle and non-market reject cattle (Figures 27 and 28).

Table 12. Mean average daily gains (kg/day) and feed conversion efficiencies (kg feed per kg liveweight gain), and differences between means between market reject and non-market reject cattle

Variable	Non-market reject cattle		Market reject cattle		Difference between means[1]	95% CI	P
	No.	Mean (SD)	No.	Mean (SD)			
Average daily gain[2,3]	17,469	1.14 (0.42)	160	0.94 (0.75)	-0.37	-0.33 to -0.41	<0.001
Average daily gain *meat*[4]	16,990	0.99 (0.25)	82	0.87 (0.33)	-0.33	-0.28 to -0.37	<0.001

[1] Estimated mean for market reject cattle minus mean for non-market reject cattle, adjusted for treatment, feedlot, induction weight and days on feed

[2] Values <-2 kg/day and those >3 kg/day were excluded before analyses

[3] Values for cattle whose out weights were in any of the 6 peaks for that variable were available for these variables but were excluded before analyses

[4] Values <-0.5 kg/day and those >2.25 kg/day were excluded before analyses

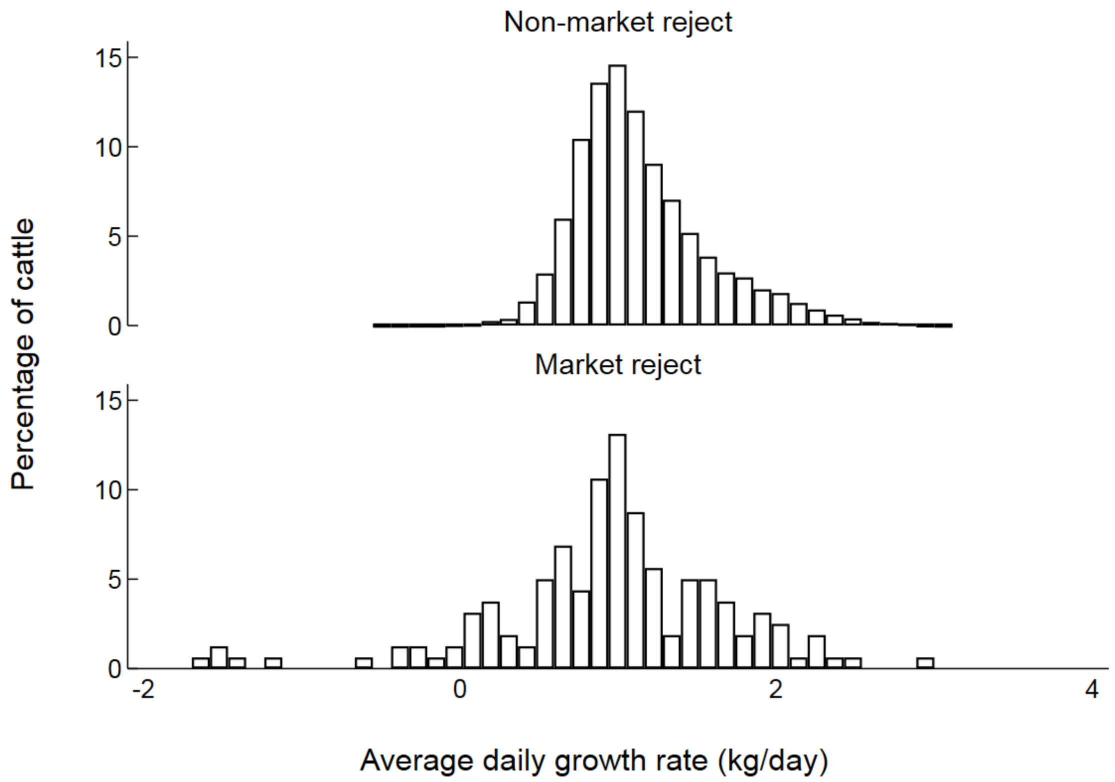

Figure 27. Distributions of average daily growth rates for non-market reject and market reject cattle. Average daily growth rates weights <-2 kg/day and those >3 kg/day were excluded before analyses along with values for cattle whose out weights were in any of the 6 peaks for that variable.

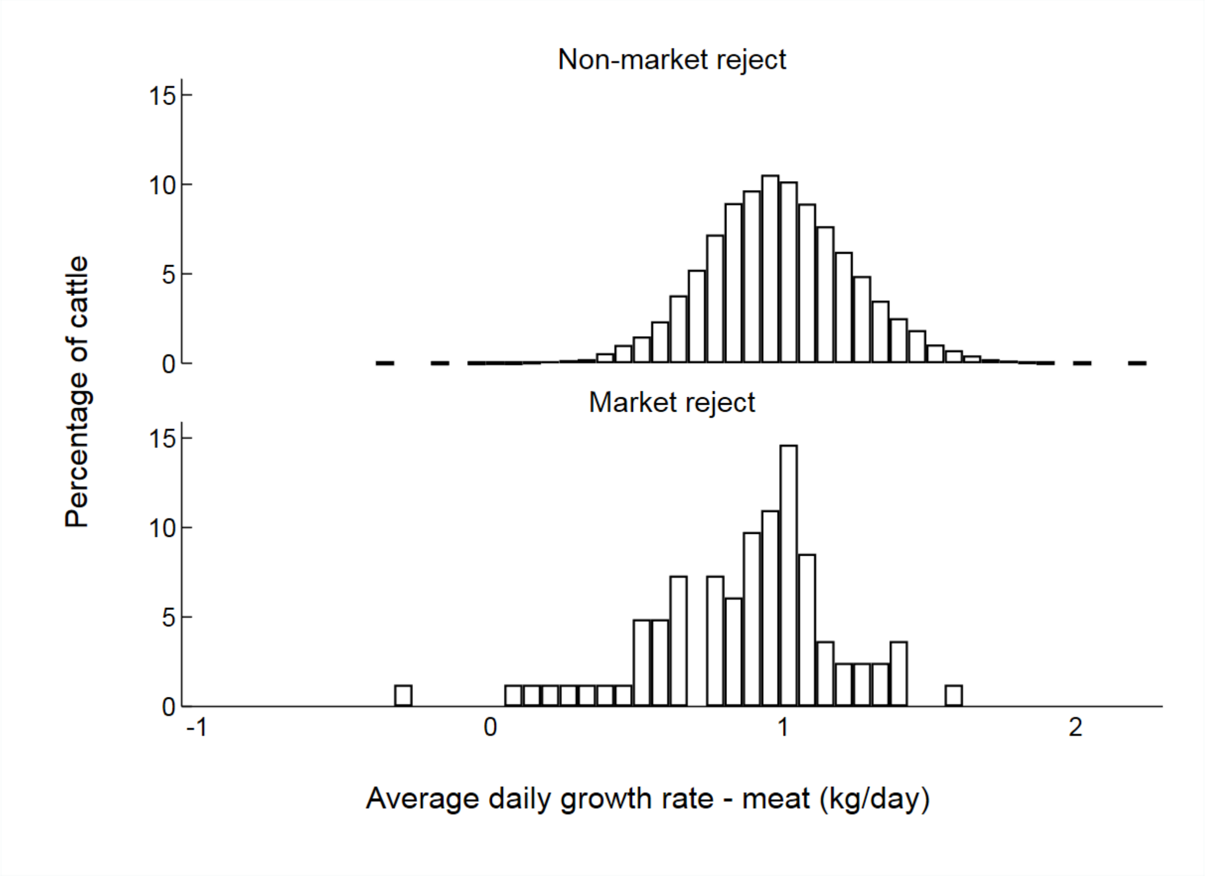

Figure 28. Distributions of average daily growth rates - *meat* (ADG-M) for non-market reject and market reject cattle.

4.5.7 Grading fail

Cattle were classified as grading fails where:

a. if MSA graded, MSA fail was indicated or
b. if chiller assessment was available, the carcass meat colour score was 4 or greater or
c. if an animal's hot standard carcass weight was unknown and this and other animals from the same lot killed on the same date in the same establishment number with unknown hot standard carcass weights constituted less than 10% of a set of 25 or more animals.

Remaining cattle were classified as grading successes only if MSA graded and chiller assessment were available, and they either had a hot standard carcass weights or were from a set of 25 or more animals

The distribution of study cattle by grading fail status and treatment group is shown in Table 13. The odds ratio for being a grading fail (treated relative to control cattle; adjusted for feedlot) was 0.77 (95% CI 0.42 to 1.40; P=0.390).

These results do not support the hypothesis that acclimation affects the risk of an animal being a grading fail. However, based on this 95% CI, these results are compatible with acclimation having quite large adverse or beneficial effects.

Table 13. Distribution of study cattle by grading fail status and treatment group

Grading fail status	**Control cattle**		**Treated cattle**	
No	6,928	97.7%	7,032	97.2%
Yes	161	2.3%	200	2.8%
Data insufficient to classify animal	2,444		2,286	
Pooled	9,533	100.0%	9,518	100.0%

4.5.8 Carcase attributes

Distributions of P8 fat depth, eye muscle area and MSA index for control and treated cattle are shown in Figures 27, 28 and 29 and results of statistical comparisons are shown in Table 14.

For each of these variables, differences between means for treated cattle relative to control cattle were small, 95% confidence intervals relatively narrow, and p-values high (Table 14). These results indicate that, if these variables are affected by acclimation, any such effects are, at most, modest.

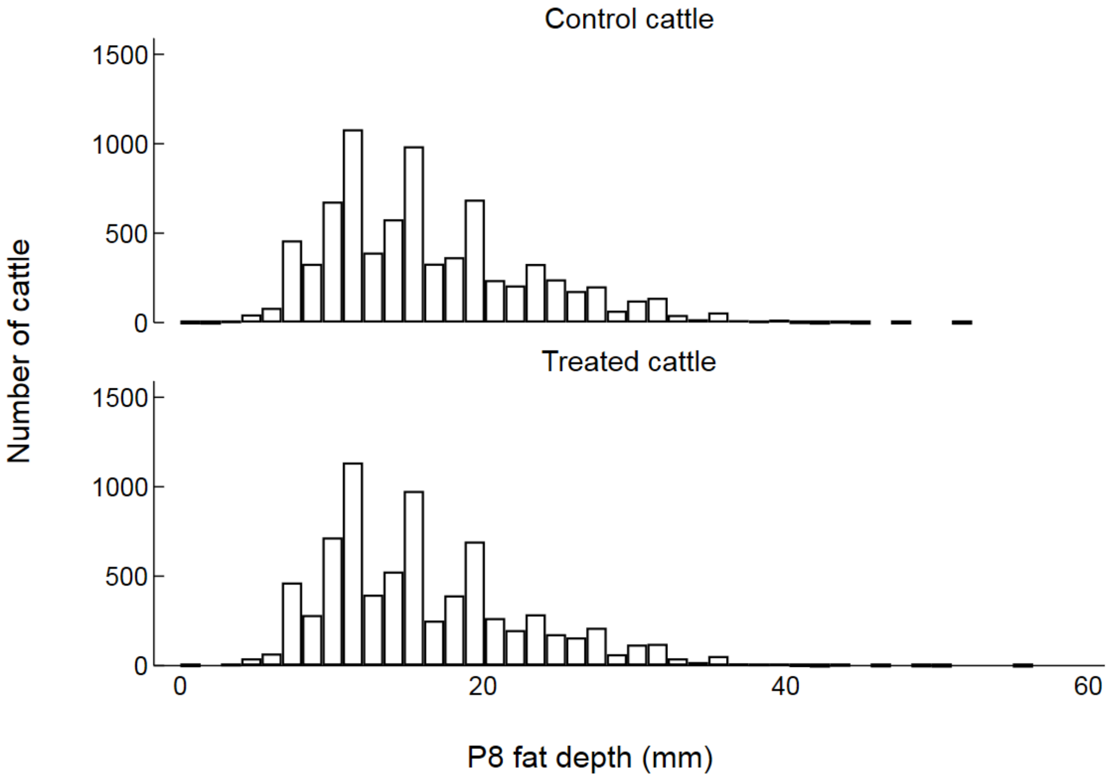

Figure 29. Distributions of P8 fat depth (mm) for control and treated cattle.

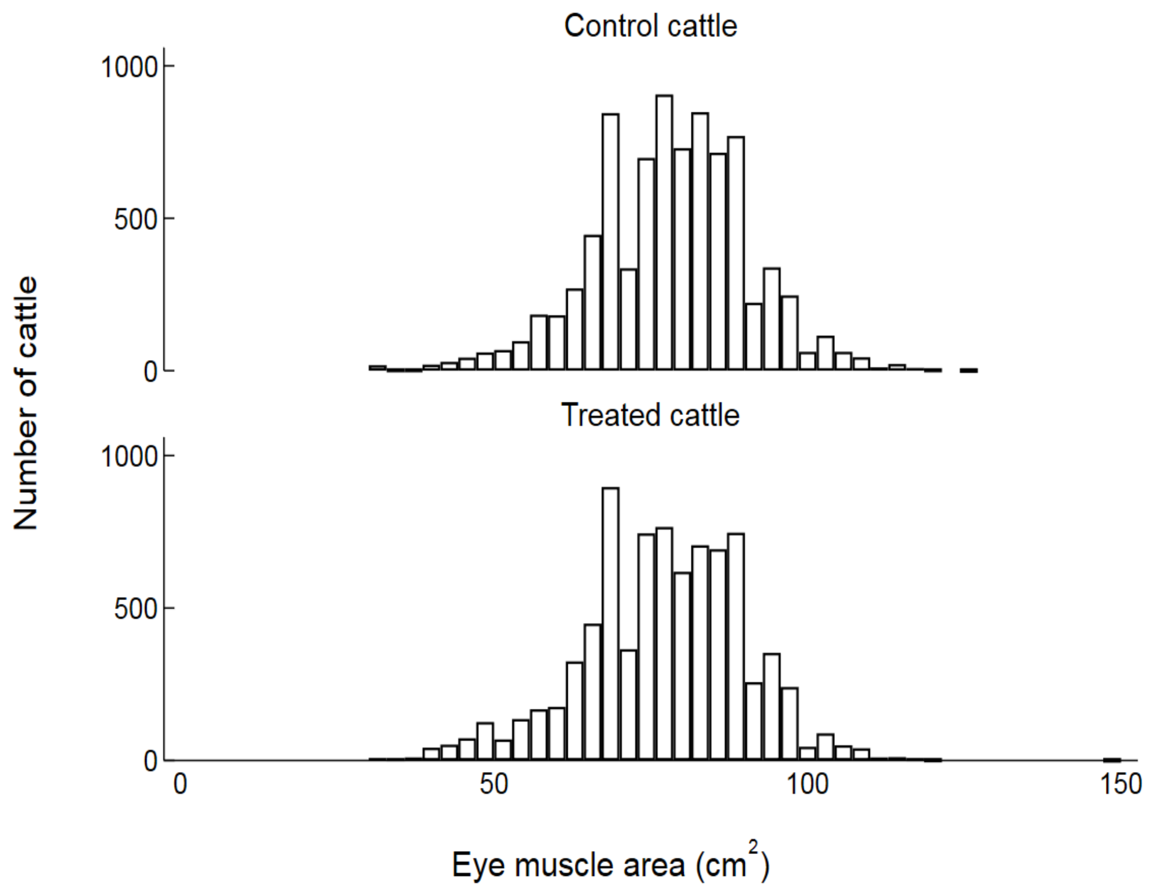

Figure 30. Distributions of eye muscle area (cm^2) for control and treated cattle.

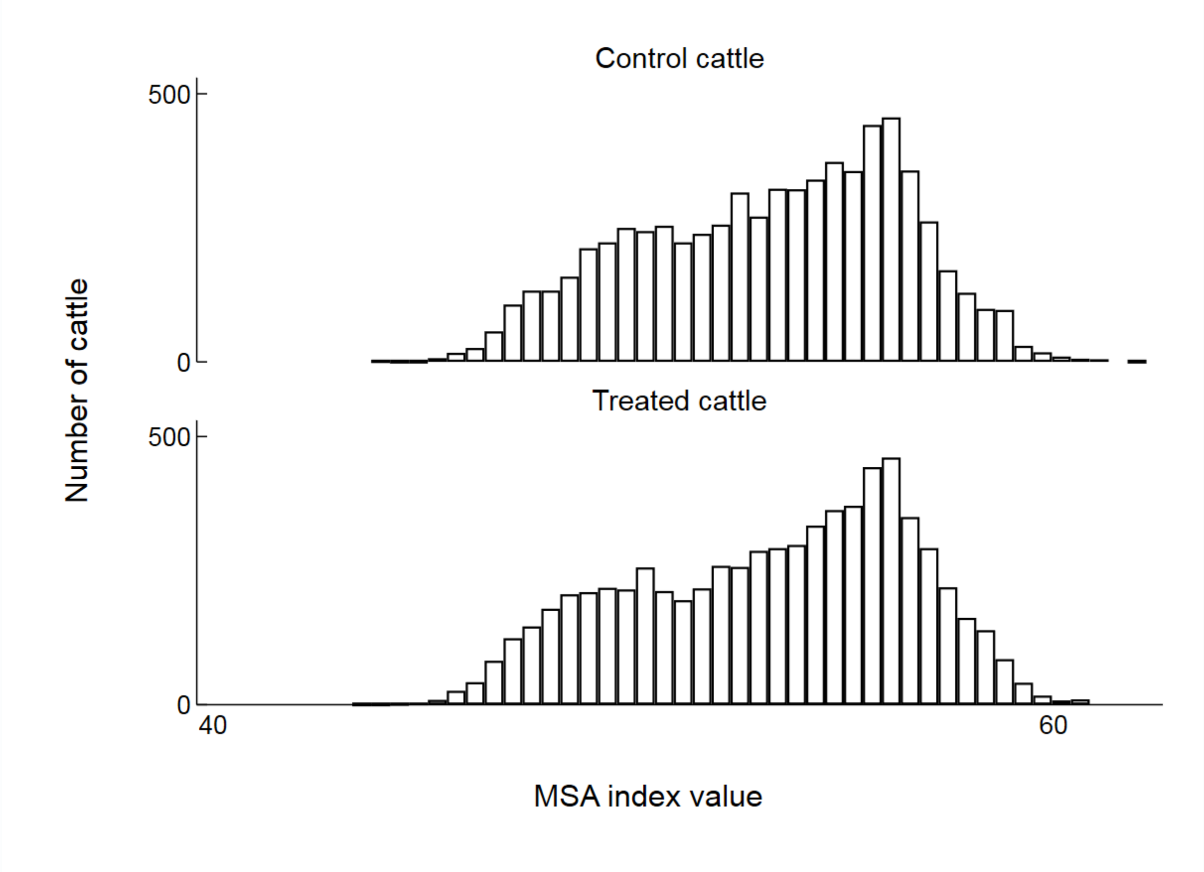

Figure 31. Distributions of MSA index for control and treated cattle.

Table 14. Mean P8 fat depths, eye muscle areas and MSA index values, and differences between means between treated and control cattle

Variable	Control cattle		Treated cattle		Difference between means[1]	95% CI	P
	No.	Mean (SD)	No.	Mean (SD)			
P8 fat depth (mm)	7,928	16.5 (6.8)	7,728	16.3 (6.7)	-0.3	-1.2 to 0.6	0.542
Eye muscle area (cm^2)	8,409	78.2 (12.5)	8,283	77.1 (13.1)	-0.8	-2.6 to 1.0	0.389
MSA index	6,928	53.3 (3.1)	7,032	53.3 (3.3)	-0.1	-0.8 to 0.5	0.640

[1] Treated minus control adjusted for feedlot

4.5.9 Marbling

Distributions of marbling scores for control and treated cattle are shown in Table 15. The odds ratio for any category or higher (rather than a lower category) for treated relative to control cattle was 0.96 (95% CI 0.76 to 1.22; P=0.748). The p-value for the Brant test was 0.523, a result consistent with the proportional odds assumption being true.

These results do not support the hypothesis that acclimation affects marbling score. However, based on these 95% CIs, these results are compatible with acclimation having quite large adverse or beneficial effects.

Table 15. Distributions of marbling scores for control and treated cattle

Marbling score	Control cattle		Treated cattle	
0	1,874	22.1%	1,852	22.2%
1	4,550	53.7%	4,513	54.2%
2	1,617	19.1%	1,586	19.0%
3	353	4.2%	296	3.6%
4	59	0.7%	63	0.8%
5	14	0.2%	16	0.2%
6	4	0.0%	3	0.0%
Not recorded	1,062		1,189	
Pooled	9,533	100.0%	9,518	100.0%

4.5.10 Meat colour

Distributions of meat colour categories for control and treated cattle are shown in Table 16. Of carcasses with meat colour recorded, percentages that were 4 or greater were 1.8% (149/8,410) for control cattle and 2.3% (192/8,284) for treated cattle. The odds ratio for being 4 or greater (rather than 3 or less) for treated cattle relative to control cattle adjusted for feedlot was 0.91 (95% CI 0.50 to 1.65; P=0.761).

These results do not support the hypothesis that acclimation affects the odds of meat colour category being 4 or greater. However, based on these 95% CIs, these results are compatible with acclimation having quite large adverse or beneficial effects.

Table 16. Distributions of meat colour categories for control and treated cattle

Meat colour	Control cattle		Treated cattle	
1	35	0.4%	25	0.3%
1B	1,098	13.1%	1,093	13.2%
1C	3,062	36.4%	3,135	37.8%
2	3,334	39.6%	3,091	37.3%
3	732	8.7%	748	9.0%
4	82	1.0%	89	1.1%
5	46	0.5%	70	0.8%
6	21	0.2%	33	0.4%
Not recorded	1,123		1,234	
Pooled	9,533	100.0%	9,518	100.0%

4.5.11 Feed delivered and consumption

Amounts of feed offered per head were compared over time between treated and control cattle at lot level, with total feed offered to the lot each day expressed as kg per animal. Amounts were compared only up to day 50 as, for some lots, all cattle were exited from day 54. Amount of feed offered increased rapidly initially, before almost plateauing (Figures 30 and 31).

For feed offered on an as fed basis, the joint p-value for interactions between treatment and each of linear and quadratic terms for time was 0.842 so these interaction terms were removed from the model. The estimated mean amount of feed offered on an as fed basis was 0.22 kg less (95% CI 0.59 less to 0.15 more; P=0.246) for treated lots relative to control lots.

For feed offered on a dry matter basis, the joint p-value for interactions between treatment and each of linear and quadratic terms for time was 0.964 so these interaction terms were removed from the model. The estimated mean amount of feed offered on a dry matter basis was 0.11 kg less (95% CI 0.43 less to 0.21 more; P=0.508) for treated lots relative to control lots.

These results indicate that, if amount of feed offered is affected by acclimation, any such effect is relatively small.

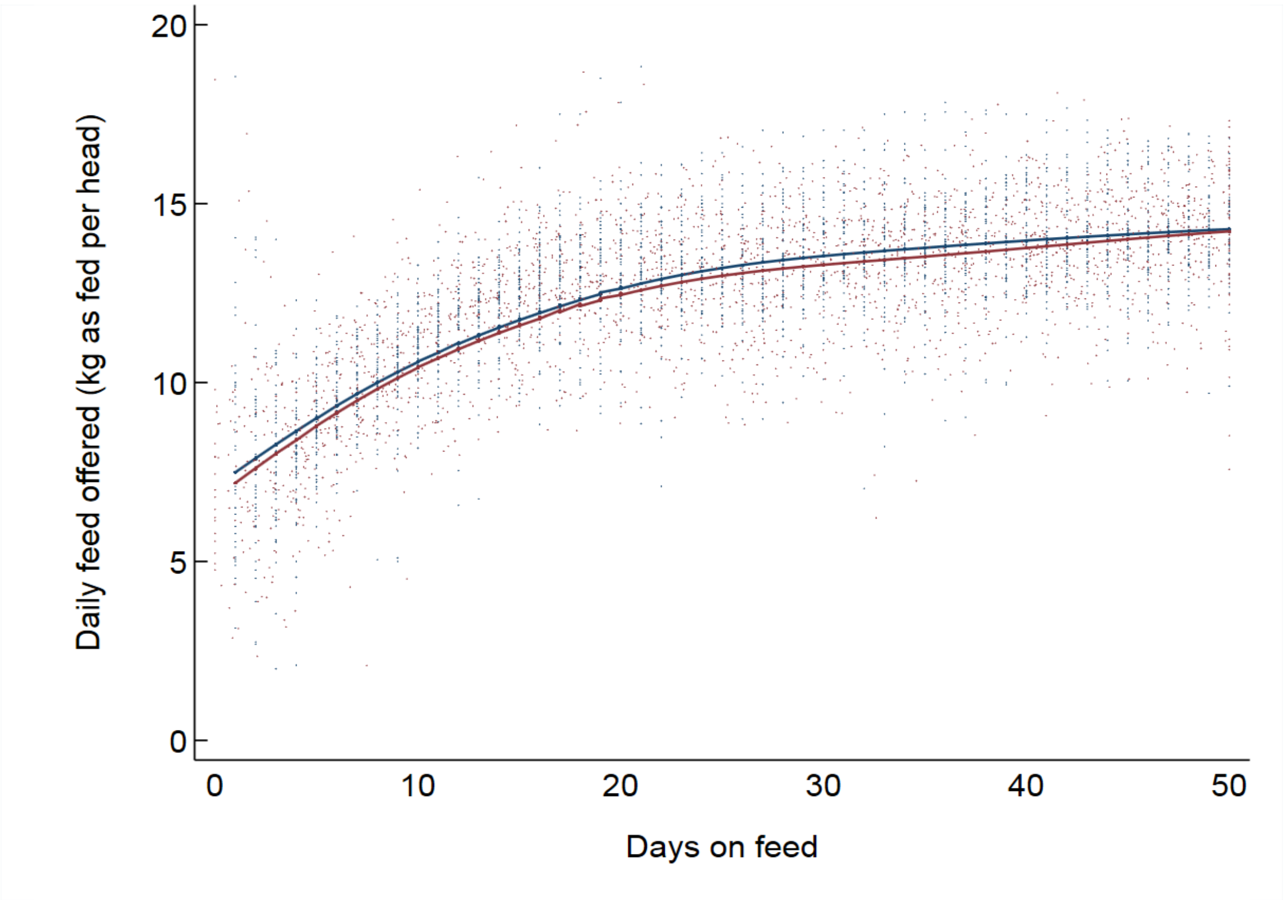

Figure 32. Distributions of amounts of feed offered daily on an *as fed* basis per head for control (blue dots and line) and treated (red dots and line) cattle. Lowess (i.e. locally weighted regression) lines of best fit are shown. Each dot represents the amount of feed offered to a particular lot on the day as shown. Dots for treated lots (red dots) were jittered (i.e. randomly spread slightly) to avoid covering dots for control lots (blue dots).

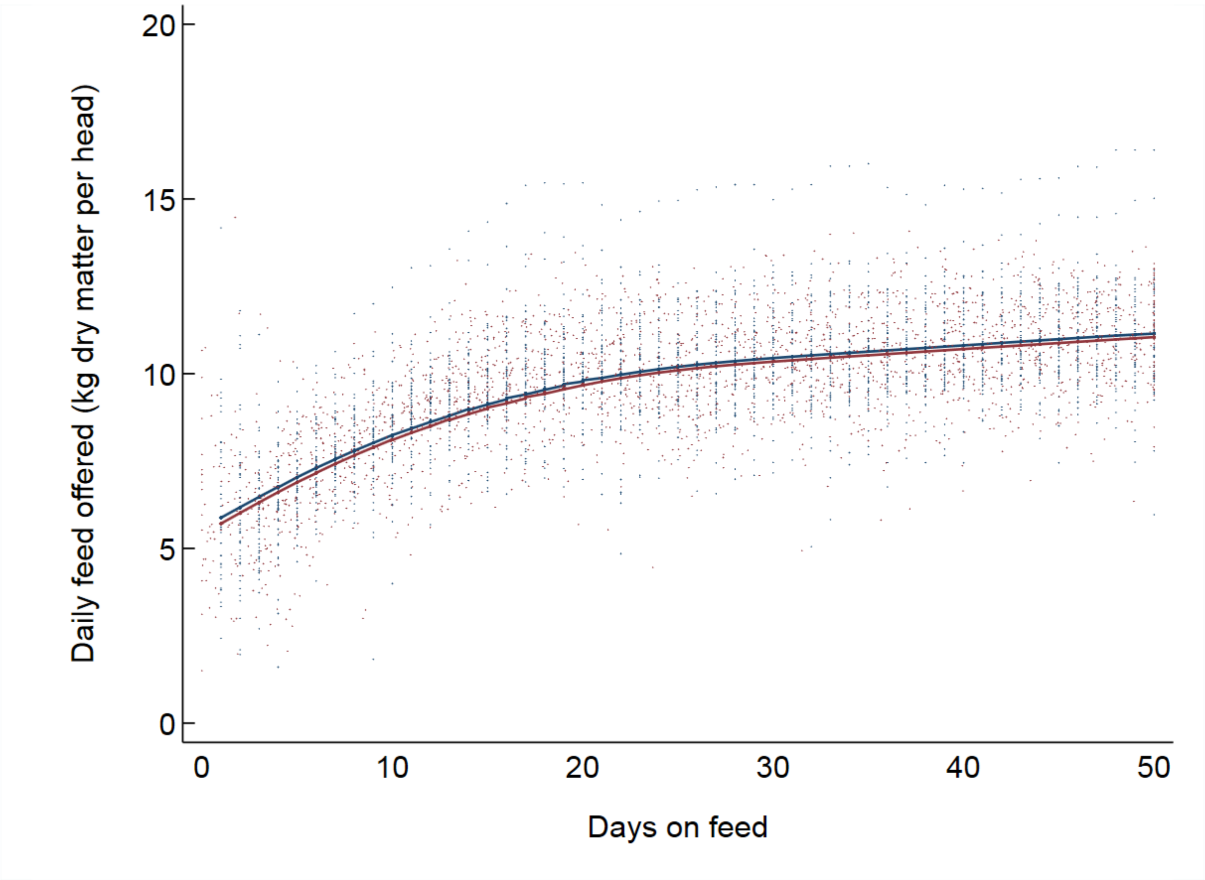

Figure 33. Distributions of amounts of feed offered daily on a *dry matter* basis per head for control (blue dots and line) and treated (red dots and line) cattle. Lowess (i.e. locally weighted regression) lines of best fit are shown. Each dot represents the amount of feed offered to a particular lot on the day as shown. Dots for treated lots (red dots) were jittered (i.e. randomly spread slightly) to avoid covering dots for control lots (blue dots).

In addition, total amounts of feed up to day 50 were compared between treated and control lots (Figures 32 and 33; Table 17). Total amounts of feed up to day 50 (both as fed and dry matter) were not significantly different between treated and control lots.

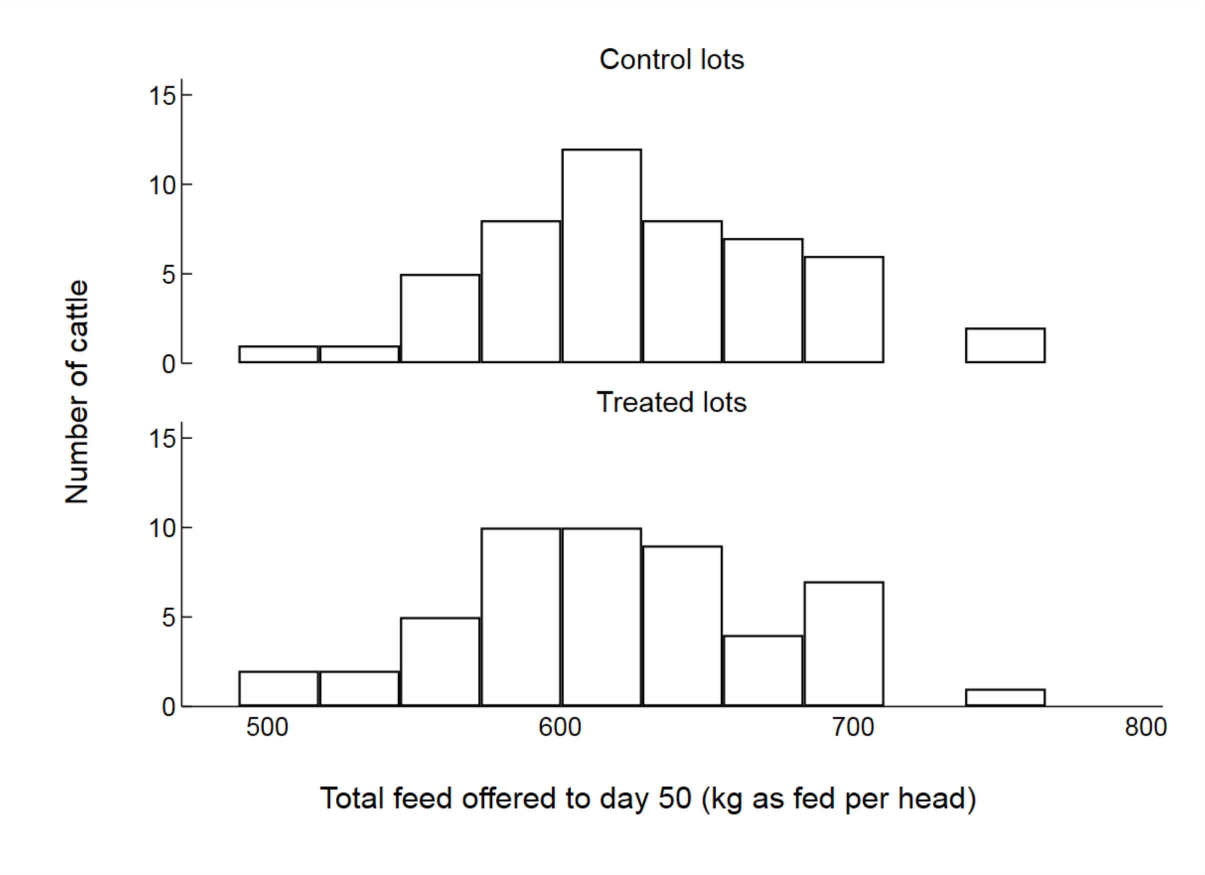

Figure 34. Total amounts of feed up to day 50 for control and treated lots: kg feed on an *as fed* basis

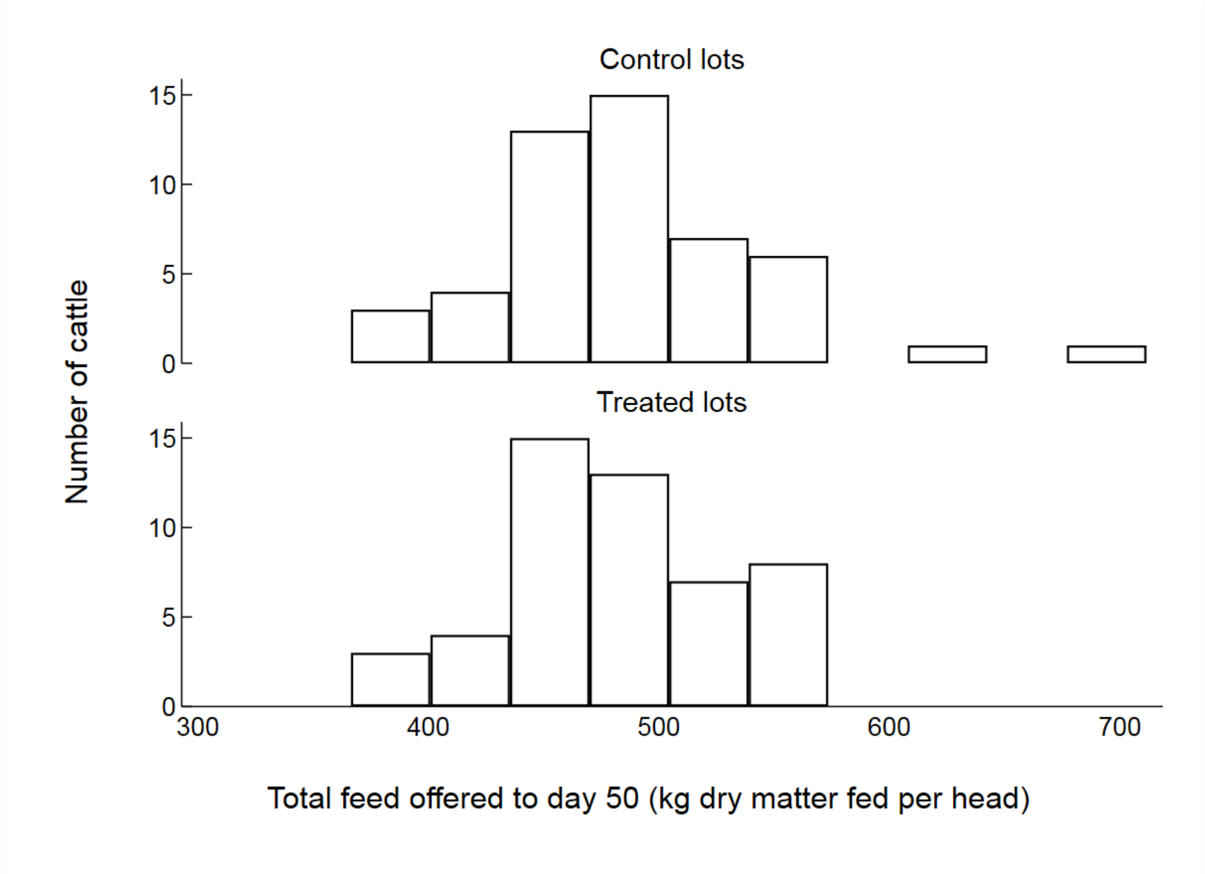

Figure 35. Total amounts of feed up to day 50 for control and treated lots: kg feed on a *dry matter* basis

Table 17. Mean total amounts of feed up to day 50, and differences between means between treated and control lots

Variable	**Control lots**		**Treated lots**		**Difference between means**[1]	**95% CI**	**P**
	No. lots	**Mean (SD)**	**No. lots**	**Mean (SD)**			
As fed basis	50	626.6 (52.8)	50	616.6 (55.6)	-9.9	-29.8 to 9.9	0.324
Dry matter basis	50	485.4 (61.1)	50	479.9 (45.8)	-5.5	-22.6 to 11.6	0.522

[1] Estimated mean for treated lots minus mean for control lots, adjusted for feedlot

4.5.12 Faecal cortisol metabolite concentrations

Faecal cortisol metabolite concentrations were measured on multiple days in all 20 lots from one feedlot (feedlot 22). On each sampling day, 8 to 11 faecal pats were sampled. For 6 of the 20 lots, cattle were inducted on one day while for the remaining 14 lots, cattle were inducted over two consecutive days. Days on feed at each sampling was calculated for each lot as the number of days from induction date or, for these latter 14 lots, from the second date when cattle were inducted.

Faecal cortisol concentrations were compared using means of values from the 8 to 11 faecal pats collected from the lot on the same day. Variability of concentrations from 8 to 11 faecal pats collected from the lot on the same day is shown in Figure 34. Lot-days with higher mean values also had greater variability.

Concentrations decreased rapidly from day 1 in a curvilinear fashion (Figures 35 and 36). Concentrations were compared between treatment and control cattle only up to day 50 as after this time, concentrations in most samples were low.

The joint p-value for interactions between treatment and each of linear and quadratic terms for time was 0.994 so these interaction terms were removed from the model. The estimated mean faecal cortisol concentration was 1.9 units less (95% CI 23.9 less to 20.0 more; P=0.863) for treated lots relative to control lots.

Analyses were also performed restricting data to days 1 to 10. The joint p-value for interactions between treatment and each of linear and quadratic terms for time was 0.626 so these interaction terms were removed from the model. For days 1 to 10, the estimated mean concentration was 4.4 units less (95% CI 42.8 less to 34.1 more; P=0.823) for treated lots relative to control lots.

These results do not support the hypothesis that acclimation affects mean faecal cortisol concentration. However, based on this 95% CI, these results are compatible with acclimation having quite large adverse or beneficial effects.

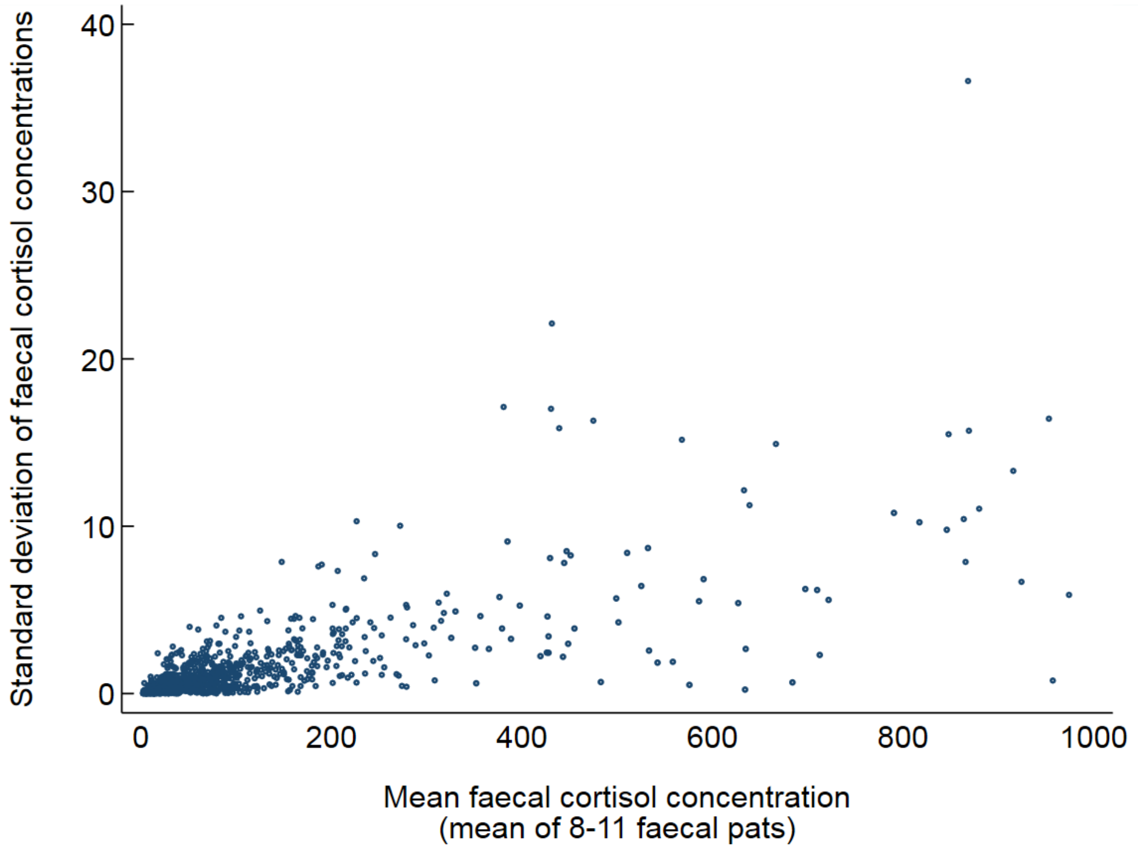

Figure 36. Scatterplot of standard deviations of faecal cortisol concentrations from 8-11 faecal pats collected from one lot on one day versus means of those concentrations.

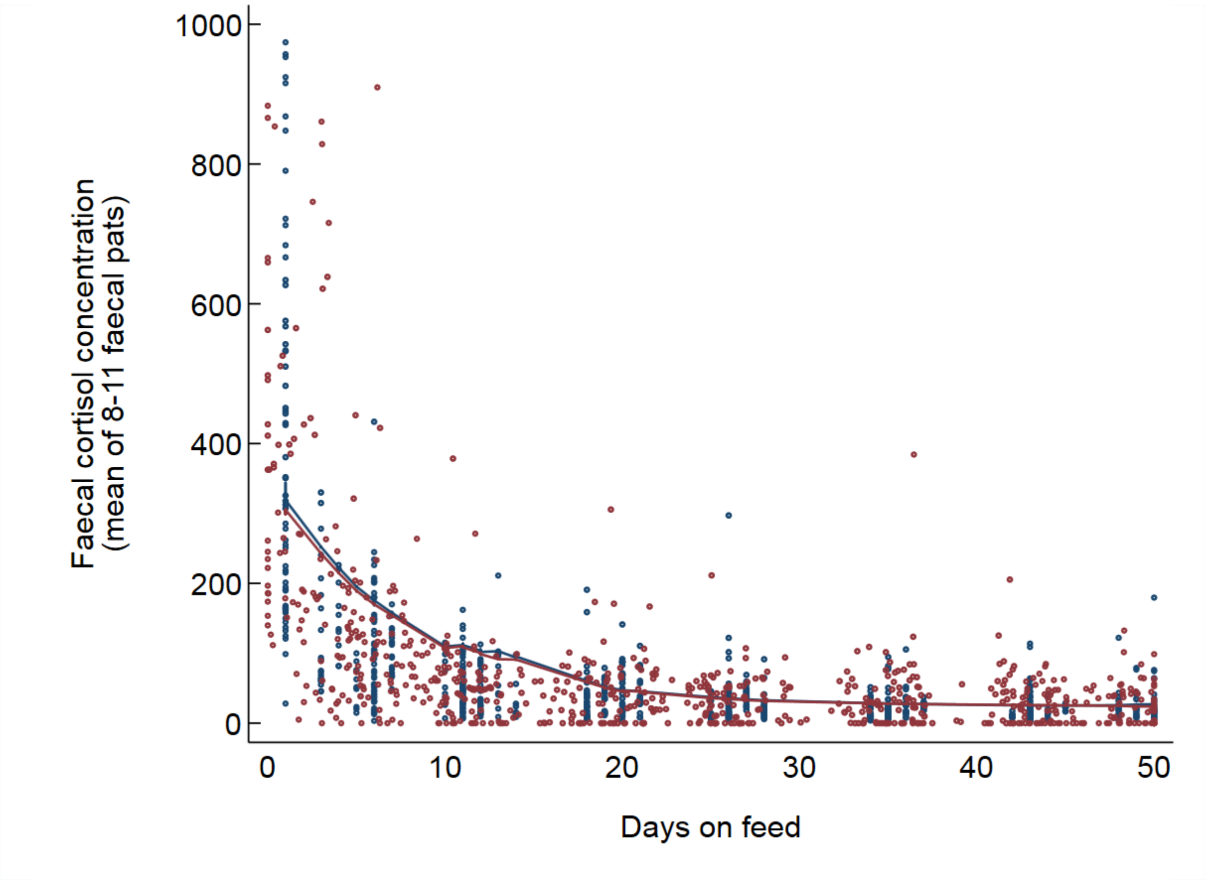

Figure 37. Distributions of mean faecal cortisol concentrations from 8-11 faecal pats collected from one lot on one day up to day 50 for control (blue dots and line) and treated (red dots and line) lots. Lowess (i.e. locally weighted regression) lines of best fit are shown. Each dot represents the mean faecal cortisol concentration for a particular lot on the day as shown. Dots for treated lots (red dots) were jittered (i.e. randomly spread slightly) to avoid covering dots for control lots (blue dots).

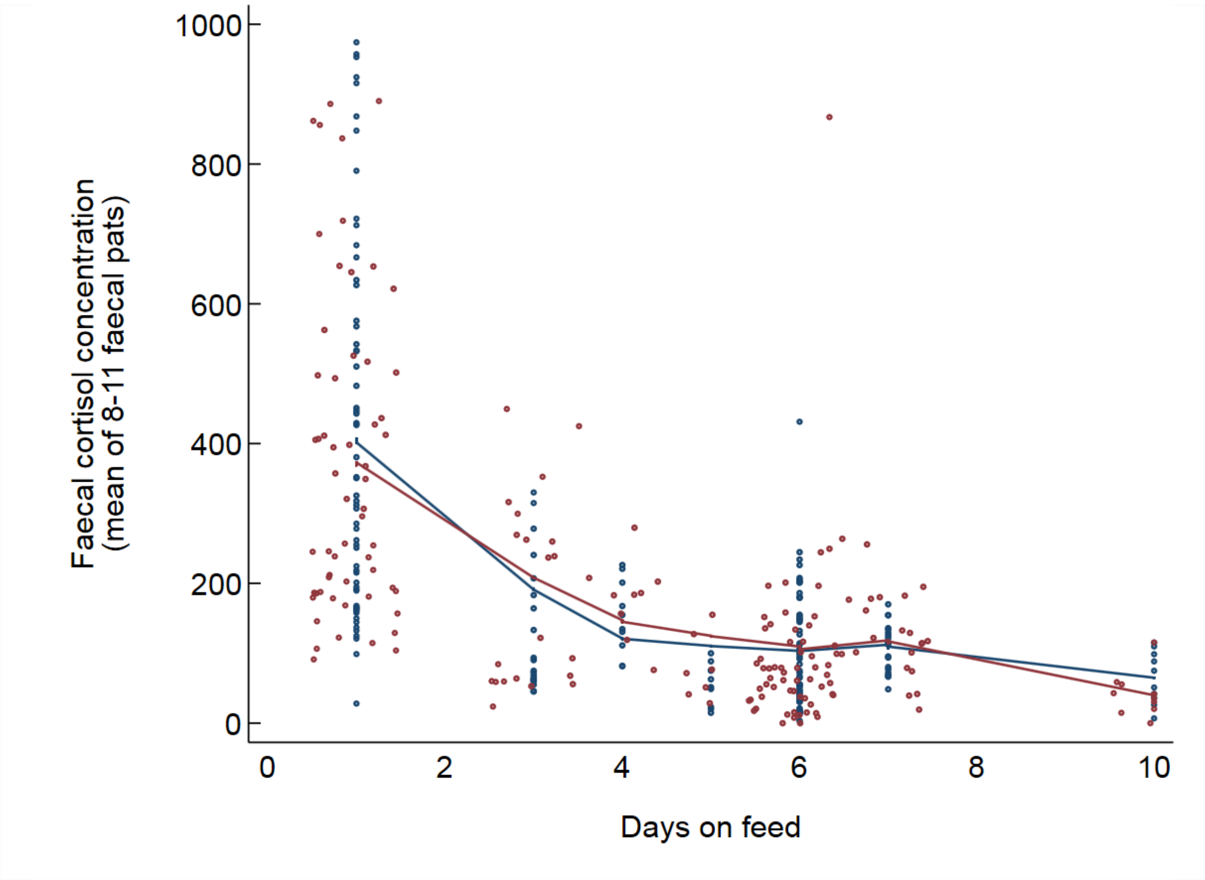

Figure 38. Distributions of mean faecal cortisol concentrations from 8-11 faecal pats collected from one lot on one day up to day 10 for control (blue dots and line) and treated (red dots and line) lots. Lowess (i.e. locally weighted regression) lines of best fit are shown. Each dot represents the mean faecal cortisol concentration for a particular lot on the day as shown. Dots for treated lots (red dots) were jittered (i.e. randomly spread slightly) to avoid covering dots for control lots (blue dots).

4.6 Assessment of interactions with treatment

All results above assess the main effects of acclimation i.e. any differences between treated and control cattle averaged over all cattle. However, it was possible that the effects of acclimation varied between subgroups of cattle. To explore this, some factors that may have potentially interacted with acclimation were assessed. Effects on average daily gain *meat* (ADG-M), being pulled (for any reason and by reason) and MSA index were assessed.

P-values for (joint) interaction terms between treatment and various factors are shown in Table 18. Most p-values were high, thus providing no support of the hypothesis that the effect of acclimation varies between the respective subsets of cattle. Further investigation would be required before conclusions are reached for interaction terms with low p-values. Some of these were because of sparse data (e.g. few cattle with extreme chute scores being pulled for the specified reason). For chute score variables, some were due to interaction between treatment and just a single score category, whereas an increasing (or decreasing) effect of treatment with increasing score would be more plausible.

Table 18. P-values for (joint) interaction terms between treatment and various factors on seven outcome variables

Potential interacting factor	Outcome variable						
	Average daily gain meat	Pulled with first pull for:					MSA index
		any reason	BRD	being a buller	foot problem	observation	
Feedlot	0.997	0.805	0.889	<0.001	0.458	0.713	0.993
Cohort	<0.001	[1]	[1]	[1]	[1]	[1]	<0.001
Sex	0.873	0.922	0.898	0.956	0.042	0.146	0.671
Dentition	0.217	0.985	0.778	0.923	0.909	0.143	0.473
Source category	0.394	0.861	0.774	0.956	0.147	0.807	0.272
Chute scores							
Entry	0.640	0.092	0.144	<0.001	0.379	0.587	0.467
Catch	0.656	0.474	0.061	0.811	0.883	0.044	0.527
Resist	0.886	0.978	0.800	0.452	0.499	0.814	0.728
Vocal	0.190	0.135	0.012	0.068	0.669	<0.001	0.254
Faecal	0.012	0.273	0.550	<0.001	<0.001	<0.001	0.710
Exit	0.563	0.170	0.334	0.975	0.387	0.734	0.870
Jigger used	0.770	0.095	0.073	0.444	0.996	0.843	0.467
Horns tipped	0.174	0.739	0.540	0.422	0.810	0.849	0.017
Time	0.513	0.001	<0.001	<0.001	<0.001	<0.001	0.349

[1] Interactions with cohort were not assessed for these outcome variables as the data were too sparse for those analyses

4.6.1 Chute variables and exit velocity assessment

Correlations between chute score variables were assessed using Spearman's correlation coefficients (Table 19). For each pair-wise assessment, all animals with both scores (between 18,471 and 18,476 animals) were used. No scores were closely correlated; the highest correlation coefficients were for correlations between resist and each of vocal and exit (0.35 and 0.34, respectively). If misclassification errors were minimal when allocating chute scores, these results indicate that these various chute scores are largely describing different attributes of the animal.

Table 19. Spearman's correlation coefficients for correlations between chute scores for entry, catch, resist, vocal, faecal, and exit; bolded coefficients are significant at the 0.05 level

	Entry	Catch	Resist	Vocal	Faecal
Entry					
Catch	**0.08**				
Resist	**0.09**	**0.03**			
Vocal	**0.07**	**0.04**	**0.35**		
Faecal	**-0.06**	0.02	0.00	0.01	
Exit	**0.20**	**0.03**	**0.34**	**0.28**	**-0.14**

In addition to the nine chute variables, for a subset of study cattle from feedlot 22, the average velocities were calculated for each animal as they moved the 1.5 metres from the crush release to when their head aligned with the start of the gate. These exit velocities were calculated by counting numbers of video frames on video footage. These data were available for 516 of the 529 animals in one cohort (258 of the 265 control animals and 258 of the 264 treated animals). Video footage was not available for the last 13 animals inducted.

Some preliminary analyses of velocity were performed. Distributions of exit velocities are summarised by chute exit score in Table 20 and Figure 37. There was considerable overlap in velocities for cattle with various chute exit scores, indicating that chute exit score is not a close surrogate for exit velocity.

Table 20. Distributions of exit velocities by chute exit score

Chute exit score	No. cattle	Exit velocity (m/second)			
		Minimum	Maximum	Mean	SD
1	3	0.38	0.89	0.66	0.26
2	103	0.22	1.97	0.79	0.31
3	212	0.08	1.56	0.82	0.35
4	172	0.19	1.44	0.77	0.32
	26	0.20	1.14	0.77	0.30
Pooled	516	0.08	1.97	0.80	0.33

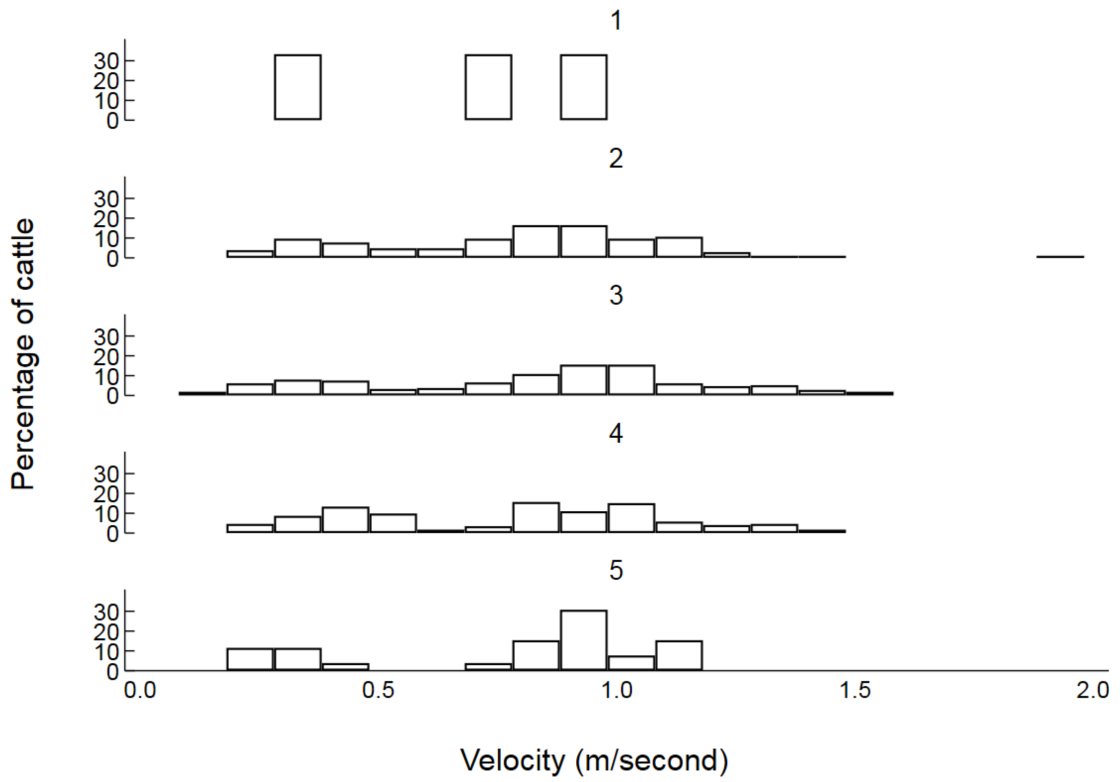

Figure 39. Distributions of exit velocities by chute exit score (1, 2, 3, 4 or 5).

Distributions of exit velocities are summarised by the other chute variables in Table 21. Useful comparisons were only possible for chute variables with at least modest variation (entry, resist and vocal). For each of these, there was considerable overlap in velocities for cattle with various scores, suggesting that these chute scores are not surrogates for exit velocity.

Table 21. Distributions of exit velocities by other chute variables

Chute variable	**No. cattle**	**Exit velocity (m/second)**			
		Minimum	**Maximum**	**Mean**	**SD**
Entry					
1	210	0.08	1.56	0.75	0.34
2	157	0.12	1.97	0.82	0.33
3	130	0.17	1.50	0.85	0.30
4	18	0.35	1.44	0.80	0.36
5	1	1.10	1.10	1.10	
Catch					
1	508	0.08	1.97	0.80	0.33
2	4	0.32	1.29	0.75	0.45
3	2	0.34	0.42	0.38	0.05
4	0				
5	2	0.20	0.63	0.41	0.30
Resist					
1	159	0.08	1.50	0.78	0.31
2	185	0.15	1.50	0.80	0.33
3	139	0.20	1.97	0.83	0.35
4	31	0.17	1.34	0.78	0.32
5	2	0.31	0.83	0.57	0.37
Vocal					
1	273	0.08	1.56	0.78	0.31
2	109	0.12	1.44	0.79	0.34
3	102	0.19	1.97	0.81	0.36
4	30	0.33	1.29	0.89	0.30
5	2	1.21	1.44	1.33	0.16
Faecal					
1	502	0.08	1.97	0.80	0.33
2	0				
3	0				
4	11	0.25	0.99	0.66	0.29
5	3	0.65	1.07	0.93	0.25
Jigger used					
Not used	514	0.15	1.97	0.80	0.33
Used once					
Used more than once	1	0.08	0.08	0.08	
Horns tipped					
No	511	0.08	1.97	0.80	0.33
Yes	4	0.94	1.29	1.08	0.17
Time					
1	2	1.07	1.29	1.18	0.16
2	498	0.08	1.97	0.79	0.33
3	14	0.29	1.56	1.01	0.38
4	2	1.07	1.34	1.21	0.19
5	0				

Scatterplots to assess associations between average daily growth rate *meat* (ADG-M) and exit velocity, and MSA index and exit velocity are shown in Figures 38 and 39, respectively. There is no evidence of a strong association for either relationship.

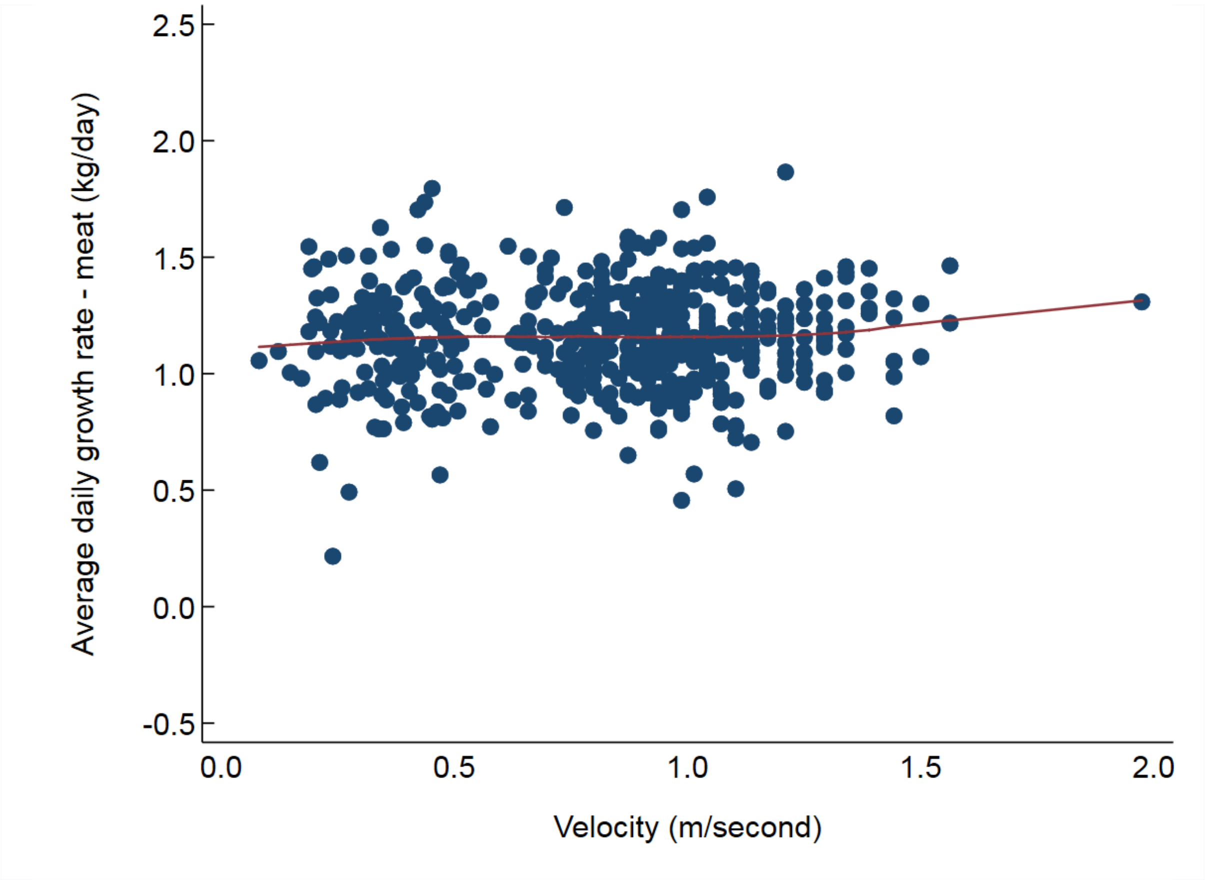

Figure 40. Distributions of average daily growth rate *meat* (ADG-M) by exit velocity. The red line is the Lowess (i.e. locally weighted regression) line of best fit.

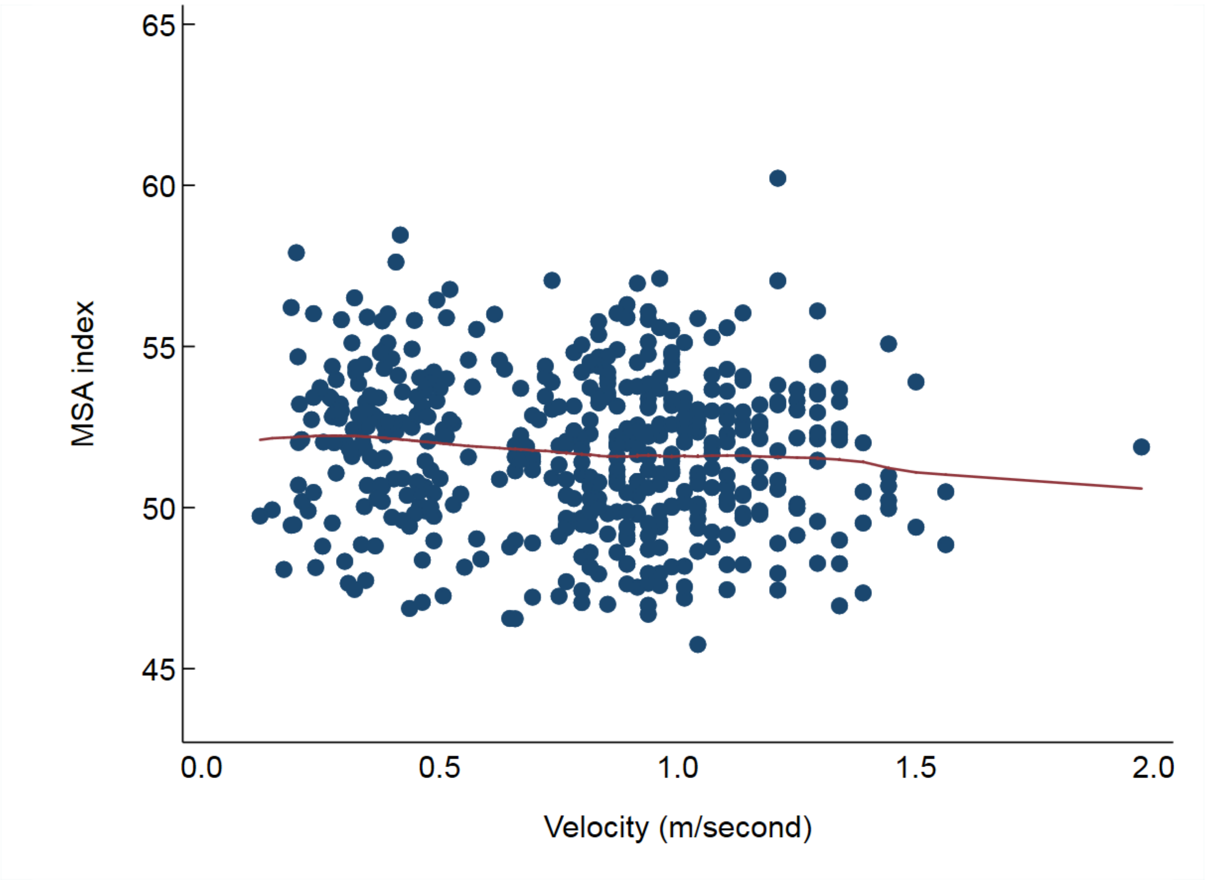

Figure 41. Distributions of MSA index by exit velocity. The red line is the Lowess (i.e. locally weighted regression) line of best fit.

4.6.2 Determinants of being pulled for any reason

The results section reporting now moves beyond effects of acclimation. The next four sections consist of results of analyses not to assess the effects of acclimation, but rather to identify determinants of being pulled for any reason, being pulled for BRD, average daily growth rate – *meat* (ADG-M) and MSA index. These analyses are unrelated to acclimation but were performed using that same dataset.

Potential determinants of being pulled were assessed using models as described above. Each potential determinant (other than cohort) was assessed adjusted for feedlot. The significance of each was assessed using (joint) Wald p-values, calculated using Stata's -testparm- command. Those with p-values <0.05 (other than source category) were then simultaneously forced into a multivariable model and (joint) Wald p-values calculated after adjustment for the other variables in the model. For continuous exposure variables, linear and quadratic terms were fitted.

As values for source category were available for only 7,136 of the 19,051 study animals, effects of this variable were assessed in a separate model adjusted for all other variables forced into the multivariable model. As cohort was completely nested within feedlot, as there were relatively few feedlots, and as cohort effects may have in fact been due to pen effects, only univariable effects of cohort were assessed. Effects of cohort on risk of being pulled were not assessed due to some cohorts having few pulls.

P-values for potential determinants of being pulled for any reason adjusted for feedlot are shown in Table 22, and results from the multivariable model are shown in Table 23. The overall p-value for chute entry score was 0.093 so this variable was removed from the model. In the consequent model, the overall p-value for chute exit score was 0.210 so this variable was then removed from the model.

The hazard of being pulled varied markedly by feedlot, and with dentition (animals with 1 to 4 permanent incisors were less likely to be pulled than those with no permanent incisors). The hazard of being pulled also varied with chute entry score (animals with scores of 2 or 3 were less likely to be pulled than those with scores of 1) and with chute exit score (animals with scores of 2 or higher were at less risk than those with scores of 1). Hazard of being pulled also varied with chute faecal score. Animals with scores of 3 being more likely to be pulled than those with scores of 1, but this result should be viewed with caution as virtually all animals with chute faecal scores of 3 were from one cohort.

Table 22. P-values for potential determinants of being pulled (for any reason) adjusted only for feedlot

Feedlot	<0.001[1]
Induction weight	
Linear term	0.203[2]
Quadratic term	0.250[3]
Sex	0.949
Dentition	<0.001
Source category	<0.001
Chute variables	
Entry	0.004
Catch	0.567
Resist	0.055
Vocal	0.082
Faecal	0.003
Exit	<0.001
Jigger used	0.697
Horns tipped	0.411
Time	0.961

[1] Univariable p-value

[2] P-value for linear term only relative to no induction weight terms

[3] P-value for additional effect of quadratic term over linear term only

Table 23. Results from a multivariable model of being pulled (for any reason)

Variable	**Adjusted sub-hazard ratio**[1]	**95% CI**	**P**[2]
Feedlot			**<0.001**
4	Reference group		
22	0.8	0.6 to 1.0	0.080
24	1.1	0.7 to 1.6	0.698
26	0.3	0.2 to 0.4	<0.001
28	0.7	0.5 to 1.2	0.183
Dentition (number of permanent incisors)			**<0.001**
0	Reference group		
1 or 2	0.7	0.6 to 0.9	<0.001
3 or 4	0.8	0.7 to 1.0	0.031
5 or more	1.3	0.9 to 1.7	0.127
Chute entry score			**0.017**
1	Reference group		
2	0.8	0.8 to 0.9	0.001
3	0.8	0.7 to 1.0	0.041
4 or 5	0.8	0.5 to 1.2	0.331
Chute faecal score			**0.022**
1	Reference group		
2	1.0	0.8 to 1.4	0.714
3	1.5	1.1 to 1.9	0.004
4	1.2	0.8 to 1.7	0.389
5	1.3	0.9 to 1.8	0.197
Chute exit score			**<0.001**
1	Reference group		
2	0.7	0.6 to 0.9	<0.001
3	0.6	0.5 to 0.8	<0.001
4	0.6	0.5 to 0.7	<0.001
5	0.7	0.6 to 1.0	0.024

[1] Estimated sub-hazard ratio relative to reference group adjusted for all other variables listed

[2] Bolded p-values are overall Wald p-values for variables; unbolded p-values are Wald p-values for the respective category relative to the reference category

After adjustment for all variables in Table 23, source category was associated with being pulled (overall P<0.001). Relative to cattle in cohorts formed with cattle from only 1 property identification code (PIC), cattle in cohorts formed with cattle from 2 to 10 PICs had higher hazard of being pulled (adjusted sub-hazard ratio 1.3; 95% CI 1.1 to 1.6; P=0.001), as did those from saleyards (adjusted sub-hazard ratio 3.8; 95% CI 2.1 to 6.9; P<0.001). Thus, after adjustment for all variables in Table 23, cattle from saleyards had the highest risk of being pulled, those in cohorts formed with cattle from 2 to 10 PICs had the next highest risk, and those in cohorts formed from 1 PIC had the lowest risk.

4.6.3 Determinants of being pulled for BRD

P-values for potential determinants of being pulled for BRD adjusted for feedlot are shown in Table 24, and results from the multivariable model are shown in Table 25. The overall p-value for chute entry score was 0.093 so this variable was removed from the model. In the consequent model, the overall p-value for chute exit score was 0.210 so this variable was then removed from the model.

The hazard of being pulled for BRD varied markedly by feedlot, and with dentition (animals with 1 to 4 permanent incisors were less likely to be pulled than those with no permanent incisors). The hazard of being pulled for BRD also varied with chute faecal score. Animals with scores of 3 being more likely to be pulled for BRD than those with scores of 1, but this result should be viewed with caution as virtually all animals with chute faecal scores of 3 were from one cohort.

Table 24. P-values for potential determinants of being pulled for BRD adjusted only for feedlot

Feedlot	<0.001[1]
Induction weight	
Linear term	0.061[2]
Quadratic term	0.648[3]
Sex	0.540
Dentition	<0.001
Source category	<0.001
Chute variables	
Entry	0.037
Catch	0.956
Resist	0.172
Vocal	0.164
Faecal	0.006
Exit	<0.001
Jigger used	0.764
Horns tipped	0.756
Time	0.793

[1] Univariable p-value

[2] P-value for linear term only relative to no induction weight terms

[3] P-value for additional effect of quadratic term over linear term only

Table 25. Results from a multivariable model of being pulled for BRD

Variable	Adjusted sub-hazard ratio[1]	95% CI	P[2]
Feedlot			**<0.001**
4	Reference group		
22	0.3	0.2 to 0.5	<0.001
24	1.4	1.0 to 2.2	0.076
26	0.4	0.3 to 0.6	<0.001
28	1.3	0.8 to 2.2	0.283
Dentition (number of permanent incisors)			**<0.001**
0	Reference group		
1 or 2	0.7	0.6 to 0.9	<0.001
3 or 4	0.8	0.6 to 0.9	0.015
5 or more	0.7	0.5 to 0.9	0.018
Chute faecal score			**0.012**
1	Reference group		
2	1.1	0.8 to 1.4	0.614
3	1.8	1.3 to 2.4	0.001
4	1.2	0.7 to 2.0	0.559
5	1.3	0.9 to 1.9	0.166

[1] Estimated sub-hazard ratio relative to reference group adjusted for all other variables listed
[2] Bolded p-values are overall Wald p-values for variables; unbolded p-values are Wald p-values for the respective category relative to the reference category

After adjustment for the three variables in Table 25 and chute entry and exit scores, source category was associated with being pulled for BRD (overall P<0.001). Relative to cattle in cohorts formed with cattle from only 1 property identification code (PIC), cattle in cohorts formed with cattle from 2 to 10 PICs had higher hazard of being pulled (adjusted sub-hazard ratio 2.1; 95% CI 1.6 to 2.7; P<0.001), as did those from saleyards (adjusted sub-hazard ratio 4.4; 95% CI 2.3 to 8.3; P<0.001). Thus, after adjustment for the three variables in Table 25 and chute entry and exit scores, cattle from saleyards had the highest risk of being pulled for BRD, those in cohorts formed with cattle from 2 to 10 PICs had the next highest risk, and those in cohorts formed from 1 PIC had the lowest risk.

4.6.4 Determinants of average daily growth rate *meat:* ADG-M

Potential determinants of average daily growth rate *meat* and MSA index were assessed using methods as described above for being pulled except that linear regression was used, with lot fitted as a random effect. Stata's -xtreg- command was used, with the maximum likelihood random effects estimator. Likelihood ratio test p-values were used in place of the use of Wald p-values described in the methods above.

P-values for potential determinants of ADG-M adjusted for feedlot are shown in Table 26, and results from the multivariable model are shown in Table 27.

After accounting for the other variables in the multivariable model, ADG-M still varied markedly by feedlot, with two of the five feedlots having considerably higher rates. This means that differences between feedlots were probably not due to those other variables (induction weight, sex, dentition, and chute entry and vocal scores). ADG-M varied with induction weight (higher in those heavier at induction), sex (higher in males), and dentition (higher in animals with no permanent incisors compared to those with 1 or more permanent incisors). Estimated effects of chute entry and vocal scores were small.

Table 26. P-values for potential determinants of average daily growth rate – *meat* (ADG-M) adjusted only for feedlot

Feedlot	<0.001[1]
Cohort	
All cohorts	<0.001[1]
First 5 cohorts enrolled within feedlot	<0.001[1]
Induction weight	
Linear term	<0.001[2]
Quadratic term	<0.001[3]
Sex	<0.001
Dentition	<0.001
Source category	<0.001
Chute variables	
Entry	0.026
Catch	0.744
Resist	0.177
Vocal	0.032
Faecal	0.823
Exit	0.967
Jigger used	0.107
Horns tipped	0.469
Time	0.506

[1] Univariable p-value

[2] P-value for linear term only relative to no induction weight terms

[3] P-value for additional effect of quadratic term over linear term only

Table 27. Results from a multivariable model of average daily growth rate – *meat* (ADG-M)

Variable	**Adjusted difference in average daily growth rate – *meat* (kg/day)**[1]	**95% CI**	**P**[2]
Induction weight			**<0.001**
Linear term	-0.20[3]	-0.27 to -0.124	<0.001
Quadratic term	0.0003[3]	0.0002 to 0.0004	<0.001
Feedlot			**<0.001**
4	Reference group		
22	0.22	0.14 to 0.29	<0.001
24	0.07	0.00 to 0.15	0.063
26	0.02	-0.05 to 0.10	0.568
28	0.11	0.04 to 0.19	0.003
Sex			**<0.001**
Female	Reference group		
Male	0.11	0.08 to 0.13	<0.001
Dentition (number of permanent incisors)			**<0.001**
0	Reference group		
1 or 2	-0.03	-0.03 to -0.02	<0.001
3 or 4	-0.03	-0.04 to -0.02	<0.001
5 or more	-0.10	-0.11 to -0.08	<0.001
Chute entry score			**0.024**
1	Reference group		
2	0.01	0.00 to 0.01	0.078
3	0.00	-0.01 to 0.01	0.465
4 or 5	-0.02	-0.05 to 0.00	0.082
Chute vocal score			**0.053**
1	Reference group		
2	-0.01	-0.01 to 0.00	0.130
3	-0.01	-0.02 to 0.00	0.038
4	-0.01	-0.02 to 0.00	0.051
5	0.02	-0.01 to 0.04	0.260

[1] Estimated differences from reference group (or, for induction weight, estimated effect of a 100 kg increase in induction weight) adjusted for all other variables listed

[2] Bolded p-values are overall likelihood ratio test p-values for variables; unbolded p-values are Wald p-values for the respective term or, for categorical variables, for the respective category relative to the reference category

[3] Coefficients for 100 kg increase in induction weight; see Figure 40 for predicted average daily growth rates – meat at various induction weights

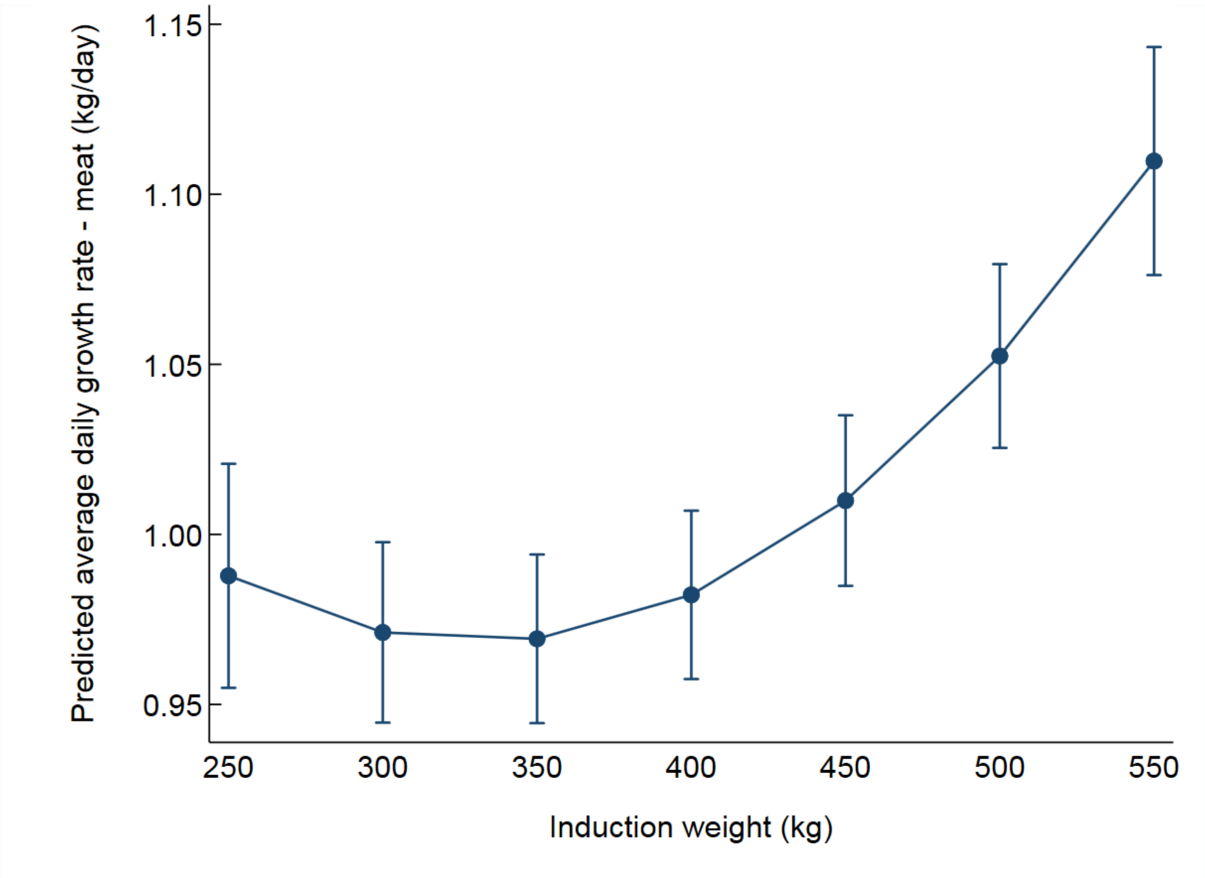

Figure 42. Predicted average daily growth rates – *meat* (ADG-M) at various induction weights adjusted for all variables in Table 27. Bars represent point-wise 95% confidence intervals for predicted values at various induction weights.

After adjustment for all variables in Table 27, source category was associated with average daily growth rate – *meat* (overall P<0.001). Relative to cattle in cohorts formed with cattle from only 1 property identification code (PIC), cattle in cohorts formed with cattle from 2 to 10 PICs had higher average daily growth rates – *meat* (adjusted difference 0.04 kg/day; 95% CI 0.02 to 0.07; P=0.001), as did those from saleyards (adjusted difference 0.10 kg/day; 95% CI 0.06 to 0.14; P<0.001).

On univariable analysis, average daily growth rate – *meat* varied by cohort; overall P values for all cohorts and for just the first 5 cohorts enrolled within each feedlot were both <0.001 (Table 26). Estimated differences in average daily growth rate – *meat* between cohorts are shown in Table 28. Mean growth rates for cohorts varied widely, differing by 0.72 kg/day from the lowest to the highest cohort. These differences may have been due to pen effects and/or differences in animal attributes between cohorts. Pen data were not available precluding exploration of pen effects.

Table 28. Estimated differences in average daily growth rate – *meat* (ADG-M) between cohorts

Feedlot and cohort identification number	Difference in average daily growth rate – *meat* (kg/day)[1]	95% CI	P
Feedlot 4			
100001	Reference category		
100002	-0.09	-0.12 to -0.06	<0.001
100003	-0.05	-0.08 to -0.02	<0.001
100004	-0.12	-0.15 to -0.09	<0.001
100005	-0.25	-0.28 to -0.22	<0.001
100006	-0.30	-0.33 to -0.27	<0.001
100007	-0.11	-0.14 to -0.08	<0.001
100008	-0.27	-0.33 to -0.22	<0.001
100009	-0.28	-0.34 to -0.21	<0.001
100010	-0.25	-0.30 to -0.19	<0.001
Feedlot 26			
100012	-0.51	-0.54 to -0.48	<0.001
100013	-0.19	-0.22 to -0.16	<0.001
100014	-0.41	-0.44 to -0.38	<0.001
100015	-0.40	-0.43 to -0.37	<0.001
100016	-0.20	-0.23 to -0.17	<0.001
100017	-0.28	-0.31 to -0.25	<0.001
100018	-0.21	-0.25 to -0.18	<0.001
100019	-0.20	-0.23 to -0.17	<0.001
100020	-0.18	-0.22 to -0.15	<0.001
100021	0.02	-0.03 to 0.06	0.457
Feedlot 22			
100023	0.16	0.13 to 0.18	<0.001
100024	0.04	0.02 to 0.07	0.002
100025	0.00	-0.03 to 0.03	0.997
100026	0.06	0.04 to 0.09	<0.001
100027	0.21	0.18 to 0.24	<0.001
100028	0.04	0.01 to 0.07	0.010
100029	0.13	0.10 to 0.16	<0.001
100030	0.07	0.04 to 0.10	<0.001
100031	-0.23	-0.26 to -0.20	<0.001
100032	-0.14	-0.17 to -0.11	<0.001
Feedlot 24			
100034	-0.25	-0.28 to -0.23	<0.001
100035	-0.22	-0.25 to -0.19	<0.001
100036	-0.20	-0.22 to -0.17	<0.001
100037	-0.11	-0.14 to -0.08	<0.001
100038	0.02	-0.01 to 0.05	0.128
100039	-0.21	-0.23 to -0.18	<0.001
100040	-0.34	-0.37 to -0.31	<0.001

100041	-0.17	-0.20 to -0.14	<0.001
100042	-0.08	-0.11 to -0.05	<0.001
100043	-0.19	-0.23 to -0.16	<0.001
Feedlot 28			
100045	0.06	0.02 to 0.09	0.004
100046	-0.01	-0.05 to 0.03	0.549
100047	-0.10	-0.13 to -0.06	<0.001
100048	-0.24	-0.28 to -0.20	<0.001
100049	-0.07	-0.11 to -0.03	<0.001
100050	-0.37	-0.41 to -0.33	<0.001
100051	-0.28	-0.32 to -0.24	<0.001
100052	-0.27	-0.31 to -0.23	<0.001
100053	-0.31	-0.35 to -0.28	<0.001
100054	-0.11	-0.15 to -0.07	<0.001

[1] Estimated difference from univariable analysis relative to reference category (cohort 100001, the first cohort enrolled in feedlot 4)

4.6.5 Determinants of MSA index

P-values for potential determinants of MSA index adjusted for feedlot are shown in Table 29, and results from the multivariable model are shown in Table 30. Chute catch score was removed from the multivariable model as, after adjustment for other variables in that model, the overall p-value for this variable was 0.251.

After accounting for the other variables in the multivariable model, MSA index still varied markedly by feedlot. This means that differences between feedlots were probably not due to those other variables (average daily growth rate – meat, induction weight, sex, dentition, and six chute score variables). MSA index varied with average daily growth rate – meat and induction weight (higher in those with higher average daily growth rates – meat, and in those that were heavier at induction), sex (higher in females), and dentition (higher in animals with no permanent incisors compared to those with 1 or more permanent incisors).

Six chute score variables were also associated with MSA index. Mean MSA index values were highest in cattle with chute entry scores of 1 (relative to ≥2), chute resist scores of 2 to 5 (relative to 1), chute vocal scores of 1 (relative to 2 or 3), chute faecal scores of 4 (relative to 1), and chute exit scores of 1 (relative to 3 to 5), and in cattle whose horns were not tipped. As for all multivariable models, all estimated effects are adjusted for all other variables in the model. Thus, if misclassification errors when allocating chute scores were minimal, the estimated effects of each chute score variable are independent of effects of other chute score variables (and indeed, independent of all other variables in the model). Some of the estimated effects of chute score variables were relatively small (changes of 0.1 to 0.3 units relative to the reference group).

Table 29. P-values for potential determinants of MSA index adjusted only for feedlot

Feedlot	<0.001[1]
Cohort	
All cohorts	<0.001[1]
First 5 cohorts enrolled within feedlot	<0.001[1]
Induction weight	
Linear term	<0.001[2]
Quadratic term	<0.001[3]
Days on feed	
Linear term	0.475[2]
Quadratic term	0.964[3]
Average daily growth rate - meat	
Linear term	<0.001[2]
Quadratic term	<0.001[3]
Sex	0.007
Dentition	<0.001
Source category	0.013
Chute variables	
Entry	<0.001
Catch	0.024
Resist	0.002
Vocal	<0.001
Faecal	0.019
Exit	<0.001
Jigger used	0.152
Horns tipped	0.010
Time	0.065

[1] Univariable p-value

[2] P-value for linear term only relative to no terms for this variable

[3] P-value for additional effect of quadratic term over linear term only

Table 30. Results from a multivariable model of MSA index

Variable	Adjusted difference in MSA index[1]	95% CI	P[2]
Average daily growth rate - meat			**<0.001**
Linear term	-0.9[3]	-1.7 to -0.1	0.023
Quadratic term	1.4[3]	1.0 to 1.8	<0.001
Induction weight			**<0.001**
Linear term	-2.3[4]	-3.2 to -1.4	<0.001
Quadratic term	0.003[4]	0.002 to 0.005	<0.001
Feedlot			**<0.001**
4	Reference group		
22	-4.2	-5.2 to -3.3	<0.001
24	-3.8	-4.8 to -2.9	<0.001
26	-0.1	-1.1 to 0.8	0.786
28	-2.2	-3.2 to -1.3	<0.001
Sex			**<0.001**
Female	Reference group		
Male	-0.5	-0.8 to -0.3	<0.001
Dentition (number of permanent incisors)			**<0.001**
0	Reference group		
1 or 2	-0.6	-0.7 to -0.5	<0.001
3 or 4	-0.5	-0.6 to -0.4	<0.001
5 or more	-0.3	-0.6 to -0.1	0.003
Chute entry score			**<0.001**
1	Reference group		
2	-0.2	-0.3 to -0.1	<0.001
3	-0.3	-0.5 to -0.2	<0.001
4 or 5	-0.7	-1.0 to -0.4	<0.001
Chute resist score			**<0.001**
1	Reference group		
2	0.2	0.1 to 0.3	<0.001
3	0.1	0.0 to 0.3	0.024
4 or 5	0.2	0.1 to 0.4	0.010
Chute vocal score			**<0.001**
1	Reference group		
2	-0.1	-0.2 to 0.0	0.003
3	-0.3	-0.4 to -0.2	<0.001
4	0.0	-0.1 to 0.2	0.648
5	0.3	-0.1 to 0.6	0.112

Chute faecal score			**0.026**
1	Reference group		
2	0.0	-0.2 to 0.2	0.704
3	0.4	0.0 to 0.8	0.067
4	0.5	0.2 to 0.9	0.004
5	0.2	0.0 to 0.4	0.125
Chute exit score			**<0.001**
1	Reference group		
2	-0.1	-0.3 to 0.0	0.122
3	-0.3	-0.5 to -0.1	0.002
4	-0.5	-0.7 to -0.3	<0.001
5	-0.3	-0.6 to 0.0	0.056
Horns tipped			**0.013**
No	Reference group		
Yes	-0.3	-0.6 to -0.1	0.013

[1] Estimated differences from reference group (or, for average daily growth rate - *meat* and induction weight, estimated effects of a 1 kg and 100 kg increase, respectively) adjusted for all other variables listed

[2] Bolded p-values are overall likelihood ratio test p-values for variables; unbolded p-values are Wald p-values for the respective term or, for categorical variables, for the respective category relative to the reference category

[3] Coefficients for 1 kg increase in average daily growth rate – meat (ADG-M); see Figure 41 for predicted MSA index values at various average daily growth rates - meat

[4] Coefficients for 100 kg increase in induction weight; see Figure 42 for predicted MSA index values at various induction weights

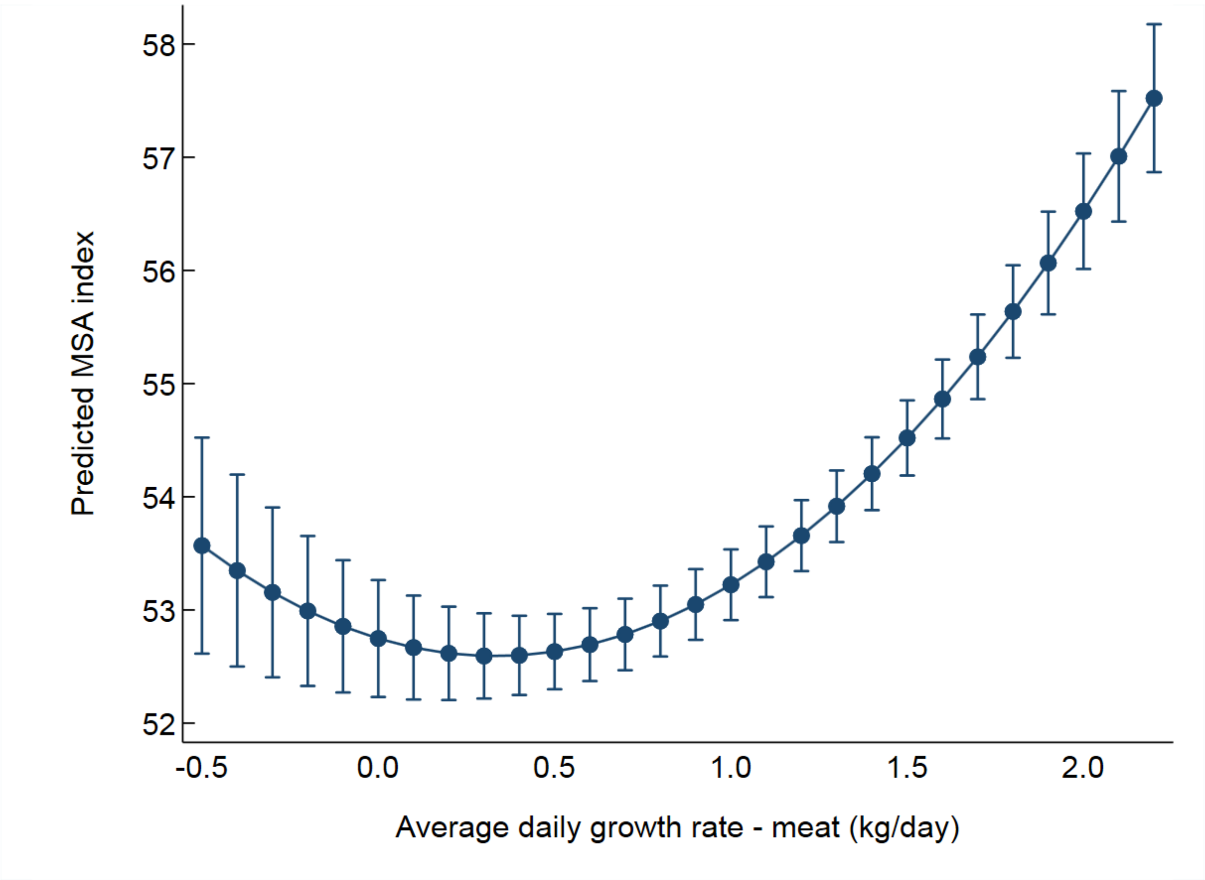

Figure 43. Predicted MSA index values at various average daily growth rates - *meat* (ADG-M) adjusted for all variables in Table 30. Bars represent point-wise 95% confidence intervals for predicted values at various growth rates.

A quadratic term has been used from the analysis of data for predicted MSA index at various average daily growth rates (ADG-M) but note the very wide error bars present at low rates of gain. Thus, at low ADG-M values, the prediction of MSA is not at all robust, however prediction is much improved at higher rates of gain, before error effects impact again as ADG-M approaches 2.0 kg/day

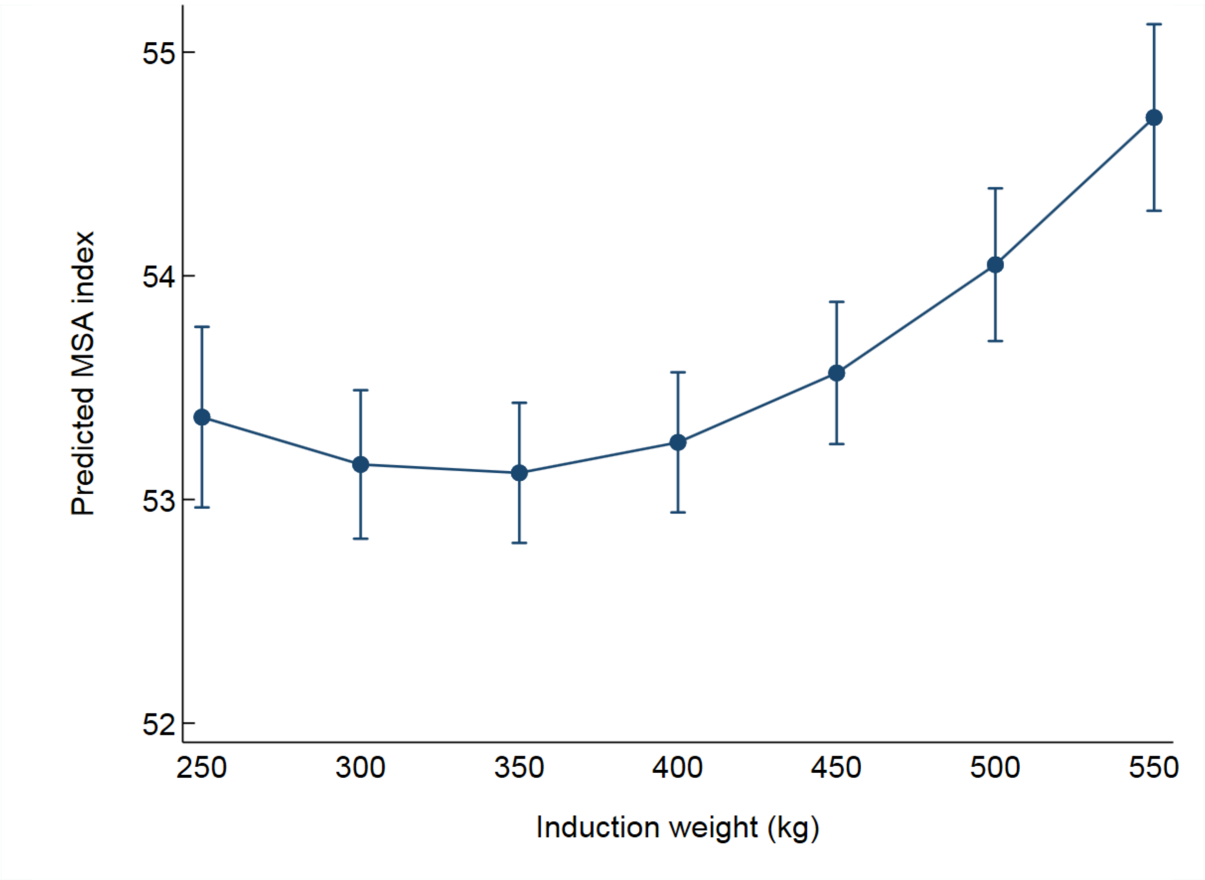

Figure 44. Predicted MSA index values at various induction weights adjusted for all variables in Table 30. Bars represent point-wise 95% confidence intervals for predicted values at various induction weights.

After adjustment for all variables in Table 30 and chute catch score, the overall p-value for source category was 0.437. Relative to cattle in cohorts formed with cattle from only 1 property identification code (PIC), the estimated difference in MSA index for cattle in cohorts formed with cattle from 2 to 10 PICs was 0.2 units higher (95% CI -0.3 to 0.7; P=0.418), and the estimated difference for cattle from saleyards was 0.3 units higher (95% CI -0.3 to 0.9; P=0.312).

On univariable analysis, MSA index varied by cohort; overall P values for all cohorts and for just the first 5 cohorts enrolled within each feedlot were both <0.001 (Table 29). Estimated differences in MSA index between cohorts are shown in Table 31. Mean MSA index values for cohorts varied widely, differing by 7.4 units from the lowest to the highest cohort. These differences may have been due to pen effects and/or differences in animal attributes between cohorts. Predictive MSA index improves in this dataset for induction weights > 400kg

Table 31. Estimated differences in MSA index between cohorts

Feedlot and cohort identification number	Difference in MSA index[1]	95% CI	P
Feedlot 4			
100001	Reference category		
100002	-1.2	-1.9 to -0.5	0.001
100005	0.1	-0.6 to 0.8	0.792
100006	0.1	-0.5 to 0.8	0.667
100007	-1.8	-2.5 to -1.1	<0.001
100008	-2.2	-3.0 to -1.4	<0.001
100009	-1.9	-2.9 to -1.0	<0.001
100010	-1.6	-2.4 to -0.8	<0.001
Feedlot 26			
100012	-0.5	-1.1 to 0.2	0.156
100013	-3.7	-4.4 to -3.1	<0.001
100014	0.2	-0.5 to 0.9	0.542
100015	-0.4	-1.0 to 0.3	0.270
100016	-0.2	-0.9 to 0.5	0.550
100017	-0.4	-1.0 to 0.3	0.233
100018	-0.2	-0.9 to 0.5	0.556
100019	0.0	-0.6 to 0.7	0.977
100020	-0.5	-1.1 to 0.2	0.191
100021	-0.3	-1.1 to 0.4	0.371
Feedlot 22			
100023	-1.5	-2.1 to -0.8	<0.001
100024	-4.9	-5.6 to -4.3	<0.001
100025	-4.3	-4.9 to -3.7	<0.001
100026	-5.4	-6.1 to -4.8	<0.001
100027	-4.9	-5.6 to -4.3	<0.001
100028	-3.1	-3.7 to -2.5	<0.001
100029	-6.6	-7.2 to -6.0	<0.001
100030	-3.4	-4.1 to -2.8	<0.001
100031	-7.2	-7.8 to -6.6	<0.001
100032	-6.4	-7.1 to -5.8	<0.001
Feedlot 24			
100034	-3.8	-4.5 to -3.2	<0.001
100035	-3.2	-3.8 to -2.6	<0.001
100036	-6.7	-7.4 to -6.1	<0.001
100037	-6.8	-7.5 to -6.2	<0.001
100038	-6.6	-7.3 to -6.0	<0.001
100039	-4.0	-4.6 to -3.4	<0.001
100040	-2.0	-2.7 to -1.4	<0.001
100041	-1.8	-2.5 to -1.2	<0.001
100042	-4.3	-4.9 to -3.6	<0.001

100043	-5.0	-5.6 to -4.3	<0.001
Feedlot 28			
100045	-2.7	-3.4 to -2.0	<0.001
100046	-3.1	-3.8 to -2.5	<0.001
100047	-1.5	-2.1 to -0.8	<0.001
100048	-2.5	-3.2 to -1.8	<0.001
100049	-3.6	-4.2 to -2.9	<0.001
100050	-2.5	-3.2 to -1.8	<0.001
100051	-1.2	-1.9 to -0.5	0.001
100052	-0.9	-1.5 to -0.2	0.012
100053	-4.9	-5.6 to -4.3	<0.001
100054	-6.6	-7.3 to -5.9	<0.001

[1] Estimated difference from univariable analysis relative to reference category (cohort 100001, the first cohort enrolled in feedlot 4)

4.6.6 Feedlot staff retention and survey questionnaire

For the five participating feedlot sites, a questionnaire interview was conducted by phone with the trained acclimators from each site who were remaining at the project's completion. The questionnaire had been supplied to the respondents preceding contact being made by the project leader who conducted the interview. The full questionnaire is available in Appendix 9.1.5 and the summary of responses are set out in the table below.

In total, ten (10) respondents across the five (5) feedlots remained at their sites at project completion from the original thirty-three (33) trained feedlot staff and were available for interview, representing a retention rate of 30%. Six (6) of the trained acclimators available at project completion were from one feedlot site and this feedlot had a retention rate of 6/8 = 75% (and represented 60% of the overall project retention rate). This particular feedlot at project inception had been exposed previously to acclimation workshops by other recognised industry practitioners and had deployed acclimation techniques as trained by these practitioners in a number of pens. For the current project however, this feedlot reverted to the schedule as directed and employed only standard industry pen management in the control pens. For the other four (4) project sites, only one (1) trained acclimator remained at project end.

In addition, two (2) trained feedlot staff from the project inception, who left their respective sites during or just after the project completion, however were still in contact with the project leader, submitted to the same questionnaire as above thus giving a total of twelve (12) respondents for the main questionnaire. Further, these two staff members submitted to six (6) extra questions as set out in the appendix (9.1.5).

Questionnaire responses

	i	ii	iii	iv	v	vi
1	12/12					
2				7/12	5/12	
3	12/12					
4	12/12					
5	1/12			7/12	4/12	
6				7/12	5/12	
7				10/12	2/12	
8				9/12	3/12	
9				10/12	2/12	
10			4/12	5/12	3/12	
11		1/12	5/12	4/12	2/12	
12			2/12	9/12	1/12	
13			3/12	7/12	2/12	
14			2/12	8/12	2/12	
15			2/12	6/12	4/12	
16			6/12	4/12	2/12	
17		2/12	6/12	4/12		
18			2/12	8/12	2/12	
19	6/12	6/12				
20	20i = Y	20ii = Y	20iii = Y	20iv = Y	20v = Y	20vi
	10/12	8/12	12/12	11/12	10/12	8/12
21			1/12	9/12	2/12	
22	• Consistent responses of select cohorts and less working once established					
23	2/2					
24v	Respondent 1 • Compensation = iv • Promotion = iv • New site acclimation program = ii • Family suitability = i • Location = ii • Company reputation = v • Testimonials = iii			Respondent 2 • Compensation = ii • Promotion = v • New site acclimation program = iv • Family suitability = iv • Location = v • Company reputation = v • Testimonials = iii		
25			1/2		1/2	
26					2/2	
27					2/2	
28				1/2	1/2	

5 Discussion

5.1 Summary

The project objectives of this study are set out below.

i. Development of a comprehensive, objective, and repeatable methodology of applying acclimation to feedlot cattle.
ii. Random allocation to pen with blocking for origin, cattle type, and purchase method.
iii. Recognition of pen as the unit of interest due to acclimation being a pen-based intervention.
iv. Allocation of appropriate controls with allowance for pen as a potential confounder.
v. Appropriate replication of treatments and control to ensure statistical validity of results
vi. Inclusion of objective measurement of the effectiveness of the acclimation method in improving cattle temperament, in producing calm and settled behaviour in cattle, constructive responsiveness to human handlers, enhancing adaptation to the feedlot environment, and any health and performance benefits.
vii. Collection of data on animal health, production, and carcase performance in project cattle.
viii. Comparison of animal health, production and faecal cortisol variables between acclimated treatment cattle and existing feedlot management control cattle
ix. Quantification of all labour inputs and determination of any efficiency or cost-benefit gained through implementation of acclimation.
x. Documentation and maintenance of existing feedlot management and handling regimes across control treatments for the duration of the study.

The experimental design of this project sought to provide a repeatable, reliable methodology in order to test the effect of acclimation across a high number of replicates, but also to install a treatment that was persistent for the duration of the feeding period of the separate enrolments. The project team thought this important in order to test for an effect also, since an acclimation treatment that was applied for only a short initial period of the feeding program and discontinued for most of the feedlot duration of these feeder cattle, may be subject to being lost in the “noise” of feedlot production generally. As such, a schedule was designed that achieved input of the acclimation treatment strategically across the feeding duration and days on feed but sought not to over-work the cattle. Additionally, the project team sought not to install a schedule that would represent an impractical work practice to apply in a commercial setting. The final acclimation schedule was, in the project team’s opinion, the best fit for these considerations. The project successfully implemented an experimental design that utilised pen as the unit of interest and randomly allocated source cattle blocked by origin, cattle type and purchase method to the treatment and control pens. Controls that were applied in the trial to ensure a repeatable and reliable methodology included constant monitoring of the experiment by project team members, on site and remotely by video feed and also verification on-site visits by the acclimation trainer. Additionally, competency tested acclimators responded overwhelmingly positive to confidence in the acclimation schedule being successfully implemented across all treatment group replicates. Further scrutiny of the acclimator staff filled out session records (examples in Appendix below) supports reliable and repeatable application of the methodology. Completion of full sessions per the acclimation schedule was better than 95% across all replicates.

Potentially, features of the experimental design itself contributed to no effect of acclimation being observed, in that an alternative schedule, and application, might have yielded positive benefits to the health, production and carcase metrics measured. It’s possible that acclimation in the initial phase of the feeding period – up to 21 days on feed, when faecal cortisol metabolite output had decreased to baseline levels in this trial – may have supported feeder cattle’s assisted habituation to the feedlot environment and allowed these feeders to respond comfortably to any subsequent man-made stimuli they experienced. The standard feedlot operations control group cattle would have undergone self-directed, graded, desensitisation to adapt to the feedlot environment in the absence of acclimation treatment. The project team also made considerations on current working knowledge of cattle cognitive ability and memory recall in designing the acclimation treatment and schedule. At the time of project inception, scientific literature was sparse on memory recall in cattle however in the interim (Hirata, 2016) describes a spatial learning and memory experiment in cattle whereby memory was reportedly detected for up to six (6) weeks. However, this memory ability was present in only 20% of the experimental subjects. Given the consideration of acclimation in the first 21 days on feed period possibly being sufficient according to the fall in faecal cortisol metabolites to baseline levels (no matter the starting level of cortisol measured in enrolments) and scientific literature supporting, somewhat, memory ability up to six (6) weeks, some justification may have been present for reducing the frequency of acclimation sessions in the trial schedule. While these observations have some basis, especially to the concept of a regular presentation of acclimation stimulus being necessary only until habituation is successfully achieved, the knowledge gaps in cattle memory recall and the requirement to detect and measure a treatment for the duration of the feeding period necessitated a more sustained acclimation program. Albeit that the acclimation treatment applied in the trial did not have any adverse effects on the trial cattle at any stage of the feeding program(s) compared to normal feedlot operations controls, in any metrics measured in this project including the physiological measure of faecal cortisol metabolite. The defined “refresher” sessions as outlined in the acclimation schedule in Appendix 9.1.2 were in some instances literally only minutes in duration, and after day seven (7) of the acclimation schedule, the minimum interval between sessions was seven (7) days. The project team had confidence that this design achieved all considerations discussed above.

Despite the possible limitations to the findings of this trial as outlined above, it is worthy to mention that the treatment group did not suffer any adverse effects compared to the control group, indicating that the acclimation treatment simply had no effect and the null hypothesis was supported. Also, of the very limited published literature available on experimental work with acclimation methods and beef feedlots, researchers determined that the acclimation program evaluated had no effect on feedlot receiving performance of dry matter intake and average daily gain, but did improve temperament (Francisco, 2012).

5.2 Data collection and analysis

5.2.1 Induction

The experimental design requirements of blocking replicates by sourcing, filling, and closing trial lots within three (3) days, capturing video footage of induction and the whole feeding period of trial and control pens and chute scoring in person, among other requirements, did limit the speed of progress of generating data for this project. A minimum of five (5) replicates per site were conducted with all stringent elements of the experimental design, however later replicates at a few sites were not conducted under induction or home pen video capture (but all other requirements were met). An excess of 100TB of video data was captured in this project. The combination of video footage of induction processes and home pen monitoring of control and treatment group in the trial replicates served a trial monitoring purpose, but also intended to provide a means of analysing a number of objective metrics to include in the behavioural assessment of the enrolments. In particular, exit velocity from the induction chute using the novel approach as outlined in the methodology above, and flight speed and distance of treatment cattle (to their handler) over the course of successive acclimation workings and in comparison, to the control group when a standard stimulus was applied (collection of faecal samples for faecal cortisol analysis). The induction chute scoring, which included chute exit velocity, for all enrolments into the trial was for the purpose of establishing a temperament baseline before home pen placement for both treatment and control cattle. This project had significant challenges in employing the subcontracted resources for data collection, processing, reporting and storage, trial administration including all trial forms admin, hardware installation and maintenance, video collection, storage and editing etc. within allocated budget. The vast majority of these resources were deployed in trial data collection, validation, processing and presenting for analysis. A more detailed outline of the data management challenges is available in the subcontractor's statement below in Appendix 9.1.4. As such, utilisation of video footage for analysis purposes was restricted to chute velocity for a sub-set of replicates at one of the project sites however no flight zone distance measurement or flight speed analysis was conducted in home pens for any of the replicates. The feedlot site chosen for the chute exit velocity analysis also possessed a complete set of faecal cortisol results to integrate with the other variables in the dataset.

5.2.2 Temperament

The temperament testing of enrolments into this project comprised a subjective numerical scale of various induction chute score variables, combined with the objective measure of chute exit velocity. Temperament scoring at induction and enrolment in this project for treatment and control cattle sought to provide a baseline for comparison at a later date in the feeding period for instances when the treatment and control groups were re-presented to a handling chute and acclimation effect could be tested. However, given that the project was run on commercial sites, there was no inclination for feeders to be returned to processing facilities to have the chute scoring repeated for comparison purposes. A very small number of instances of re-implant did occur at one feedlot site however the dataset is too small for meaningful analysis. The chute scores and exit velocities collected across the project replicates were analysed for inter-relationships and relationships to other health, production and carcase variables measured in the project. Previous researchers have found relationships between temperament, performance, and immune function in feedlot cattle (Fell, 1999), productivity and carcase / meat quality of feedlot cattle and temperament (Petherick, 2002) and a collection of these studies are summarised in *Australian Beef The Leader Conference* (Ferguson, 2014). Researchers have also found strong relationships between disposition score and live feedlot health and performance and carcase traits (Reinhardt, 2009). However, other researchers have published findings that do not support any significant correlation between feeding behaviour and growth performance with temperament, however there were correlations with certain carcase attributes (Gaspers, 2014)

In this project, individual temperament measures appeared to exert effects on an individual basis only, and there was little agreement between temperament measures. Consequently, a collective score of all temperament measures also did not hold a strong relationship to other health, production and carcase variables measured. For two of the production outcome measures, ADG-M and MSA index, relationships to temperament variables can be summarised that exit velocity as measured held no strong association with either of these outcomes, however six (6) x chute score variables were associated with MSA index as an outcome and two (2) chute score variables were weakly associated with ADG-M. Chute scores were also determined not to be good surrogates for exit velocity as measured. (Vetters, 2013) evaluated exit velocity (flight speed) and chute exit score to determine relationships between temperament and average daily gain; there was variation between days of chute scoring and only moderate agreement between exit velocity, exit score and ADG.

Calmer cattle, as determined by low scores of chute entry, vocalisation and chute exit were associated with higher MSA index scores. Weaker MSA index associations were established between chute resistance and faecal release / tail swish in the chute, and paradoxically, higher scores in these two were associated with higher MSA index scores. Interestingly, there was an association between horn tipping procedure at induction and a lower MSA index score. Low chute entry and vocalisation scores were also associated with higher ADG-M outcomes, but these relationships were weak. Possible criticisms of the temperament assessment mechanism(s) employed in this project could include the variation in personnel involved handling and processing the trial enrolments, the feedlot sites and the project team members involved in making the subjective scores. There was potential for much variation in handling methods at induction on the separate trial sites as acclimation methods and principles were only employed post-induction. On the exit velocity measurements, the methodology used was not typical of many studies referenced below. However, it did seek to take account of behavioural elements of cattle leaving an induction chute that the standard methods cannot cater for. Also, chute exit as a temperament variable did return some of the best relationship to production outcomes as discussed above, and an expanded analysis of the captured exit velocity data might establish a better association between these two variables ultimately such that exit velocity is determined to be a better surrogate of chute exit than was established in the smaller dataset reported here. Additionally, a systematic measurement error may be embedded in the exit velocities recorded in this subset of data – review by a third party might be warranted in conjunction with expanding the whole dataset of collected chute exits on video, to include all cattle captured in this project, in order to test the relationship of this temperament variable to feedlot health and performance further.

To limit the variable effects of subjective temperament estimation, researchers have utilised more objective measures such as exit velocity as outlined above. More recently, wearable technologies such as triaxial accelerometers to measure behaviour elements in the restraint chute have been utilised. A group of researchers from Texas A&M compared these two objective measures with the more standard categorical scoring method of chute behaviour to evaluate temperament and examined the relationship of these temperament measures to production and performance variables of growth and feed efficiency (Bourg et al., 2007). These researchers determined that the objective modalities were useful measures of temperament, however correlations to performance traits carried a breed effect.

5.2.3 Faecal cortisol

The physiological variable of faecal cortisol metabolite utilised as a stress indicator in this project demonstrated no difference between acclimation treatment and standard control cattle in the one feedlot site where the complete set of replicates were analysed. Faecal samples collected for cortisol metabolite assay were collected at the same time in treatment and control pens and in between acclimation sessions so as not to impact the acclimation sessions. Additionally, a standard approach and collection pattern across the pen so as not to mimic the acclimation procedure. Initial discussion and engagement with the diagnostic laboratory providing the faecal cortisol assay service indicated that pooled analysis of the set of samples collected at each session for each experimental pen would be suitable. However, on review of the initial pooled analysis results, co-efficient of variance effects were not within appropriate limits (<10%) and as such, ongoing analysis was run on individual samples within each collection session. Consequently, this had budget impacts, so the full analysis set was restricted to one site. This site also held the extent of exit velocity analysis for the project, however relationships between the pen level faecal cortisol assay results and objective temperament measures could not reasonably be evaluated given the faecal samples were only identifiable by pen / lot and not by individual. Despite laboratory budget limitations only allowing evaluation of one complete set of faecal samples from one site, all the samples from the other sites that were collected in the same standardised methodology have been frozen stored and can be assayed at a later date.

5.2.4 Summary

This project did not detect any quantitative benefit in terms of improved feedlot health, performance, or carcase attributes in applying the described acclimation treatment to feedlot cattle. It is possible that acclimation had no effect due to the majority of trial enrolments having temperaments at the docile end of the scale. In all temperament scoring elements, the majority frequency of scores were below median. These more docile centric enrolments may also have driven the lack of relationships demonstrated between temperament variables and health, production, and carcase outcomes. Consequently, since habituation to the feedlot environment would be relatively facile for more docile domesticated feeders compared to higher temperate, extensively raised feeders, acclimation effects may have been diminished. Additionally, the five feedlot sites conducting the project consistently operate at industry best-practice standards, including cattle handling methods, and health, feeding and welfare management. As such, intrinsically adverse stimuli inducing more fearful reactions and sensitisation, opposite to habituation, were invariably less likely on these sites. These two factors in combination could possibly diminish any acclimation effects further. Statistical methods used in the analysis of this project were supported by a high number of replicates in a repeatable methodology, as such, any effects of treatment should have been detectable.

5.3 Implications

A direct, positive return on investment for acclimation could not be supported by the findings of this project. Extra human resources in terms of staff hours spent on acclimation did not return benefits in feedlot cattle health, production or carcase attributes, over standard feedlot work practice. Typically, longer acclimation sessions ranged from 15 – 30 minutes and as such represented up to one (1) x livestock staff equivalent hours which represented a negative return on investment if measured in the performance values utilised in this trial. This analysis does not however, consider other efficiencies that may arise from acclimation methods producing well-handled and trained cattle, nor human resources benefits and augmented skillsets in acclimation competent staff that may also indirectly lead to productivity and/or economic benefits.

It is significant to note that no adverse findings in these key feedlot health and performance metrics, nor any negative variation in the physiological measure utilised, were observed in the groups of acclimation treatment cattle compared to the standard practice control groups. There is an industry notion that extra handling of cattle in home pens, including laneway exercise, through the feeding period is detrimental to consumption and gain performance – these project findings do not support this convention. There is grounding, and supportive evidence, to implicate extroverted handling methods, combined with extended time off feed and water, as contributing to depleted muscle glycogen and dark cutting. Acclimation principals and methods are built around quiet, low stress, techniques to transfer cattle from home pens to dispatch and are not designed to elicit running or agitation. Additionally, extended acclimation sessions are not typically conducted near dispatch date. There were no differences in carcase attributes or carcase downgrades between acclimation treatment or control cattle in this project.

The results of this study determined there were no differences in pull rates, for any cause(s), or rate of death loss and reject salvage between acclimation treatment cattle and standard controls. Industry proponents of acclimation suggest that rates of “non-eater” / “non-starter” pulls are reduced in acclimated pens, presumably due to a more improved and expedient habituation to the feedlot environment and feedlot nutrition. There is also suggestion, and anecdotal evidence only, that this effect can be appreciated by sudden lifts in consumption evident in acclimated cattle from a time point of approximately 7 days on feed. This project did not detect any difference in consumption between acclimated treatment or standard control cattle at any time point after induction onto every one of the project sites. Also, assessments of consumption levels in the first two weeks on feed would need to control for factors such as the natural transition of more fibrolytic bacteria in the rumen microbiome (suited to high forage diets) to more amylolytic bacteria (suited to higher grain diets) (Tajima et al., 2001) and (Schwartzkopf-Genswein, 2015) that may be one of the principal drivers of a lift in consumption. The other sources of variability that would need to be controlled in this type of analysis include feed additives utilised such as monensin, bunk management, frequency of feeding, breed differences, receival and induction specifications etc. Another observation from industry personnel is that starter pens with digestive upset (e.g. acidosis) obtain benefit in the sub-clinical and less clinical cases by utilising the home pen exit and laneway exercise component of the acclimation schedule as detailed in the appendix section below. This notion comes from observation of exuberance behaviour in some pens of cattle that are laneway exercised in this manner and a degree of this behaviour being observed in digestive upset affected pens as they are exercised. The working theory being that this exuberance behaviour is associated with a positive altered mood, mediated by exercise, and stimulates further activity, appetite, and drinking. To the project researchers' knowledge, this effect has not been investigated in an experimental setting and there was no opportunity to examine this effect in this project.

A summary of the questionnaire responses from livestock staff that participated in the project, captured within this report, was generally very supportive of acclimation principles of handling feedlot cattle in multiple locations and situations during normal feedlot operations. In particular, respondent's supported exposing new livestock staff recruits to the training methods utilised in this project and advancing new employee skillsets with acclimation handling principles. Majority of responses also supported applying an acclimation schedule only to select groups of incoming cattle based on a risk assessment of temperament, breed, and sourcing location (high Bos Indicus content, extensive northern Australian sourcing) and high transit stress (long distance travelled and duration of off feed and water as part of transit). Additionally, some respondents felt that acclimation could be used as a therapeutic intervention measure, for starter cattle that did not initially fit the risk matrix of requiring acclimation, but signals of substandard habituation early in the feeding period (such as reduced consumption and/or behavioural indicators consistent with persistent fear responses to human handlers) warranted them to be managed with an acclimation schedule. Some respondents also advocated altering the acclimation schedule for select groups of starter cattle and most respondents advocated reducing the frequency of acclimation sessions after 30 days on feed. All respondents supported the fact that undergoing acclimation training and gaining competency delivered a positive element to job satisfaction and agreed that there is a human resources benefit. This human resource benefit is difficult to calculate a cost-benefit towards and is not attempted in this report. Only a very small set of responses could be captured for livestock staff and acclimation project participants that had seen the whole project through at a trial site and since transitioned to another feedlot. Neither of the respondents cited ongoing acclimation programs at the site they were leaving or the site they were going to as higher importance than promotion opportunities or the reputation of the company they were going to work for, however, they did support sharing their skillset and also more formal acclimation training being conducted at the sites they were going to work at.

The researchers involved in this project are confident that no difference in feedlot cattle health, performance or carcase attributes could be detected due to acclimation handling. The controls practiced in the experimental design - principally the disciplined approach to random allocation of treatment – and blocking by cattle sourcing, competency testing of acclimation practitioners throughout the whole experiment, and the sample size analysed, gives sufficient validity and power to the analysis. Difficulties with generating some additional objective and physiological measures to test as variables in this project centred on the unexpected complexities in data capture and management from the participating feedlot sites and running the faecal cortisol metabolite assay. In both instances, subcontractors tasked with supplying these datasets extended beyond budget limitations available. As such, in the case of Management for Technology subcontractor, office hours spent on managing the feedlot and abattoir data capture and management consumed much of the available resources that was hoped to be directed towards generating a fuller set of exit velocity data from induction and enrolment of trial cattle, and measures of flight zone in home pens from the installed video cameras. In the case of University of Western Australia diagnostic laboratory, the necessity to run assays on individual faecal samples as opposed to the expected pooling, also consumed the allocated resources and budget. A report from Management for Technology is included in the appendix below. This project's findings would be strengthened by augmenting the total dataset of variables to include more complete subsets of (chute) exit velocity and faecal cortisol metabolite assays and generating a complete set of flight zone (distance) measurements from the home pen video footage. Flight zones would be compared between treatment (acclimated) and control pens at the standardised times that faecal samples were collected.

The project researchers maintain that two significant contributing factors for the findings of no difference between acclimated treatment cattle and standard controls, are that practically all cattle enrolled scored sufficiently low in temperament, (even taking into account the variability in temperament scoring as discussed above), and, that all five (5) project sites utilised for this project had well established best practice cattle handling methods and protocols. The experimental design and project methodology was robust to detect differences due to acclimation, however in the environment of docile end of temperament scale feeder cattle enrolled, and, best practice commercial sites as locations, even small differences attributable to acclimation could not be confidently detected. It is suggested that detectable differences, and likely positive benefits in the metrics measured in this project, would be delivered to feedlot operations characterised by feeding more highly temperamental cattle and/or had lower existing standards of cattle handling methods, practices, and protocols than the project sites.

6 Conclusions/recommendations

Despite not demonstrating a direct economic benefit in acclimated cattle in commercially operating feedlots, the project investigators strongly support the principles of low-stress stock handling and acclimation (as practiced in this project) to all feedlot operators. The full acclimation schedule as outlined in this project, applied to the temperate of cattle enrolled at the sites where the work was conducted, did not yield differences or benefits in specific health and production metrics, however the working principles at the heart of acclimation and low-stress stock handling are preferable to be utilised in many cattle handling situations and points of production in a beef feedlot. The principles of this type of handling are built around setting up cattle to move calmly through handling facilities, laneways, into and out of pens etc, which has obvious goals of low stress and low risk of injury to cattle and human handlers. This aligns directly with good stockmanship and high standards of cattle handling. Other principles central to acclimation include the use of a controlled application of body position pressure (on flight zone) to a group of cattle, or an individual, and the provision of space for the cattle to move to coinciding with a release of the applied pressure to reward the cattle for moving in the desired direction. This translates in closer quarters handling facilities to good practices such as avoiding overfilling the sections and spaces in these facilities with cattle, as this inevitably leads to increased (and observable by behaviour) stress levels in the cattle as they have no space(s) to move to. This is simply good practice when it comes to cattle handling but is also consistent with reduced risk of injury to cattle and human handlers, and reduced risk of damage to handling facilities.

These same principles translate to home, hospital, receival, dispatch and other pens when moving and handling cattle for whatever reason. Also, obvious advantages accrue to pen riders monitoring health in home pens if they have good knowledge of behavioural indicators in cattle demonstrating fearful and calm states and have the necessary skillset to move identified “pulls” (cattle diagnosed to need removal from the pen for appropriate treatment) away from pen mates and out into laneways. These are also good foundations of pen riding and disease surveillance.

In situations of closer contact with cattle such as in laneways and handling facilities, acclimation principles are just as relevant as in home-pens. There are some particular aspects of close quarter cattle handling however, such as the preference to work cattle from the front of the group and draw cattle past the handler, as opposed to a forcing position from the back. This affords good sight of the range of cattle behaviours present in the group that cattle handlers use to modify their body position, and to be able to utilise controlled pressure and release to space principles as above. There are instances and situations where handlers can only be positioned at the rear of a group of cattle moving through handling facilities, but acclimation principles can still be utilised in terms of ensuring there are not too many cattle placed in the infrastructure – ensuring space to move to – and controlled pressure / release body movements and manoeuvres can still be practiced. What is not consistent with good cattle handling practices and acclimation principals is the use of heavy goads, frequent use of electric prodders, shouting and yelling from behind a group of cattle – especially in scenarios of having over-filled the handling space - in order to force them in an opposing direction. This can sometimes be an inclination of handlers that consider positioning at the back of cattle groups as the only method to move them. Again, good standards of practice align directly with acclimation principles and are demonstrated as reduced injury risk, lower stress, and a livestock team with a skillset whereby cattle move quietly and willingly through handling facilities via handlers that are few in number and require only body position to effect cattle movement. Cattle handling facilities that are designed to separate human handlers from the flow of cattle, constructed with external walkways and remote-controlled gates can still be operated successfully using the principles detailed above. Handlers can still position themselves correctly in near optimum positions and use extensions of their bodies by way of flags that attract attention and apply constructive pressure but are not used as goads. The principle of avoiding over-filling of handling facilities still holds for all types of designs.

The acclimation schedule applied to feeder cattle in home pens in this experiment was designed to test for any health and production benefits of acclimation, however a practical application of the techniques – in the context of discussion on best practice cattle handling – is in the movement of a whole pen of cattle to another location. Just as cattle can be set up for calm, efficient, orderly, and willing movement through handling facilities, so too can groups of cattle in home pens be set up for a similar style of movement out of home pens and into laneways. Again, this is in keeping with best practice and good stockmanship but also limits injury risk and high stress levels in the handled stock.

Adoption of low-stress stock handling principles, which form the basis of the acclimation concept, and the training of livestock staff to levels of competency in acclimation is in keeping with good stockmanship and best practice. Additionally, this is also aligned with good human resource management – employees genuinely have enriched job satisfaction raising their skill set in these low-stress stock handling and acclimation techniques.

From an industry perspective, adoption of these handling methods and raising standards as such, are good optics for our stakeholders, other industries, and other unrelated bodies to witness. The Australian feedlot industry is no stranger to excellence, and consistent utilisation of low-stress stock handling techniques is aligned with this mission. Intuitively, good practice of low-stress stock handling works in concert with good animal welfare which the Australian feedlot industry also seeks to constantly optimise and pursue continual improvement.

While the project researchers recommend the use of low-stress stock handling techniques for all instances of cattle handling, the application of the formalised acclimation schedule as outlined in this report may only be warranted in select groups of cattle. The project team postulate that reserving the interventionist acclimation schedule as a management program for feeders that have much higher anxiety and temperament, and possibly have transit stress impacts additionally, is probably a more efficient and cost-effective deployment. The acclimation program in these instances should not be regarded as a panacea, as the usual and well established good husbandry methods which optimising cattle comfort, consumption and hydration would be paramount also. Further, feedlot sites that have little knowledge and/or past exposure within their livestock team to the techniques of low-stress stock handling and acclimation programs, may benefit from formalised training in these disciplines. These sites may benefit in human and animal terms, from a general raising of livestock staff skillsets and cattle handling standards such that human-cattle interactions are more harmonious and there is reduced risk of injury and stress in both human and cattle participants. (Lima et al., 2017) demonstrated improvements in behaviour, improved temperament as measured by chute exit velocity, and reduced cortisol release in Nellore breed (India originating *B. Indicus*) cattle from minor corral (cattle yards) modifications and the adoption of good cattle handling practices. In this work, the adoption of good handling practices principally involved the abolition of aversive handling practices, such as the overuse of dogs, electric prodders and handlers yelling at the cattle. The modification simply involved the removal of these high stress inputs and a calmer body language from the handlers.

Thus, the project researchers recommend a risk assessment process is undertaken for all new feeders placed on a feedlot, for their suitability and need to be enrolled into a structured acclimation program and not applying a universal application of acclimation to all feeders. In all instances of handling, for all cattle on the feedlot, at any stage of feeding, at all locations, the principles of low-stress stock handling are recommended absolutely.

Further research is warranted following on from the findings of this project. In the first instance, completing the datasets of chute exit velocity and faecal cortisol metabolite, as well as home pen flight zone comparisons between acclimated and control cattle would be beneficial. In completing the larger dataset collected for this entire project with the exit velocity, flight zone and faecal cortisol data outstanding, a more detailed examination of inter-relationships between all the data collected at induction, through the feeding phase and at the abattoir could be achieved.

Additionally, the large bank of home pen video footage stored could be utilised for further cattle behavioural studies and analysis – possibly to generate a set of behavioural indicators that conform to states of good animal welfare, health, and production. For further analysis of acclimation effects in this project, review of specific video footage is possible thanks to the time and date stamping, and storage of the footage in specific folders. This can be cross-referenced with the descriptions of acclimation sessions made by the Acclimators as they followed the schedule for each replicate.

It could be useful to repeat this project and alter the design such that acclimation is only applied as a treatment in feeder cattle scoring high in temperament assessment at induction. Further enhancement of the temperament assessment could be achieved by utilising additional objective measures such as triaxial accelerometers in the chute that give an output of “escape behaviour”. Also, utilising video footage of induction cattle as was performed in this project, a process of qualitative behavioural assessment whereby multiple observers give consensus on temperament scoring (Stockman, 2011) and (Stockman, 2012) may reduce possible measurement error arising from the use of a single, different observer at multiple sites. Obviously, another possible modification to the experimental design employed in this project is to alter the acclimation schedule, specifically the number of sessions, the intervals between sessions and the type of session employed.

This project did utilise two useful items of measurement variable and apparatus in the physiological measure of stress in faecal cortisol metabolite and the solar powered video surveillance monitoring of experimental home pens. Faecal cortisol metabolite, when analysed on a single sample basis, proved reliable and descriptive for all the replicates analysed. Its main, and significant, advantage as a physiological stress measure however was its remote to the animal utility, such that no restraint was necessary in order to collect the samples. Incorporation of any cortisol measure in many previous studies has been impacted by the effect on cortisol measurement itself by restraining animals during collection. In this project, the cortisol analysis reflected cattle in their more normal and natural states. This feature of faecal cortisol monitoring has seen its successful application in evaluating adaptation and habituation of wild animals to zoo enclosures and similar. The one disadvantage however was the blinding as to which individual the samples were from – as such the cortisol analysis in this project was lot (replicate) based. Nonetheless, future studies requiring a measure of stress response in experimental animals could consider the advantages of faecal cortisol over the more traditional methods of monitoring this variable.

Variants of the solar powered video cameras utilised in this project could be employed in future work involving monitoring of home pens such as heat stress, facial recognition, further welfare indicator work etc.

This project did highlight the issues of data capture and management from commercial feedlots for the purposes of running a large-scale research project, on multiple sites, and based on many multiples of variable on 20,000 individual cattle. These limitations are further detailed in the appendix section below. The subcontractor tasked with data management for this project proposes an industry project that conducts a review of the data systems in use across a large number of feedlots (e.g. 30) and their respective operational processes for ensuring data integrity. This would also include a review of terminology and data value ranges in use. The results of the review could then be used to develop a published and endorsed language for feedlot data including data integrity standards. This approach would ensure that all feedlots would be "talking a common language" as well as providing means for standardised industry reporting to satisfy market and consumer demands for evidence of compliance.

7 Key messages

The key message from this project is that the principles of low-stress stock handling should be utilised at every opportunity when interacting with cattle. The skillsets contained within low-stress stock handling and acclimation programs are universally applicable when handling cattle in close quarters, induction / hospital / drafting / receival / dispatch facilities and in feedlot pens.

Acclimation, as a structured management intervention of feedlot cattle, is probably best employed on a risk assessment basis such that it is reserved for high anxiety, high temperament cattle that demonstrate significant fearfulness of the feedlot environment and human handlers. It may be that feeder pens present sometime after induction as requiring acclimation management, and this is still appropriate as the acclimation techniques and programs can be initiated later in the feeding period.

There is no direct economic benefit attributable to acclimation as an intervention treatment alone, however the skillsets employed within these programs are in concert with best practice cattle handling, good animal welfare standards and also enrich the job satisfaction of employed livestock staff.

Feeders that have been yard-weaned and/or have been exposed to low-stress stock handling methods on-farm, pre-feedlot, would have much more capacity to adapt to the feedlot environment and demonstrate behaviour consistent with successful habituation. The Australian feedlot industry benefits significantly from feeder cattle managed as such through the supply chain.

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9 Appendix

9.1 Acclimation procedure

9.1.1 Pre-acclimation

Approach the gate to the pen and observe and note the behaviour of the cattle and position in the pen before you enter it. (Cattle at feedbunk, at water trough, % of cattle standing, lying down, chewing their cud, sick cattle and or pulls, cattle segregation in pen if a mixed group). Obvious pulls are removed from the pen before the acclimation process. Pen riding will occur after acclimation for the early am sessions.

9.1.2 Acclimation process: within pen, on foot, initial sessions

a) Get all cattle to stand up, do this by moving in a zig zag manner through the pen diagonally from the gate you enter.
b) Once all the cattle are standing up and aware of your presence, move the cattle to a corner of the pen (in the first instance, choose <u>not</u> the corner associated with the gate where cattle enter and exit).
c) Hold the cattle in the corner. Get them to bunch up a little and observe all the cattle, paying particular attention to the cattle which are furthest from you. You should not create a situation where cattle to want to break away and leave the herd – measure flight zone in this manner. Slight pressure application.
d) Once the cattle are just standing there and have given this recognition, walk away to release the pressure. The cattle should stand there and not move. Position yourself in the pen to cover the pen area, so as to prevent/minimise cattle breaking away.
e) Now move the cattle to the opposite corner using the pen perimeter to guide them - position so that a handler is at the rear of the herd and another handler is on the side to the front of the herd. We want the cattle to walk. If they decide to run, do not try to stop them, just be in front and in a position to prevent them from running around the pen.
f) Now that they are in the opposite corner, re position yourselves to hold the cattle to repeat parts c and d.
g) Move the cattle back to the original corner.
h) This holding and moving element should be done three times as a minimum. Assess and record the behaviour of the cattle:
    1. Are they settling more easily in the corner?
    2. Are they following your suggestion to move off to the other corner?
    3. Are they walking or running?
    4. Are cattle trying to run/break away?
i) If you are not improving the behaviour of the cattle stop what you are doing. Reassess what you are doing and how you are doing it.
j) If you are making the cattle behaviour worse, STOP and come back later.
k) Now that you have the cattle holding, moving off and taking commands and direction from the handlers, you can now take them for a walk around the pen – the “droving” element.

l) You now take the cattle for a clock wise or anti clockwise walk around the pen. Move the cattle off just like you would go from corner to corner, however continue moving the cattle out of the corner and around the pen (continuous flow).
    1. We are looking to get three laps of the pen during the droving element as a maximum. Be careful not to overwork the cattle, it may only be useful to do one or two laps in the first session.

m) Towards the end of the droving element, the worked cattle are directed to the centre of the pen and "parked" in the centre – i.e. the movement is completed here.

n) Aims of this exercise include:
    i. We are looking for the cattle to take direction: direction around the pen.
    ii. To move at the pace, we want: a walk with purpose, no running.
    iii. For the cattle to slow down and stop when we want them to.
    iv. Park/hold in the centre of the yard when we stop.
    v. Holding the cattle in the middle of the pen, with them resting/standing there and not walking off, tells us that they are comfortable with us and each other. 360 degrees means that cattle are vulnerable and can also run in 360 degrees if we do not have their mind correct.
    vi. If they are difficult cattle it is better to have one good win in the initial instance and then build on this in subsequent sessions.

o) Make an assessment on the training event and record the result and walk away and leave the cattle. Remember cattle have a good memory, it is very important how and when you leave the cattle.

The most effective training sessions are short and leave the cattle on a positive note.

9.1.3 Acclimation process: within pen on foot and laneway exit

Repeat the process as per "within pen" acclimation for steps (a) to (g).

Now that you have the cattle holding, moving off and taking commands and direction from the handlers, you can now take them out of the pen.

a) To take them out of the pen you have two options:
    i. Hold the cattle in the opposite corner to the gate:
        1. One handler opens the gate for pen exit then returns to the mob.
        2. Then move the cattle in the direction of the gate, one handler working the back and side of the mob, and the other handler working the side and front/lead of the mob. The pen perimeter can be used – cattle follow an "L" shape of perimeter to the gate corner.
        3. You MUST have someone in the lead of the cattle to take them out of the pen and into the lane.
        4. Once all the cattle are out of the pen, slow and then stop them and hold them for no longer than 2 minutes.
        5. Now walk them back into the pen and hold them on the feed bunk.
        6. The person in the lead walking them back into the pen must be in a position to prevent the cattle from running in.

        7. The person at the back should not chase the cattle, make sure you release the pressure.
    ii. <u>Hold them in the corner where the gate is:</u>
        1. Once you have the cattle in the corner and settled, one handler moves toward the gate to open it.
        2. The cattle will have most likely been drawn out of the pen by curiosity and follow the handler down the lane way.
        3. You MUST have someone in the lead of the cattle to take them out of the pen and into the lane.
        4. Once all the cattle are out of the pen, slow and then stop them and hold them for no longer than 2 minutes.
        5. Now walk them back into the pen.
        6. The handler in the lead walking them back into the pen must be in a position to prevent the cattle from running in.
        7. The handler at the back should not chase the cattle, make sure you release the pressure.

b) Hold the cattle (park) on the feedbunk, it is preferable if there is feed in the feedbunk during the initial sessions. If there is no feed in the bunk, park the cattle in the middle of the pen or on a water trough.
c) Release the pressure and walk away from the cattle as they are parked/settled on the feedbunk (or water trough / centre of the pen).
d) Make an assessment on the training event and record the result and walk away and leave the cattle.

9.1.4 Acclimation process: Combination of moving in the pen on foot, and out of the pen on horse

Repeat the “within pen” acclimation process on foot as above for steps (a) to (g), then:

a) Choose the direction which best suits the cattle exiting the pen (clockwise or counter clockwise).
b) Repeat moving and holding element on horse - you should only have to move the cattle once around the pen and then get ready for exit.
c) Hold cattle in corner opposite gate; one handler opens gate then returns to mob.
d) Move the cattle around the pen, out the gate and into the lane in one continuous smooth movement (half a droving element).
e) Cattle should walk around the pen, out the gate and down the lane.
f) Once out in the lane, slow the cattle to a stop and then hold/park them for 1- 2 minutes.
g) Return the cattle to the pen at a walk. The lead handler positions themselves to control the lead and take the cattle and park them on the feedbunk.
h) If there is no feed in the bunk park the cattle in the middle of the pen or on a water trough.
i) Make an assessment on the training event and record the result. Ride away and leave the cattle. Remember, cattle have a good memory. It is very important how and when you leave the cattle.

- Do not overwork cattle: they either become unresponsive and too quiet and/or get sick of it and get sour.
- If you have to, stop the exercise and re-start, do it ON FOOT.

9.1.5 Acclimation process: Combination of moving in the pen and out of the pen on horse

All the elements above as for the acclimation process of moving in the pen on foot and exit on horse are followed excepting that the whole process is conducted on horse. There are only three “move and holds” required in total before exiting cattle from the pen.

9.1.6 Acclimation process: refresher on foot or on horse

This exercise seeks to be brief and only to remind cattle of basic pressure – give – release effect so as to stay “in touch” with acclimation and maintain the experimental effect.

a) Get all cattle to stand up, do this by moving in a zig zag manner through the pen diagonally from the gate you enter.
b) Once all the cattle are standing up and aware of your presence, move the cattle to (any) corner of the pen.
c) Hold the cattle in the corner, get them to bunch up a little and observe all the cattle, pay particular attention to the cattle which are furthest from you. You should not create a situation where cattle to want to break away and leave the herd – measure flight zone in this manner. Slight pressure application.
d) Once the cattle are just standing there and give this recognition, back away to release the pressure. The cattle should stand there and not move.
e) Leave the pen.

9.1.7 Acclimation schedule and record

- Days applied to separate session activities below are nominal – weather events, weekend rosters and similar may fall on the intended dates. As such, a three (3) day range around the nominal dates operates.
- Note that the only activities applied to control pens, apart from normal feedlot operations, was collection of faecal samples at the equivalent time and date to treatment pens, for the purposes of submitting for faecal cortisol metabolite assay.

9.2 Acclimation schedule record

QUIRINDI FEEDLOT SERVICES PTY LTD

Cattle Acclimation Schedule Record

NOTE: ***Faecal Cortisol Sample Collection form and Cattle acclimation Pen Session Record must be followed and completed for each session.***
NOTE: ***Days marked as (nominal) allow for up to 5 days after this day for completion should weather and other extenuating circumstance apply.***

ACCLIMATION COORDINATOR: __________

Feedlot:________________ **Cohort Number:_____**

Cohort name: ______________________	Treatment Lot		Control lot
	Nominal date	Actual date	
Pen Number			
Lot Number			
Induction start date and number of head			
Induction complete date and number of head			
No of Head			
Faecal collection midday of lot closed date.			
Session 1: **(first day after lot is closed) Day 1 - initial acclimation, morning, on foot, within pen only; park**			
Session 2: Day 2 – acclimation **on foot, within pen only; park**			
Session 3: Day 3 – acclimation **on foot and pen exit on horse**			
Faecal collection: Day 5 – 7:00am			
Session 4: Day 7 (nominal) – acclimation **and pen exit on horse**			
Faecal collection: Day 10 (nominal) – 7:00am			
Session 5: Day 14 (nominal) – Refresher on foot			
Faecal collection: Day 18 (nominal) – 7:00am			
Session 6: Day 21 (nominal) – acclimation **and pen exit on horse**			
Faecal collection: Day 25 (nominal) – 7:00am			
Session 7: Day 30 (nominal) – Refresher on foot			

Faecal collection: Day 34 (nominal) – 7:00am			
Session 8: Day 38 (nominal) – Refresher on horse			
Faecal collection: Day 42 (nominal) – 7:00am			
Session 9: Day 45 (nominal) – Refresher on foot			
Faecal collection: Day 49 (nominal) – 7:00am			
Session 10: Day 50 (nominal) – acclimation **and pen exit on horse** **Acclimation on foot and pen exit on horse if 60-70 days fed			
Faecal collection: Day 54 (nominal) – 7:00am			
Session 11: Day 60 (nominal) – Refresher on foot			
Faecal collection: Day 64 (nominal) – 7:00am			
Session 12: Day 70 (nominal) – Refresher on horse			
Faecal collection: Day74 (nominal) – 7:00am			
Session 13: Day 80 (nominal) – Refresher on foot			
Faecal collection: Day 84 (nominal) – 7:00am			
Session 14: Day 90 (nominal) – acclimation **and pen exit on horse** **Acclimation on foot and pen exit on horse if 100-120 days fed			
Faecal collection: Day 94 (nominal) – 7:00am			
Session 15: Day 120 (nominal) – Refresher on foot			
Faecal collection: Day 124 (nominal) – 7:00am			
Session 16: Day 130 (nominal) – Refresher on horse			
Faecal collection: Day 134 (nominal) – 7:00am			
Session 17: Day 140 (nominal) – acclimation **and pen exit on horse** **Acclimation on foot and pen exit on horse if 150 days fed			
Faecal collection: Day 144 (nominal) – 7:00am			
Session 18: Day 150 (nominal) – Refresher on horse			
Faecal collection: Day 154 (nominal) – 7:00am			
Session 19: Day 160 (nominal) – Refresher on foot			
Faecal collection: Day 164 (nominal) – 7:00am			
Session 20: Day 170 (nominal) – acclimation **and pen exit on horse** **Acclimation on foot and pen exit on horse if 180-190 days fed			
Faecal collection: Day 174 (nominal) – 7:00am			
Session 21: Day 180 (nominal) – Refresher on horse			
Faecal collection: Day 184 (nominal) – 7:00am			

Session 22: Day 190 (nominal) – acclimation **and pen exit on horse**			
Faecal collection: Day 194 (nominal) – 7:00am			
Exit Start date and number of head			
Exit Complete date and number of head – Lot Closed			

NOTE: ** For session 10, 14, 17 and 20 if these lots nearing close out, then the "Pen Exit" procedure is start on foot and end on horse. Compared to non-close out sessions where the procedures is all on horse.

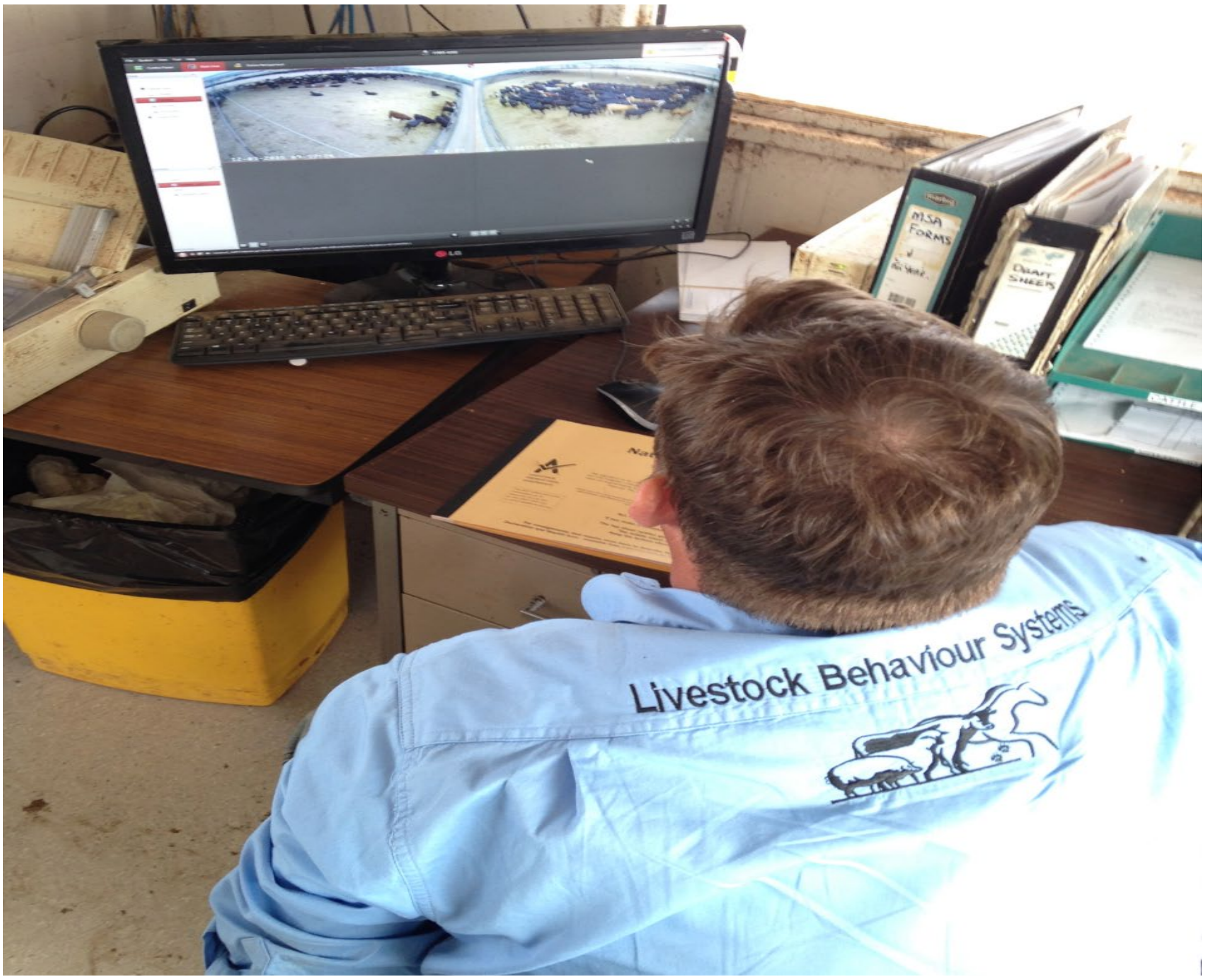
Fresh faecal sample being collected using the barcoded sample collectors


B6


B6


06-11-2014 05:48:15
KC1 08


06-11-2014 12:19:13
KC1 08


MSA Forms
Draft Sheets
Livestock Behaviour Systems

9.3 Individual animal temperament chute scoring

The acclimation project included a process to measure individual animal temperament. This include two separate methods.

Method one was the use of a 9-point chute scoring system. Every induction animal for the project had a chute score assigned. To ensure consistency is chute scoring a training module with competency assessment was developed. This training and competency assessment is available at: http://www.cattle-acclimation.com.au/scoring.asp. All chute scores for the acclimation project are record as individual values from 1 to 5. This data was analysed between each of the values to definite statistical consistency is measurement recording. All chute scoring was videoed for the purpose of auditing of the chutes scores against the observable behaviours.

The value of the chute scoring system is that it takes a number of behavioural as well as operational measurement into account. An example is where the crush operator requires many attempts to restrain the animal and many operational procedures are applied to the animal. This animal many exhibit a violent chute release, where this behaviour is a consequent of the circumstances not a clear representation of the animal's temperament. By including the both the animal observed behaviour.

Chute Scoring System

Score	Score element 1 – Chute Entry Score	Score element 2 – Clean Catch	Score element 3 – Restraint Behaviour	Score element 4 – Amount and Type of Vocalisation	Score element 5 – Faecal Release and Tail Swishing	Score element 6 – Chute Release Behaviour	Score element 7 – Process activity 'Jigger Use'	Score element 8- Process Activity 'horn tipping'	Score element 9 – Length of Time Held in Chute
1	Enter consistent pace- walk (not inhibited)	Correct catch in one attempt	Stands calmly for procedures	Little or no vocalisation	No	Walk	No	No	0 TO 15 SECONDS
2	Enter consistent pace- slow trot (not inhibited)	Correct on second attempt, starts calmly	Starts calm and becomes restless and intermittently resist processing procedures	Short, infrequent, low volume vocalisations	Tail swishing	Trot/ pulls back but exits immediately at constant pace			16 TO 30 SECONDS
3	Baulk (reluctant to enter) and /or trot with lunge at end (looking to escape?, increasingly stressed)	Correct on third attempt	Restless and intermittently resists processing procedures/ Drops down	Starts quietly but volume increases		Pull back/ reluctantly exits / canter			31 TO 45 SECONDS
4	Very fast trot or canter with lunge at end (very stressed)	Over 3 attempts	Vigorously shakes chute and continually resists processing procedures	Loud vocalisations, more frequent than silence episodes	Yes	Jump or lunge forward/ pulls back and hits back door/	Used once		46 TO 60 SECONDS
5	Reluctant start, Increasing acceleration to canter through crush, loud bang on catch.(very stressed, likely to injure itself)	Missed, head catch or body catch	Violently shakes chute, resists procedures, attempts escape, Highly distressed by procedure.	Extended bellowing, loud and continuous, tongue extended	Yes, with tail swishing	Scrambling or falling/ very fast canter exit/ bangs limbs on exit	Used more than once	Yes	MORE THAN 60 SECONDS

The second method of measurement was the videoing of every chute exit for the purpose of calculating exit velocity.

To calculate exit velocity, the video is analysed to calculate the average velocity between two nominal points, one point being the chute head bail and the other point being a number of metres away for the head bail. Using simple trigonometry, the velocity between the two points is calculated. The video analysis process is also able to calculate the initial acceleration from the chute as well as identity any instances of recoiling where the animal initially moves forward and then pulls back into the chute. The traditional photo eye-based chute velocity measurement methods could not record the numerous variations in how the animal exits the chute and thus had a wide range of unrecorded measurement variation.

The reviewing of the videos in comparison of the calculated chute velocity and the recorded chute score through observation demonstrated that the historical photo eye-based exit velocity is a very unreliable method for determining animal temperament due to the error rates because of baulking behaviour and the operational procedures that impact the animal.

Chute videos are available for viewing at:

http://www.cattle-acclimation.com.au/jbs-v-20140716-c.asp

http://www.cattle-acclimation.com.au/jbs-v-20140716-b.asp

http://www.cattle-acclimation.com.au/eld-v-20140715-c.asp

http://www.cattle-acclimation.com.au/eld-v-20140715-b.asp

http://www.cattle-acclimation.com.au/mor-v-20140708-c.asp

http://www.cattle-acclimation.com.au/mor-v-20140708-b.asp

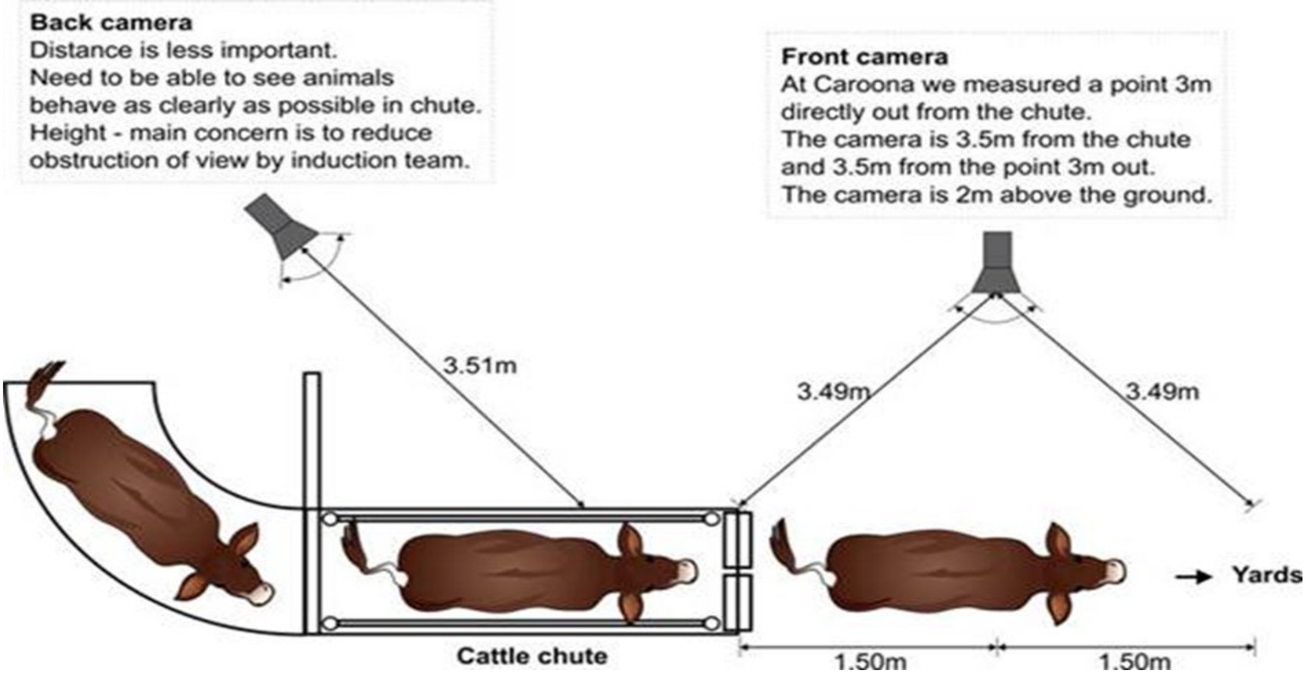
http://www.cattle-acclimation.com.au/tey-v-20140709-c.asp

http://www.cattle-acclimation.com.au/tey-v-20140709-b.asp

http://www.cattle-acclimation.com.au/smi-v-20140709-c.asp

http://www.cattle-acclimation.com.au/smi-v-20140709-b.asp

The diagram below shows the process for the camera positions as well as the calculation method.



Back camera
Distance is less important.
Need to be able to see animals behave as clearly as possible in chute.
Height - main concern is to reduce obstruction of view by induction team.

Front camera
At Caroona we measured a point 3m directly out from the chute.
The camera is 3.5m from the chute and 3.5m from the point 3m out.
The camera is 2m above the ground.

This needs labelling etc – it is the more classic method of doing exit velocity

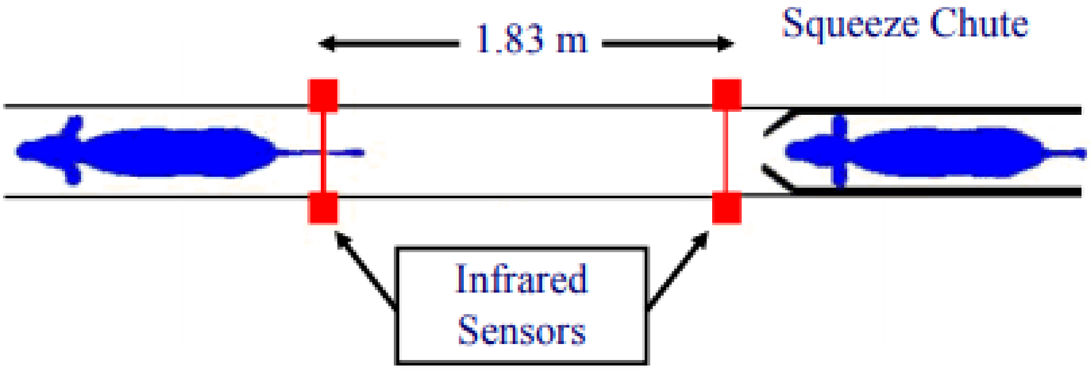
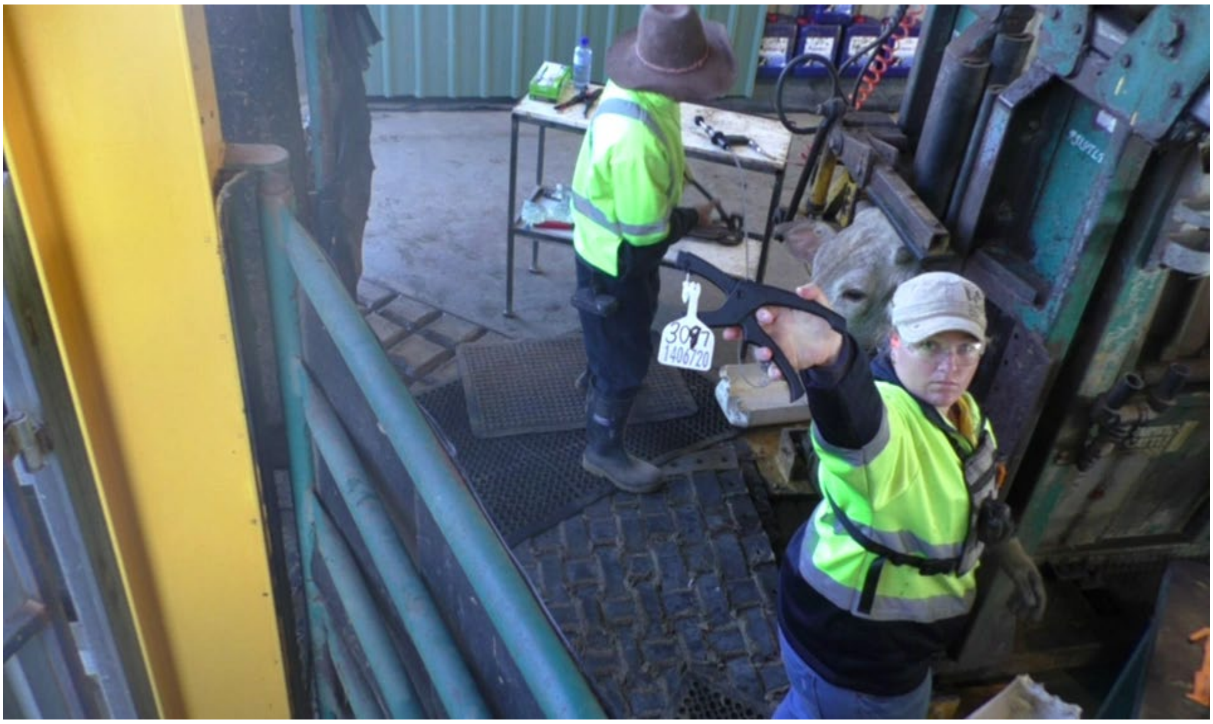


Figure 1. Diagram detailing measurement of exit velocity in cattle.

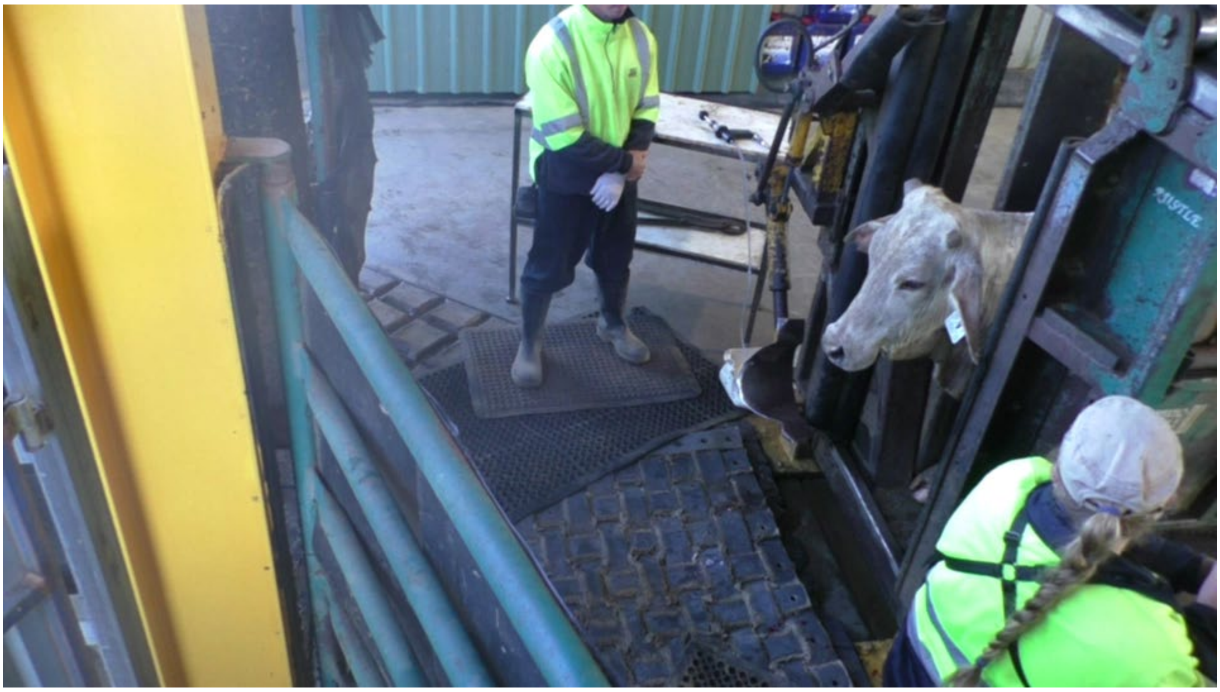
The following images were captured from one of the chute videos. These still images show the process from head bale grab through to the animal leaving the chute. Each video has the date and time in the meta-data for the video. The details below show the time mark from the video.

Catch (time mark 6:40:00)

View ear tag to identity each animal.



Release (time mark 7:14:21)



The total time in crush of 35.8 second was measured using the video timing.

For flight speed a distance measurement of 1.5 metre from crush to gate with a measured travel time of 22 frames (0.92 seconds) determined from time when crush fully opened, showed that in this instance the average velocity was 1.38 metres per second.

Flight velocity (time mark 7:15:19)

The induction for the lots were recorded. The process of reviewing the videos shows a range of exit behaviours that are not captured in traditional flight speed measurement. There are many instances of cattle moving forward and then backing up before finally moving through the exit gates. These cattle may jump wildly creating a very slow traditional flight speed due to the baulking before moving. Other cattle that walked slowing out of the crush gave the same traditional flight speed. These inconsistencies in behaviours confound the traditional flight speed measurement.

The use of the novel Chute Score method used at time of induction had a more robust method to address the inconsistency shown with the traditional flight speed measurement. This has been demonstrated in the analysis of novel Chute Score method used in this project.

9.4 Report from subcontractor: Management for Technology / Init Media (Des Bowler)

Acclimation project work program review and data quality errors

The acclimation project has been in action since March 2015. Since that time the project has collected data from over 19,000 head of cattle from feedlot arrival through to MSA grading. This is spread across 5 feedlots and 100 lots (50 cohorts).

The original work plan was for feedlots to:

1. Induction each cohort as 1 process over 1 to 2 days and record all data related to the lots on specified forms. This also included chute scoring and video recording of the induction sessions. All induction session data is to be sent electronically.
2. Conduct acclimation sessions on the treatment lots and not of the control lots and record the session details on to specified forms.
3. Collect faecal samples following a protocol and record all the details on specified forms.
4. Feed the cattle recording all feed data through the feedlot bunk system and send the feed data electronically.
5. Record all health events through the feedlot system and send the health data electronically.
6. Record all death events through the feedlot system and send the death data electronically.
7. Keep all cattle together until time of exit. Record the exit on specified forms as well as electronically and send data.
8. Exit the cattle to a processor that conducts MSA grading.
9. Collect the slaughter data feedback electronically and MSA grading data feedback electronically and send the data.
10. Close the lots and send the close out reports as PDFs.

All of the above data was imported through the AHD system. This was through the data files for the feedlot management systems for the operational feedlot data. NLIS and MSA databases were integrated for kill records based on the RFID at time of induction.

The basic assumption for all of the above was that the feedlots had control over their data and the choice of processor for the MSA grading.

The projects basic premise is that the project data is collected, consolidated, and reported based on the data supplied from the feedlots. This premise assumes the data is close to 100% correct. This however is not the case. The data quality issues have resulted in a 10-fold increase the labour required for recording, processing, and reporting the project data.

A few examples are:

1. The feedlot inducted the cattle in January and started them on feed in March. All feed, health, transfer and exit records have the days of feed value out by approximately 50 days. This results in gain, ADG and various other reporting data to be incorrect.
2. Due to commercial requirements, the cattle exited the feedlot and were slaughtered without MSA grading resulting in no MSA data being available.
3. The cattle were drafted, and a large percentage of the cattle were sent to processing early resulting in a large variation in DOFs.
4. Cattle went to multiple processing plants resulting in different grading processing being applied and many not being MSA graded.
5. The processing plant where cattle were MSA graded entered the body number incorrectly in the MSA grading records. This resulted in no match between the NLIS database and the MSA data. These animals' records had to be manually manipulated to create a match.

Overall, there were many animals transferred to other lots, lost their RFIDs, exited the feedlot early and/ or are processed by plants that do not grade carcases. The specified exit forms were not completed in many cases resulting in no readily available exit detail. Several thousand cattle could not be accounted for from the processor feedback. The NLIS searches found the processing plants where many of cattle were killed. These search results allowed for manually tracing the animals and manually trying to obtain any sort of slaughter data. Where the RFID had failed or could not be matched the animal data is incomplete in the acclimation dataset.

Due to the fragmented and inconsistent nature of the data, an additional data audit had to be conducted to cross check the manually manipulated data to ensure corrections had not impacted any results.

The full data set is available on this link: http://www.animal-health-data.net.au/reports/ACCLIMATION_ALL.csv

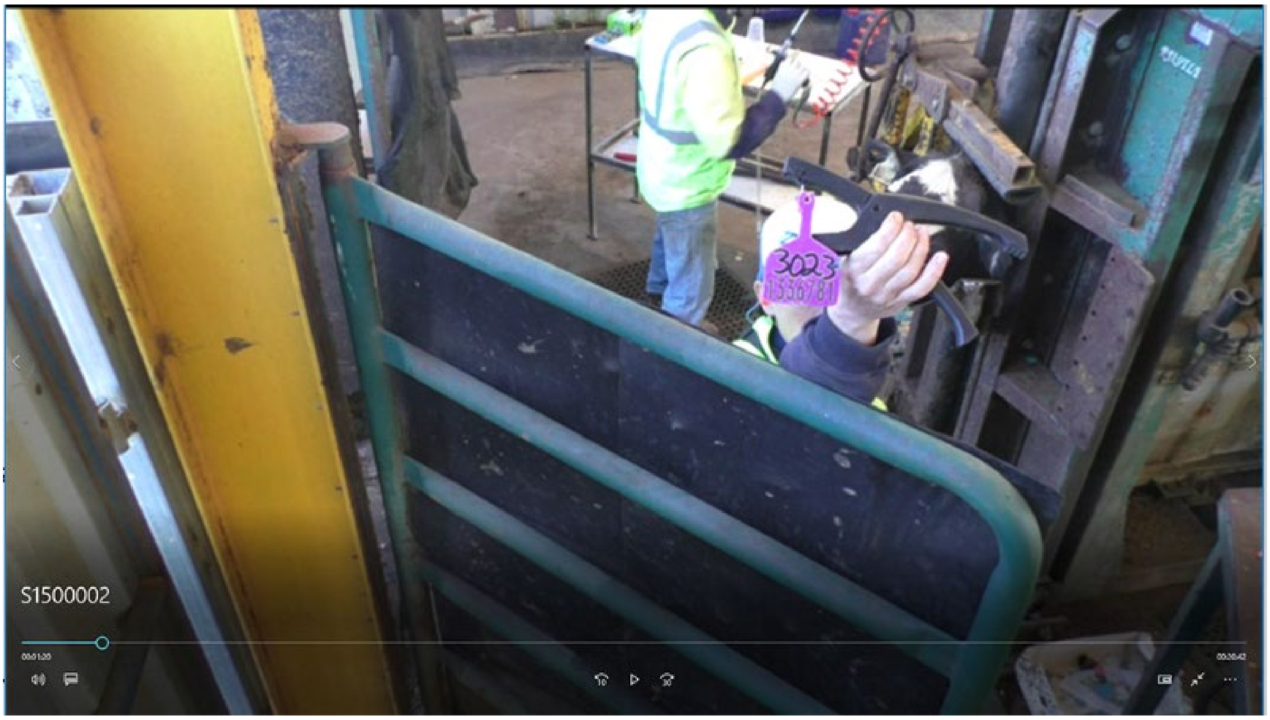
All of these issues where not able to be identified at the commencement of the project and not included in the project budget.

The acclimation process relies on data collected at the feedlot at numerous interactions times from induction through to exit. Some of this data is collected on forms that are submitted on an event basis, such as faecal cortisol sample collection. Other data is collected from exported files from the feedlot systems. This exported data is created at the feedlot through sessions such as induction, hospital, exits and bunk. The exported data files go through an importing data validity checking algorithm when they are received on a weekly basis. The result of the validity checking has identified numerous data integrity issues in feedlot exported data.

The acclimation schedule required feedlots to induct, feed, and exit cattle as a cohort. An instance of a feedlot inducting a research cohort under additional Lot numbers led to a loss in resources in order to accommodate it. Another cohort was inducted utilising a different form layout. This caused errors during validation and required extensive auditing to correct. A consistent issue with one feedlots exit records being processed incorrectly required follow up. This resulted in a small minority of cattle with induction records that completely lack any exit information, from exit weight or date, to MSA grading and carcase attributes.

As part of the Benefits for acclimation study, cattle were to MSA graded. Data audits show that out of 19051 animals, 14778 received an MSA grading. Out of those animals, 14322 have an MSA Index recorded. This issue has caused a large amount of time being spent chasing missing and incorrect data. From a feedlot perspective individual animal data errors have very little overall feedlot commercial impact, however for the purpose of the project, any errors in data may indicate an acclimation effect on the treatment or control lots that is in fact data aberration instead of an actual effect. To overcome this potential impact on the results all data is scrutinised to ensure validity. This issue of poor data quality various across the 5 feedlots, but all the feedlot had this issue to some extent.

Where issues have been identified with manually prepared records such as the chute scoring sheets the induction video are used to resolve any inconsistency. The videos have meta data for the date and time which are matched to induction and session records. (See attached example of the ear tag displayed during induction).



The project to date has shown that there are considerable data quality issues with individual animal records exported from the feedlot systems. One entire cohort comprised of 510 animals was unable to be used due to mis-entry of observation results. There are also 442 animals with ID's also being used on different animals.

There have been many projects conducted by MLA as well as AFLA that are based on data provided by feedlots. There is an expectation that the data supplied by feedlots is highly accurate and a reliable source of information. This project has shown that this assumption is incorrect. The current evidence shows that the level of effective utilisation of data collection systems and their respective levels of data validity checking varies greatly between feedlots. The result is the data is considered highly suspect with no simple means to validate it accuracy.

The hypothesis is that there is a skills deficiency within the feedlot sector to effectively implement, operate and maintain data collection systems and the related reporting. There may be a number of causes of these skills deficiencies, including;

1. Lack of training of operational personnel.
2. High employee turnover resulting in a very high training demand.
3. Feedlot software system being too complex or requiring too high a level of configuration and maintenance.
4. Or a combination of all of the above.

An issue that may also be a contributing factor is the lack of consistency in definitions and terminology in use in the feedlots. Each feedlot can make up their own coding system for any number of attributes and measurements. This results in the feedlot systems being highly configurable. The consequence is the compounding of errors due to poor configuration and inconsistent terminology use. This is typically referred to as a lack of “industry information standards”. In the processing sector terminology is defined in language and industry training includes the AUS-MEAT language to ensure consistency across all plants. This does not exist in the feedlot sector.

9.5 Questionnaire to trained acclimator feedlot staff remaining at end of project

ACCLIMATION PROJECT

Staff questionnaire

THE ACCLIMATION TRAINING AND PROJECT

1. Did you undergo the full training program for the acclimation trial? That is, all the on-site exercises and the theory requirements?
    i. YES
    ii. NO

2. Did you feel that you understood the training and were equipped satisfactorily to acclimate cattle once the project began at your feedlot site?
    i. No, I didn't understand any of the training and was not equipped
    ii. I understood only a small part of the training and was only slightly equipped
    iii. I understood about 50:50 of the training and was similarly equipped
    iv. I understood most of the training and was mostly equipped
    v. I understood practically all of the training and was nearly 100% equipped
        i. If answers i, ii, iii – why was this the case?

3. Were you still involved with the project when Boyd Holden visited the site to verify that the acclimation skills of the livestock staff remained suitable for the project?
    i. YES
    ii. NO

4. Did you continue to acclimate cattle after this visit noted in question (3)?
    i. YES
    ii. NO

5. How much did you enjoy the acclimation project training?
    i. Did not enjoy it all
    ii. Only enjoyed it a bit
    iii. Neither enjoyed it or didn't enjoy it
    iv. Enjoyed most of it
    v. Enjoyed all of it, very satisfied

6. After training and accreditation, and once the project started on your feedlot site, were you able to successfully apply all the application protocol, in full only to the treatment pen?
    i. No, not at any time
    ii. Only on a very few occasions
    iii. About 50:50
    iv. Yes, most of the time
    v. Yes absolutely, practically all the time
        i. If no, why was this the case?

7. Did you feel you were successful in applying the application protocol to the treatment pen(s) you were involved in for the entire duration of the project?
   i. No, none of the time
   ii. Only on a very few occasions
   iii. About 50:50
   iv. Yes, most of the time
   v. Yes absolutely, practically all the time
      i. If no, why was this the case?

8. Was the acclimation protocol and schedule easy to understand and implement?
   i. No, it was very difficult to understand and implement
   ii. No, it was difficult to understand and implement
   iii. Only half of the protocol could be understood and implemented
   iv. Yes, it was mostly easy to understand and implement
   v. Yes, it was very easy to understand and implement
      i. If no, why was this the case?

9. Did you feel that you could see a change in the treatment pen cattle over time as a result of having acclimation applied?
   i. No, no change at all
   ii. A very small change
   iii. A small change
   iv. A large change
   v. A very large change

10. If you saw a change in the cattle as they were acclimated over time, did you perceive this change to be a health and/or welfare and/or production benefit?
   i. No, no benefit
   ii. A very small benefit
   iii. A small benefit
   iv. A large benefit
   v. A very large benefit

ACCLIMATION AS A WORK PRACTICE

11. Apart from the specific requirements of the acclimation project, did you approach any of your daily work differently as a result of this training and your acclimation skills?
   i. No, I didn't approach anything differently
   ii. Not really, I changed very little in my approach
   iii. To some extent, I changed my approach
   iv. Yes, I changed my approach noticeably
   v. Yes, absolutely, I radically changed my approach thanks to the training
      i. If yes, briefly what did you change?

12. Do you feel you have a better understanding and skillset of working with cattle after the acclimation training and being involved in the project?
    i. No, none at all
    ii. Not really, just a very limited extra skillset
    iii. Only a slightly better skillset
    iv. Yes, a better skillset
    v. Yes, definitely, a much better skillset
        i. If no, why was this the case?

13. Did you share any of your training information and acclimation skills with other members of your team?
    i. No, shared nothing
    ii. Not really, just a very few things
    iii. Only a few things
    iv. Yes, a number of things
    v. Yes, a significant number of things

14. Do you feel that the acclimation training and practice assists livestock staff to avoid dangerous situations when handling cattle at the feedlot?
    i. No, not at all
    ii. Not really, only to a very small extent
    iii. Only to some extent
    iv. Yes, to a large extent
    v. Yes, absolutely, to a very large extent
        i. If yes, can you identify an example situation?

15. Would you recommend that aspects of the acclimation training and skillset was delivered to new livestock staff at your feedlot site?
    i. No, not at all
    ii. Not really, only a very few aspects
    iii. Only some aspects
    iv. Yes, a large part of the program
    v. Yes, absolutely, the whole program

16. Do you feel acclimation should be routine practice at your feedlot site?
    i. No, not at all
    ii. Not really, only on rare occasions
    iii. Only on some occasions
    iv. Yes, should be routine for most of the inducted cattle
    v. Yes, absolutely, should be routine for all of the cattle
        i. If yes for only some or rare occasions – can you outline these?

17. If acclimation was to become a normal work practice at your feedlot, would you want to change the approach and protocol you learnt for the project?
    i. Yes, I would change it radically
    ii. Yes, I would change a lot of the protocol
    iii. Only change a few selected aspects of the protocol
    iv. Not really, I would only change a very few things of the protocol
    v. Absolutely not, I would not change anything of the protocol

18. Do you feel that you can perform your livestock duties better, to any extent, as a result of your acclimation training and skillset?
    i. No, not at all
    ii. Not really, only to a very small extent
    iii. Only to some extent
    iv. Yes, to a large extent
    v. Yes, absolutely, to a very large extent
        i. If not, why is this the case?

19. If considering installing acclimation as a routine work practice at the feedlot, would you need to learn the statistical results of the trial?
    i. YES
    ii. NO
        i. If yes, what results in particular?

20. Can you indicate with yes / no if acclimation training and skillset is useful in the following operations on the feedlot;
    i. Loading and unloading Y/N
    ii. Inducting Y/N
    iii. Pen moves Y/N
    iv. Pen riding Y/N
    v. Drafting Y/N
    vi. Hospital treatments Y/N
        i. Any other operations or situations you can identify?

21. Do you feel the acclimation skillset is useful for any situation involving working with cattle, not just restricted to the feedlot?
    i. No, not at all
    ii. Not really, only to a very small extent
    iii. Only to some extent
    iv. Yes, to a large extent
    v. Yes, absolutely, to a very large extent
        i. If yes, can you outline an example?

Are there any other comments you would like to make about acclimation?

END

EXTRA QUESTIONS FOR ACCLIMATION STAFF NO LONGER AT THE PROJECT FEEDLOT SITE

22. Can you nominate which of the below is relevant for having left the project feedlot site?
    i. Attractive job opportunity in same field offered elsewhere
    ii. Family related
    iii. Change of scene, change of employment
    iv. Retired
    v. Other

23. In changing to the new job and location where you are now, rank the following factors on a scale of;
    i. Not at all important (1)
    ii. Some importance (2)
    iii. Important (3)
    iv. Very important (4)
    v. Very highly important (5)
        i. Compensation
        ii. Potential for promotion
        iii. New site has acclimation policy and program
        iv. Suitability for family
        v. Location
        vi. Company and/or site reputation
        vii. Testimonials

24. Do you feel that the site you're working at now should have an acclimation program?
    i. No, not at all
    ii. Not really, only to a very small extent
    iii. Only to some extent
    iv. Yes, to a large extent
    v. Yes, absolutely, to a very large extent
        i. If YES, why is this the case?
        ii. If NO, why is this the case?

25. Irrespective of whether the site you work at now has an acclimation program, if given the opportunity, will you share some of your skillset and new knowledge with your team?
    i. No, not at all
    ii. Not really, only to a very small extent
    iii. Only to some extent
    iv. Yes, to a large extent
    v. Yes, absolutely, to a very large extent
        i. If YES, why is this the case?
        ii. If NO, why is this the case?

26. Do you think the site where you work now would be supportive of an acclimation program?
    1. No, not at all
    2. Not really, only to a very small extent
    3. Only to some extent
    4. Yes, to a large extent
    5. Yes, absolutely, to a very large extent
        1. If YES, why is this the case?
        2. If NO, why is this the case?

27. Would you like to be re-trained or further trained in acclimation if given the opportunity?
    1. No, not at all
    2. Not really, only to a very small extent
    3. Only to some extent
    4. Yes, to a large extent
    5. Yes, absolutely, to a very large extent
        1. If YES, why is this the case?
        2. If NO, why is this the case?

28. Are there any other comments you would like to make about acclimation?

END