MEAT & LIVESTOCK AUSTRALIA

final report

Project code:	B.FLT.4005
Prepared by:	J. Gaughan, M. Sullivan, S. Woldeyohannes and N. Perkins The University of Queensland
Date published:	5th August, 2019

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

Effect of Orchard Fans on Heat Load Amelioration

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

This publication is published by Meat & Livestock Australia Limited ABN 39 081 678 364 (MLA). Care is taken to ensure the accuracy of the information contained in this publication. However MLA cannot accept responsibility for the accuracy or completeness of the information or opinions contained in the publication. You should make your own enquiries before making decisions concerning your interests. Reproduction in whole or in part of this publication is prohibited without prior written consent of MLA.

Abstract

Excessive heat load in feedlot cattle occurs when heat gain exceeds the ability of animals to lose heat through thermoregulation. Air flow (speed) is a key driver in heat loss from cattle. Technologies to alter wind speed however have not been implemented into beef cattle feedlots. It is possible that fans could be used in a feedlot setting to improve air flow, in particular wind speed. This project will determine the effect of orchard fans on feedlot cattle performance, health, welfare and profitability.

A randomised complete block study was undertaken from mid-January 2019 until mid-April 2019 at a commercial feedlot in South East Queensland using 1314 animals. There were two treatments (Fans or No Fans) and four pens (all un-shaded) per treatment. Data collected included dry matter intake (DMI), panting score and carcass traits. Weather data was collected at 10 min intervals from four on-site weather stations.

The use of fans did not improve DMI relative to no fans, did not reduce panting scores or lead to any significant differences in carcass traits apart from minor difference in carcase pH and rib fat. The cost of using the fans was $69.40 per animal (fans treatment) or $0.95 per day per animal, and as there were no objective animal welfare or production benefits it is unlikely that the fans would be a financially viable option.

Executive summary

Excessive heat load in feedlot cattle occurs when heat gain exceeds the ability of animals to lose heat through thermoregulation. Factors influencing heat gain include solar radiation, pen surface radiation and conduction, metabolic heat production and ambient temperature. Heat loss is determined by convection (wind speed) which carries heat away from the animal's surface, and by evaporation which is hindered by high humidity. Shade is a common strategy used by Australian lot feeders to prevent excessive heat gain by feedlot cattle. Regular pen cleaning is used to limit pen surface moisture and relative humidity during heat wave conditions, thereby enhancing the rate of heat loss from cattle via evaporation. Technologies to alter wind speed however have not been implemented into beef cattle feedlots. Orchard fans are commonly used in Southern Australia to prevent frosts in fruit orchards. It is possible that Orchard fans could be used in a feedlot setting to improve air flow, in particular wind speed. An increase in wind speed may be useful in reducing the heat load on cattle. This project will determine the effect of Orchard fans on feedlot cattle performance, health, welfare and profitability.

Objectives of the project include:

1. Determine the effects of orchard fans on feedlot cattle health, welfare, performance and carcass characteristics,
2. Determine the value proposition of orchard fans via ex-post cost benefit analysis, and
3. Determine the break-even leasing or purchase price of orchard fans for the amelioration of heat load

A randomised complete block study was undertaken from mid-January 2019 until mid-April 2019 at a commercial feedlot in South East Queensland. Steers and heifers (25 to 75% *Bos indicus* content; 334 kg live weight) were randomly allocated at feedlot induction to two treatments (Fans or No Fans) and four pens per treatment. All pens were mixed sex pens and un-shaded. Pens were blocked (n=4: 1 Fan pen and 1 No Fan pen per block). The fans were located approximately 5 m behind the dividing fence between two pens. A buffer pen was located between the Fan pens and No Fan pens within a row. Two rows were used at the feedlot. The pen orientation was two Fan pens, a buffer pen, and then the two No Fan pens per row. Within a row pens had the same orientation and where the same size. Orchard fan position was randomised to one side of each row. Cattle were fed for the domestic market for an average of 73 days on feed, and were not implanted with HGPs.

Four weather stations were installed and calibrated prior to the commencement of the study. The weather stations were installed parallel to dividing fences of paired fan and control treatments on the opposite side of the road from the feed bunk (approximately 4 m from the feed bunk). Weather data (dry bulb temperature, relative humidity, solar radiation, black globe temperature, wind speed {2 m height} and wind direction were collected at 10 minute intervals over the duration of the study. These data were then used to calculate heat load index (HLI) and accumulated heat load units (AHLU). Rainfall was collected on site on a daily basis at 0900 h. The weather data, HLI and AHLU were available real time which allowed continuous monitoring of weather conditions.

Daily dry matter intake was obtained at the pen level. Panting scores were obtained at the pen level, however breed type was identified. Thirteen animals per pen were administered a rumen temperature bolus that allowed rumen temperatures to transmitted real-time to a data base. Each animal was individually identified. Start and end weights were obtained for each animal, and carcass traits (MSA Grading) were obtained at slaughter.

Fans were turned on at 1800 h on any day where the heat load index (HLI) was greater than or equal to 93 units at 1200 h on that day. Once turned on the fans then ran continuously until 0600 h the

following morning. There were 28 days where HLI≥93 however due to breakdowns the fan only ran on 26 of the days in Blocks 1 & 2, and 21 days in Blocks 3 & 4. Fuel usage was recorded.

Wind speed was greater ($P<0.0001$) in pens when the fans were on (3.45 ± 0.08 and 0.85 ± 0.10 m/s respectively for Fans and No Fans, however there was no real effects on accumulated heat load. The use of fans did not ameliorate the impact of hot weather.

There were no treatment differences for DMI ($P=0.6394$) or feed:gain ($P=0.9997$). There were no treatment differences ($P=0.9342$) for ADG at 1.82 ± 0.10 kg/d and 1.83 ± 0.10 kg/d for Fans and No Fans respectively.

Hot standard carcass weight, dressing percentage, eye muscle area, marbling score and MSA Grade were not affected by treatment. Rib Fat Depth (mm) was greater ($P<0.0001$) for the Fans treatment at 7.21 ± 0.05 mm cv. 6.43 ± 0.05 mm for the No Fans treatment.

Panting scores (PS) were not affected by treatment ($P>0.1000$). Differences in Breed Type × Accumulated Heat Load were evident. A prediction model using multinomial logistic regression was developed for panting scores. The predicted probability of PS 2 was higher in BT3 (25% *Bos indicus*) for accumulated heat load ranging from 0 to about 26. Beyond accumulated heat load of 26, this probability becomes higher for BT4 (50% *Bos indicus*). However, predicted probability of PS 2.5 through 4.5 is higher for BT3 (25% *Bos indicus*) for each value of accumulated heat load above 15 units and very big differences were observed for higher values.

The predictive probability model appears to be useful in predicting the impact of hot conditions on panting score, at least for the two breed types used. The data does show that some cattle even with 50 to 75% *Bos indicus* content will respond to hot conditions by panting. Data from this study will be used to strengthen the predictive model in another MLA funded project (B.FLT.4006).

One of the perceived issues was that fans may have run for hours during early morning (0200 to 0600 h) when they were not needed e.g. cattle returned to 0 AHLU. Being able to link fans to some environmental measure such as AHLU or HLI for automated on/off could substantially reduce running costs. Another factor was natural wind. It was evident that natural wind flow could negate the effect of the fans.

Overall the use of fans did not elicit objective animal welfare or production benefits. The cost of using the fans over 73 days was $69.40 per animal (fans treatment) or $0.95 per day per animal, and as there were no production benefits it is unlikely that the fans would be a financially viable option.

Recommendations

- As there were no effect on objective measures of animal welfare, animal performance or carcase characteristics orchard fans did not have a value proposition for the lot feeder during this project.
- If work in the area of fan use at feedlots were to continue, then the type of fans and strategies for optimal use would need to be considered.
- Amelioration of heat load by other means such as use of shades, pen cleaning and nutritional management are currently better alternatives.

Table of contents

1 Background

Excessive heat load in feedlot cattle occurs when heat gain exceeds the ability of animals to lose heat through thermoregulation. Factors influencing heat gain/loss include solar radiation, pen surface radiation, metabolic heat production, wind speed, relative humidity and ambient temperature. Shade is a common strategy used by Australian lot feeders to prevent excessive heat gain by feedlot cattle. Regular pen cleaning is used to limit pen surface moisture and relative humidity during heat wave conditions, thereby increasing rate of heat loss from cattle via evaporation. However evaporative heat loss is enhanced by increasing wind speed, and a reduced wind speed can have negative impacts on the animal. Technologies to alter wind speed, which are common in dairies have not been implemented in beef cattle feedlots. Orchard fans are commonly used in Southern Australia fruit orchards to prevent frosts during the winter months. It is possible that Orchard fans could be used in a feedlot setting to improve air flow, in particular wind speed. An increase in wind speed may be useful in reducing the heat load on cattle, especially when natural airflow is limited. This project will determine the effect of orchard fans on feedlot cattle performance, health, welfare and profitability.

2 Project objectives

2.1 Research objectives

1. Determine the effects of orchard fans on feedlot cattle health, welfare, performance and carcass characteristics,
2. Determine the value proposition of orchard fans via ex-post cost benefit analysis, and
3. Determine the break-even leasing or purchase price of orchard fans for the amelioration of heat load

3 Methodology

3.1 Experimental Design

3.1.1 Treatments, pens and animals

A randomised complete block study was undertaken at a commercial feedlot (116 m above mean sea level), in Southeast Queensland, with two treatments (No Fans or Fans) with four pens per treatment being used. All pens were of mixed sex composition and un-shaded. A total of 1314 cattle were used (315 males and 999 females). Two breed types (BT) were identified: Breed Type 3 (BT3: 25% to 50% *Bos indicus* content), n=466 and Breed Type 4 (BT4: 50% to 75% *Bos indicus* content), n=848.The pen was the experimental unit. A total of eight pens were used in the study: No Fans (Control – 4 pens – pens 17, 18, 24 and 25) and (ii) Fans (4 pens – pens 14, 15, 27 and 28). Details of cattle within each treatment were: No Fans: 658 animals (244 BT3 and 414 BT4); Fans: 656 animals (224 BT3 and 432 BT4). Cattle were fed for the domestic market for an average of 73 days on feed, and were not implanted with hormonal growth promotants (HGPs).

Two rows of the feedlot were used. Within each row two adjacent pens were selected as control pens and another two adjacent pens were selected as treatment pens. Orchard fan position was randomised to a side within each row. A buffer pen separated the control and treatment pens in each row. The criteria for selecting pens was to ensure similar pen space and topography (pen details are provided below). All pens had a 4% slope from the front of the pen (feed bunk) to the rear of the pen. All of the pens used in the study were cleaned prior to the studies commencement.

Table 1. Pen and animal details.

Pen	Treatment	Pen Orientation	Pen Dimensions	Number/pen	BT3	BT4
14	Fan	East/West	50 × 30 m	180	64	116
15	Fan	East/West	50 × 30 m	176	99	77
16	Buffer Pen	-	-	-	-	-
17	Control	East/West	50 × 30 m	180	59	121
18	Control	East/West	50 × 30 m	178	108	69
	Laneway	-	-	-	-	-
24	Control	NNW/SSE[1]	29 × 42 m	150	31	119
25	Control	NNW/SSE	29 × 42 m	150	38	112
26	Buffer Pen	-	-	-	-	-
27	Fan	NNW/SSE	29 × 42 m	150	34	116
28	Fan	NNW/SSE	29 × 42 m	150	28	122

[1]NNW = North, north, west. SSE = South, south, east.

3.1.2 Animal Arrival, Induction and Treatment Allocation

Upon arrival at the feedlot, cattle were allowed to rest for 24 to 72 hours with access to good quality cereal hay *ad-libitum* (>8 % crude protein; <60 % NDF) or hay/silage diets, and *ad-libitum* access to clean drinking water. When enough cattle are obtained to fill a block (see Table 2), the cattle were inducted. For each block of the study, cattle were alternately allocated at induction to the two designated treatment pens (Table 2). When mixed sex pens were fed an attempt to have equal proportion of steers and heifers was made. Heifers were not pregnancy tested prior to arrival, or post arrival at the feedlot. The collaborating feedlot relied on the vendor's veterinary certification of pregnancy free status of incoming loads of feeder cattle.

Table 2. Block allocation to pens.

Block	Pens
1	Pens 15 & 18
2	Pens 14 & 17
3	Pens 25 & 27
4	Pens 24 & 28

3.1.2.1 Induction Procedures

Induction procedures were carried out on three occasions with blocks 1 and 2 on 17/01/2019, block 3 on 22/01/2019 and block 4 on 24/01/2019. At induction all cattle received a pour on for lice and fly treatment (Arrest Easy Dose Pour On, Virbac, Australia) dosed at 5 mL/100 kg liveweight and a management ear tag which had an individual identification number and lot number. The cattle also received an ear tag indicating the date at which they would be out of a withholding period arising from the pour on application (21 days post induction). At induction the following animal information was collected:

- Visual ID
- Breed
- Breed Type (3 or 4)
- Coat colour and length (short or long)
- Sex
- Dentition
- Live weight

Cattle were allocated to a treatment group (No Fan or Fan) by alternating the treatment allocation as the animals were processed i.e. animal 1 – No Fan, animal 2 – Fan, animal 3 – No Fan, and so on. Thirteen animals per pen were randomly selected to receive a rumen bolus for monitoring body temperature (see below for details). Cattle selected to receive a bolus were all heifers and BT4. Cattle satisfying these classifications were selected randomly as the animals were processed at induction. All cattle with a bolus had a red ear tag inserted in the right ear identifying the bolus number (1 to 104) to simplify identification within the pen.

3.1.3 Orchard Fans

Two Orchard fans (Tow and Blow; AIM Sales, Griffith, NSW) were used in the study. The Orchard fans were powered by a diesel motor with a 60 L fuel tank. This would allow approximately 12 h of continuous operation. The Orchard fans had an extendable boom which allowed the fans to be elevated above the pens. During fan operation in the current study, the boom was extended to a height of 8 m. The fan itself was angled downward and was set to oscillate so that air would be blown on to the pen surfaces. Each fan covered 2 adjacent pens. That is the fans were positioned on the fence line between the pens i.e. one fan was positioned between pens 14 and 15, and the other fan was positioned between pens 27 and 28. The fans were located approximately 5 m behind the pens. *(NB: Prior to the commencement of the study a pilot study was undertaken to determine the optimal location and boom height of the fans).*

The Orchard Fan treatment (from here on Fans) was activated (i.e. Fans turned on) at 1800 h on any day were the HLI was equal to or greater than 93 at or after 1200 h on that day. Once the Fans were turned on they then ran continuously until 0600 h the following morning.

Fuel usage was recorded each day. Maintenance and repair costs were documented to allow the running costs of the fans to be calculated.

3.1.3.1 Assessing wind speed across pens

Wind speed was monitored at different locations in all of the pens used via an anemometer (Kestrel 3500DT, Kestrel USA). The wind speed was obtained at 1.5 m above the pen surface. The anemometer was orientated toward the fan's direction in the pens with fans. Transects across the pen were conducted across the pen using a 5 m grid spacing. The wind speed in each pen was assessed on at least two occasions. An additional two readings were obtained from pens 27 and 28, and pens 24 and 25.

3.1.4 Weather Station Installation

Four weather stations (Weather Maestro 10 Channel Weather Station, Environdata Weather Stations Pty. Ltd., Warwick Qld.) were installed and calibrated by Environdata prior to the commencement of the study. The weather stations were installed parallel to dividing fences between the paired pens on the opposite side of the road from the feed bunk (approximately 4 m from the feed bunk). That is, a weather station was located between pens 14 and 15, 17 and 18, 24 and 25, and 27 and 28. Weather data (dry bulb temperature, relative humidity, solar radiation, black globe temperature, wind speed {2 m height} and wind direction were collected at 10 minute intervals over the duration of the study. These data were then used to calculate HLI and AHLU. Rainfall was collected on site on a daily basis at 0900 h. The weather data, HLI and AHLU were available real time which allowed continuous monitoring of weather conditions.

3.1.5 Rumen Temperature Boluses

Two types of radio transmitting rumen temperature boluses were used in the study. (i) SmaXtec Premium Bolus (SmaXtec, Austria); n = 70 and (ii) Smart Stock (Smart Stock, Pawnee, Oklahoma USA); n = 32. Both bolus types have relative measurement accuracy (temperature at 39°C ± 0.05°C). The Smart Stock boluses were cylindrical in shape (31 mm diameter by 83 mm in length) and weighed approximately 117 g. The boluses were an active RFID transmitter operating within a 915 to 928 MHz frequencies range and have a 90 m range. The radio signals were communicated real-time via a yagi antenna to a base station and were then transcribed to a database using proprietary software (TechTrol Inc., Pawnee, OK, USA). The SmaXtec boluses were cylindrical in shape (33 mm diameter by 130 mm in length) and weighed approximately 220 g. These boluses have an internal memory capacity of 50 days, and need to be connected to wifi for downloading. Given that wifi was not available on site, a standalone wifi device (Net Gear, 4G, Telstra, Australia) was used to provide a data link from the boluses to associated hardware (which required 240 volts) and subsequent downloading to a database. The hardware, 240 volt inverter and wifi device were located in a vehicle. The vehicle moved along the road in front of the pens to collect the bolus data. Data was obtained at the feedlot on three occasions, and again after slaughter. All boluses were recovered at slaughter. The rumen temperature data from both types was obtained at 10 minute intervals. In addition to rumen temperature the SmaXtec boluses also recorded animal activity.

All boluses were tested in a 39 ^{o}C water bath for 24 h prior to the commencement of the study. Any boluses that deviate greater than 0.5 ^{o}C from the water bath temperature were not used.

3.1.6 Feeding

Cattle were adapted to a finisher diet over an 18 day period using a two ration titration starting system (starter and finisher blended in different proportions). Within a block both the No Fan and Fan pens were transitioned to rations at the same days on feed (e.g. 14 and 17 were done on the same day). Once on the finisher diet cattle were fed once daily to *ad libitum* consumption levels. Cattle were targeted to be fed at a consistent time each day (± 15 minutes from target start time).

Three rations were used (i) Starter ration, (ii) Finisher ration and (iii) Heat Load ration. A composite sample of the Starter ration, the Finisher ration and the Heat Load Ration were taken each week and composited for monthly analysis. The samples were analysed for Dry Matter, Crude Protein, Neutral Detergent Fibre, Fat, Ash, and Metabolisable Energy was calculated (Symbio Laboratories Pty. Ltd. Brisbane).

Duplicate dry matters were conducted on a daily basis for both the starter and finisher diets. Samples were approximately 100 g and oven dried at 100 ^{o}C for a minimum of 16 h. Any orts remaining at the completion of the experiment were weighed back dry matter conducted.

Prior to the commencement of the study the mixer wagon was calibrated by a qualified technician. Scale checks on mixer wagons occurred at least once per week during the study period. Water troughs were cleaned twice per week.

3.1.7 Statistical Analysis

Weather data was categorized for statistical analysis based on maximum daily HLI (HLI_{CAT}) and maximum daily Accumulated Heat Load adjusted for breed type (AHL_{ADJ}). The following five categories of HLI_{CAT} were used: Cool <70, Moderate >70<77, Hot >77<85, Very Hot >85<95, and Extreme >95. For the AHL_{ADJ} five categories were used: No heat load < 0, Minor >0<10, Moderate >10 <20, Hot >20 <40, and Very Hot >40. Days on feed were also categorised as: DOF <20, DOF >20<40, DOF >40<60, and DOF >60.

Statistical Models:

Dry Matter Intake (DMI): The effects of Treatment (No Fans or Fans) on DMI were examined using PROC GLIMMEX (SAS Inst. Inc., Cary, NC, USA). The random effect was block. Pen was the experimental unit for DMI. PROC Mixed Model (SAS Inst. Inc., Cary, NC, USA) for a randomised block design using REML estimation was further used to determine interactions. In addition, the effects of the categorized weather parameters HLI_{CAT} and AHL_{ADJ} on DMI were examined as single parameter effects and as two and three way interactions e.g. Treatment (No Fans or Fans), HLI_{CAT} Categories, AHL_{ADJ} Categories, Days on Feed, Treatment × HLI_{CAT}, Treatment x AHL_{ADJ}, Treatment × DOF, Treatment × HLI_{CAT} × AHL_{ADJ}. Where there were no treatment effects on the measured variables, the variable data were combined and the impact of HLI_{CAT} and AHL_{ADJ} investigated. All data is presented as mean DMI at the pen level (kg/pen/day). Data are presented as least square means ± SE. When significance was indicated (P<0.05), means were separated using Tukey's Studentized range test.

Feedlot performance and carcase traits: Feedlot performance, carcass traits, and MSA Grading were analysed using a PROC Mixed Model (SAS Inst. Inc., Cary, NC, USA) for a randomised block design using REML estimation. Treatments were Fans and No Fans. Block was a random effect in the model. Pen was the experimental unit. Data are presented as least square means ± SE. When significance was indicated (P<0.05), means were separated using Tukey's Studentized range test.

Morbidity and Mortality: These traits were assessed using PROC GLIMMIX (SAS Inst. Inc., Cary, NC, USA). The random effect was block, and pen was the experimental unit. Data are presented as least square means ± SE. When significance was indicated (P<0.05), means were separated using Tukey's Studentized range test.

Rumen Temperature: Rumen temperature was analysed using a PROC Mixed Model (SAS Inst. Inc., Cary, NC, USA) for a randomised block design using REML estimation. The specific term for the repeated statement was animal within day. Treatment (No Fans or Fans) was a fixed effect. The effects of HLI_{CAT} and AHL_{ADJ} within and between treatments, and overall (all data combined) were also investigated. Animal was a random effect in the model, and pen was a fixed effect. Data are presented as least square means ± SE. When significance was indicated (P<0.05), means were separated using Tukey's Studentized range test.

Panting Score: Descriptive summary measures were used to quantify the proportion of cattle showing each of the panting score categories. Sub analysis based on treatment (Fan or No Fan), breed types and pen categories are performed. Panting scores were reclassified into two binary (PS 01, PS 2 and above) and three multinomial outcomes (PS 0 and 1, PS 2, PS 2.5 - 4.5). The corresponding number of cattle showing each of the panting scores were added to get the total counts in each of the reclassified panting score categories. Counts of cattle showing each of the panting scores was modelled using logistic regression with and without random effects. Binary outcome was modelled using Random Effects Logistic Regression. Since the same cattle were potentially observed for three times for several days, counts of cattle showing each of the panting scores could be clustered. Therefore, a random effect was represented by a variable constructed using the day and time of observation to account for potential clustering of the counts of cattle showing each of the panting scores. As a result, Random

Effects Logistic Regression was fitted using a logit link function with date and time of observation as random effect, and the ratio of number of cattle showing each of the panting scores to the total number of cattle was used as weight. The multinomial version of the panting score was modelled using a multinomial logistic regression without a random effect.

4 Results

4.1 Breed Type and Sex

There were some differences between treatments in regards to the number of heifers and steers and breed types. In the No Fans treatment there were 244 BT3 and 414 BT4 animals. The sex ratio was 151 steers and 507 heifers. For the Fans treatment there were 224 BT3 and 432 BT4 animals. The sex ratio for the Fans treatment was 163 steers and 493 heifers.

4.2 Morbidity and Mortality

There were no mortalities during the study period. During the study period 25 steers from the Fans pens were removed from the pens for veterinary treatment and 21 steers were removed from the No Fans pens (Table 3). All of these animals returned to their pens following treatment. Across treatments, 37 were treated for BRD, 5 for lameness, and 1 each for PEM, pink eye, diphtheria and injury.

On a pen basis the Fan treatment had a mean of 6.25 ± 2.58 animals per pen treated for illness (morbidity) during the study compared with 5.25 ± 2.58 animals per pen in the No Fan treatment (P=0.7931). Two pregnant animals were removed from the study. One was removed from the study at the end of the first week and the other at the end of the study (day of transport of pen to slaughter). No live weight was available for the first animal. The second had a live weight (post calving) of 486 kg. Both of these were from the No Fans treatment (NB because these animals were removed due to pregnancy this cannot be attributed as a treatment effect).

Table 3. Morbidity and mortality.

	Fans	No Fans	SE	P-value
Total Head In	656	658	-	-
Total Slaughtered	656	657	-	-
Total Rejects	0	2*	-	-
Total Morbidity**	25	21	-	-
Average Morbidity/pen	6.25	5.25	2.58	0.7931
Total Mortality	0	0	-	-

*One was sold during the trial period, and the other was not. Hence there is only 1 less animal slaughtered for the No Fans treatment.
** Individual animals treated for illness.

4.3 Climate Conditions and Fan Use

The weather parameters are presented in Table 4. The maximum ambient temperature (TA) recorded was 40.4 ^{o}C, maximum black globe temperature (BG) was 51.8 ^{o}C, maximum HLI was 109.85 units, maximum AHLU for BT3 was 42.49 units, and for BT4 it was 24.80 units. There were 24 days (out of 64 with full data sets – all weather station data combined) when TA < 30 °C and 42 days when TA > 30 °C. Of the days exceeding 30 °C, 27 days had a TA > 35 °C and 40 °C was exceeded on 1 day.

Table 4. Mean (± SE) for relative humidity (RH, %), ambient temperature (TA, °C), black globe temperature (BG, °C), solar radiation (SR, Watts/m^2), wind speed (WS, m/s), heat load index (HLI, units), accumulated heat load (AHL, units) and temperature humidity index (THI, units).

Item	Pens 14 & 15 Fan	Pens 17 & 18 Control	Pens 24 & 25 Control	Pens 27 & 28 Fan
RH, %	68.51 ± 0.15	68.17 ± 0.15	67.92 ± 0.14	66.35 ± 0.16
TA, °C	24.39 ± 0.04	24.50 ± 0.04	24.28 ± 0.04	25.19 ± 0.04
BG, °C	27.04 ± 0.07	27.08 ± 0.07	27.14 ± 0.06	28.33 ± 0.07
SR, Watts/m^2	204.26 ± 2.24	195.19 ± 2.22	178.20 ± 1.93	201.13 ± 2.38
WS, m/s	1.35 ± 0.01	1.14 ± 0.01	1.53 ± 0.10	1.49 ± 0.01
HLI, units	71.73 ± 0.10	72.29 ± 0.10	71.52 ± 0.15	73.13 ± 0.10
AHL, units	1.90 ± 0.05	3.05 ± 0.06	1.86 ± 0.04	2.09 ± 0.05
THI, units	71.90 ± 0.05	71.98 ± 0.04	71.74 ± 0.04	72.19 ± 0.04

The maximum daily HLI is a better indicator of the heat load than TA alone. The maximum HLI was ≤85 on 6 days, 85.1 to 90.0 on 12 days, 90.1 to 95 on 9 days, 95.1 to 100 on 19 days and >100 on 18 days. These data suggest that the cattle would have been under high heat load for at least some part of the 37 days when HLI>95.

Accumulated Heat Load Units were determined for both breed types. In summary the AHLU for BT3 was 0 on 20 days (i.e. No heat load), >0 <10 (Minor) on 27 days, >10 <20 (Moderate) on 7 days, >20<40 (Hot) on 8 days, and >40 (Very Hot) on 2 days (Figure 1). For the BT4 cattle the AHLU was 34 days (No heat load), 22 days at Minor heat load, 7 days of Moderate heat load and 1 day was classified as Hot.

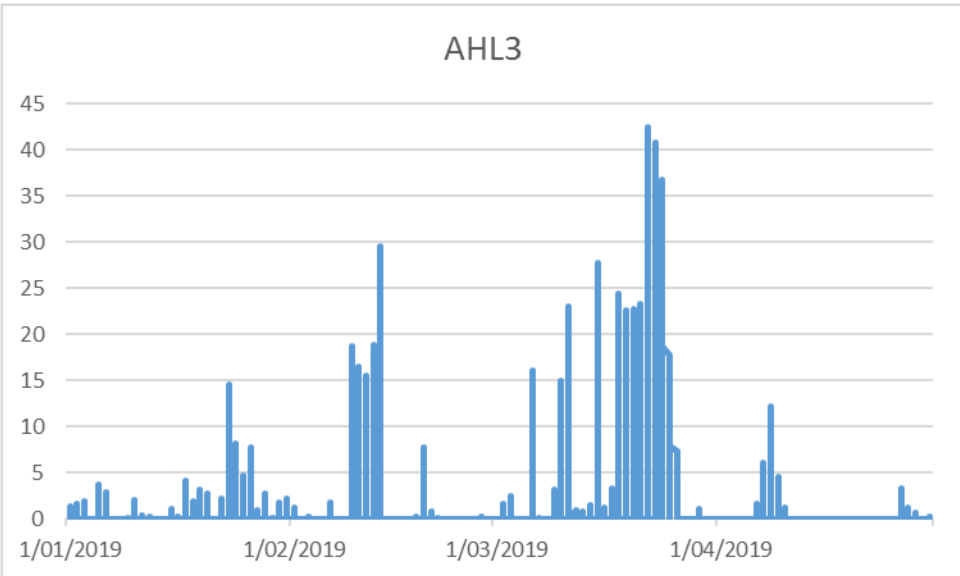

Figure 1. The accumulated heat load units adjusted for breed type 3 (AHL3) over the duration of the study.

4.3.1 Fan Operation

There were a total of 28 days where the HLI ≥ 93 at or after 1200 h for Pens 14 and 15, and 24 days for Pens 27 and 28. The difference is due to the staggered start of the study and some non-operational days for the Fans. However, the Fans were only used on 26 days for Pens 14 and 15, and 21 days for Pens 27 and 28. The Fan located at Pens 14 and 15 was not operational for 2 days when HLI ≥ 93, and the Fan located at pens 27 and 28 was not operational for 3 days when HLI ≥ 93.

The Fans ran for a total of 614.9 h and used 3124.95 L of diesel ($4,145.25). Detailed costing is presented is Section 5 of this report.

4.3.2 Effect of Fan Operation on Pen Wind Speed and Accumulated Heat Load

The wind speed was measured across each pen (5 × 5 m grids) in order to assess the effect of the Fans (or No Fans) on wind speed at a height of 1 m above the pen floor. In pens 14, 15, 17 and 18 there were 60 grids. For pens 24, 25 27 and 28 there were 48 grids. This was due to the different pen sizes. Data was collected four times from pens 24, 25, 27 and 28, and twice from pens 14, 15, 17 and 18. Wind speed was greater ($P<0.0001$) across the pens with Fans (14, 15, 27 and 28) compared with those with No Fans (17, 18, 24 and 25) at 3.45 ± 0.08 m/s and 0.85 ± 0.10 m/s for Fans and No Fans respectively. In general, the greatest 'wind' affect from the Fans was in the lower one third of the pen. Natural wind speeds greater than approximately 3 m/s (this was difficult to quantify) appeared to negate and wind effects from the fans. Especially if the natural wind flow was towards or across the direction of fan airflow.

4.4 Feed Analysis

The nutrient analysis for the diets used during the study are presented in Table 5. There is a large difference in percentage NDF between the heat load ration used in February (45.4%) and the heat load ration used in March (20.6%). This was due to a ration ingredient change where a large amount of biscuit meal was used in the March ration compared with the February ration.

Table 5. Nutrient composition of the starter, finisher and heat load rations used during the study.

Item	Starter	Finisher (Feb[B])	Heat Load (Feb)	Finisher (Mar)	Heat Load (Mar)	Finisher (Mar)
Nutrient Composition (DM Basis)						
DM, %	66.9	74.5	74.8	72.5	72.3	73.0
NDF, %	64.9	22.0	45.4	22.3	20.6	24.9
Fat, %	1.9	6.6	7.0	5.6	6.5	6.6
Protein, %	10.2	11.9	12.2	13.1	12.9	13.2
Crude Fibre, %	35.8	8.6	7.4	8.0	6.4	5.8
Ash, %	8.7	7.3	10.5	8.3	9.1	10.6
Moisture (air), %	33.1	25.5	25.2	27.5	27.7	27.0
Nitrogen Free Extract, %	43.4	65.6	62.9	64.9	65	63.7
ME, MJ/kg[A]	9.7	13.1	12.8	12.8	13.0	12.9

[A]ME (MJ/kg, DM) = 0.12 x Crude Protein + 0.31 × Ether Extract + 0.005 × Crude Fibre + 0.14 × Nitrogen Free Extract.
[B]Feb = February, Mar = March.

4.5 Days on Feed, Cattle Growth Rates, Dry Matter Intake (DMI), and Carcass Characteristics

Effects of treatment on feedlot cattle performance and carcase traits are presented below. Treatment had no effect on initial body weight (P=0.3456), final body weight (P=0.1761) and total weight gain (P=0.3425) (Table 6). There were no treatment effects for ADG ($kg.d^{-1}$) or DMI ($kg.d^{-1}$) on a pen basis (Table 6). In regards to carcass traits only rib fat depth (mm) and pH (units) differed between treatments (Table 6).

Table 6. Growth performance, days on feed, average daily gain, average dry matter intake and carcass characteristics for the Fans and No Fans treatments.

	Fans	No Fans	SE	P-value
Initial Body Weight, kg	334.80	333.65	13.58	0.3456
Final Body Weight, kg	469.91	467.46	8.88	0.1761
Total Body Weight Gain, kg	135.32	133.59	9.82	0.3425
Days on Feed	73.42	73.41	0.22	0.9751
ADG, $kg.d^{-1}$	1.82	1.83	0.10	0.9342
DMI, $kg.d^{-1}$	10.46	10.54	0.13	0.6806
F:G (DM Basis)	5.81	5.81	0.13	0.9997
HSCW, kg	248.85	248.11	6.14	0.4589
Dressing Percentage, %	52.97	53.08	0.33	0.2684
EMA, cm^2	73.89	73.99	1.76	0.7908
Ossification Score	143.18	140.35	3.81	0.0929
P8 Fat Depth, mm	11.64	11.28	0.68	0.1390
Rib Fat Depth, mm	7.21^a	6.43^b	0.50	<0.0001
pH, units	5.50^a	5.52^b	0.02	0.0036
MSA Marbling Score	272.29	272.37	7.21	0.9887
MSA Grade	57.69	57.54	0.18	0.4344

ADG and DMI are presented on a pen within treatment basis. Initial and final live weights, carcass data are the means (within treatment) of individual animal measures.

4.5.1 Weather effects on DMI

There were no treatment effects (P=0.8768) on DMI when HLI exceeded 93. When HLI > 93 the DMI were 1669.24 ± 42.67 kg/pen/day and 1676.13 ± 39.27 kg/pen/day respectively for the No Fans and Fan treatments. There were no Treatment × HLI_{CAT} effects (P=0.7756) on DMI.

4.5.2 Rumen Temperature

A total of 51,970 data points were analysed for rumen temperature (RT).

There were Treatment, HLI_{CAT} and Treatment × HLI_{CAT} interactions for rumen temperature (P<0.0001). The mean RT of the No Fans treatment was 39.49 ± 0.01 °C, compared with 39.50 ± 0.01 °C for the Fans treatment. Although the differences are significantly significant (with a 0.01 °C difference) it is probable that this is a reflection of the large data set and may not be of biological significance.

The Treatment × HLI_{CAT} interactions are presented in Table 7. Within both treatments RT decreases as HLI_{CAT} moves from Cool to Extreme. While this is somewhat counter intuitive we speculate that this may be due to the increased water consumption and decreased feed intake as conditions became hotter.

Table 7. The effect of the interaction between Treatment and HLI_{CAT} on rumen temperature (°C)

Treatment	HLI_{CAT}	Rumen Temperature ± SE
No Fans	Cool	39.56 ± 0.01[a]
	Moderate	39.50 ± 0.01[d]
	Hot	39.38 ± 0.01[c]
	Very Hot	39.37 ± 0.01[e]
	Extreme	39.35 ± 0.01[b]
Fans	Cool	39.57 ± 0.01[a]
	Moderate	39.53 ± 0.01[h]
	Hot	39.40 ± 0.01[g]
	Very Hot	39.41 ± 0.01[g]
	Extreme	39.43 ± 0.01[f]

All data was combined (i.e. rumen temperatures from both treatments combined) to investigate the impact of HLI_{CAT} and AHL_{ADJ} on RT (Table 8).

Table 18. The effect of HLI_{CAT}, and AHL_{ADJ} on rumen temperature.

Item	Rumen Temperature, °C
HLI_{CAT}	
Cool	39.57 ± 0.01[a]
Moderate	39.51 ± 0.01[c]
Hot	39.39 ± 0.01[b]
Very Hot	39.39 ± 0.01[b]
Extreme	39.39 ± 0.01[b]
AHL_{ADJ}	
Cool	39.40 ± 0.01[a]
Moderate	39.67 ± 0.01[c]
Hot	39.81 ± 0.01[b]
Very Hot	40.01 ± 0.01[d]

4.5.3 Panting Score

A total of 35,294, 37,226, 35,163, 34,593, 31,819, 35,689, 27,205, and 28,083 cattle observations, respectively, were made in pens 14, 15, 17, 18, 24, 25, 27, and 28. More than 80% of the cattle in each pen showed a panting score 0 or 1. Between 8.79% (pen 24) and 12.3% (pen 18) of the cattle showed a panting score 2. Approximately 19% of cattle in pen 15 and 11% of cattle in pen 18 showed a panting score 2.5. Moreover, 13% of cattle in pen 18 and 5% of cattle in pens 14, 17 and 25 showed a panting score 3 (Table 9). Very few animals exceed a panting score of 3.

Table 9. Panting score (PS) counts (%) by pens.

		Counts of cattle showing each of the panting scores in each pen (%)						
Pen	Total Cattle	0&1	2	2.5	3	3.5	4	4.5
14	35,294	31,996 (90.66)	3,233 (9.16)	33 (0.09)	19 (0.05)	7 (0.02)	6 (0.02)	2 (0.01)
15	37,226	33,185 (89.14)	3,896 (10.47)	71 (0.19)	38 (0.1)	22 (0.06)	13 (0.03)	10 (0.03)
17	35,163	31,410 (89.33)	3,637 (10.34)	29 (0.08)	18 (0.05)	10 (0.03)	4 (0.01)	2 (0.01)
18	34,593	30,227 (87.38)	4,256 (12.3)	38 (0.11)	44 (0.13)	30 (0.09)	20 (0.06)	14 (0.04)
24	31,819	28,972 (91.05)	2,798 (8.79)	15 (0.05)	12 (0.04)	14 (0.04)	8 (0.03)	1 (0)
25	35,689	32,037 (89.77)	3,608 (10.11)	16 (0.04)	17 (0.05)	6 (0.02)	5 (0.01)	1 (0)
27	27,205	24,001 (88.22)	3,168 (11.64)	18 (0.07)	8 (0.03)	7 (0.03)	3 (0.01)	0 (0)
28	28,083	25,200 (89.73)	2,855 (10.17)	18 (0.06)	6 (0.02)	4 (0.01)	0 (0)	0 (0)

When PS counts (%) were investigated according to pen and BT, marked difference between the BT was observed. A range from 11.29% to 16.34% for BT3 showed a panting score 2 whereas the range was 7.87% to 10.89% for BT4 (Table 10).

Table 10. Distribution of panting score counts (%) by pen and breed type.

			Counts (%) of cattle showing panting scores by pen and breed types						
Pen	BT	Total Counts	0&1	2	2.5	3	3.5	4	4.5
14	3	12,479	11,020 (88.31)	1,409 (11.29)	22 (0.18)	17 (0.14)	5 (0.04)	6 (0.05)	2 (0.02)
15	3	21,077	18,558 (88.05)	2,398 (11.38)	54 (0.26)	32 (0.15)	22 (0.1)	13 (0.06)	9 (0.04)
17	3	11,649	10,098 (86.69)	1,450 (12.45)	19 (0.16)	15 (0.13)	9 (0.08)	3 (0.03)	2 (0.02)
18	3	21,549	18,606 (86.34)	2,836 (13.16)	29 (0.13)	37 (0.17)	22 (0.1)	19 (0.09)	14 (0.06)
24	3	6,603	5,751 (87.1)	814 (12.33)	9 (0.14)	8 (0.12)	13 (0.2)	8 (0.12)	1 (0.02)
25	3	9,044	7,900 (87.35)	1,118 (12.36)	9 (0.1)	10 (0.11)	4 (0.04)	3 (0.03)	1 (0.01)
27	3	6,084	5,070 (83.33)	994 (16.34)	11 (0.18)	3 (0.05)	3 (0.05)	3 (0.05)	0 (0)
28	3	6,176	5,380 (87.11)	780 (12.63)	11 (0.18)	3 (0.05)	2 (0.03)	0 (0)	0 (0)
14	4	22,815	20,976 (91.94)	1,824 (7.99)	11 (0.05)	2 (0.01)	2 (0.01)	0 (0)	0 (0)
15	4	16,149	14,627 (90.58)	1,498 (9.28)	17 (0.11)	6 (0.04)	0 (0)	0 (0)	1 (0.01)
17	4	23,514	21,312 (90.64)	2,187 (9.3)	10 (0.04)	3 (0.01)	1 (0)	1 (0)	0 (0)
18	4	13,044	11,621 (89.09)	1,420 (10.89)	9 (0.07)	7 (0.05)	8 (0.06)	1 (0.01)	0 (0)
24	4	25,216	23,221 (92.09)	1,984 (7.87)	6 (0.02)	4 (0.02)	1 (0)	0 (0)	0 (0)
25	4	26,645	24,137 (90.59)	2,490 (9.35)	7 (0.03)	7(0.03)	2(0.01)	2(0.01)	0(0)
27	4	21,121	18,931 (89.63)	2,174 (10.29)	7 (0.03)	5(0.02)	4(0.02)	0(0)	0(0)
28	4	21,907	19,820 (90.47)	2,075 (9.47)	7 (0.03)	3(0.01)	2(0.01)	0(0)	0(0)

Comparing cattle within Fan and No Fan pens, evidence of difference in the proportion of cattle with higher panting scores was absent. As it can be seen from Table 11, similar percentages of cattle in the Fan and No Fan treatments had panting scores 2 through to 4.5.

Table 11. Distribution of panting score counts (%) by pen and treatment (fan).

Pen	Treatment	Total Counts	Counts (%) of cattle showing panting scores by pen and treatment						
			0&1	2	2.5	3	3.5	4	4.5
14	Fan	35,294	31,996 (90.66)	3,233 (9.16)	33 (0.09)	19 (0.05)	7(0.02)	6 (0.02)	2 (0.01)
15	Fan	37,226	33,185 (89.14)	3,896 (10.47)	71 (0.19)	38 (0.1)	22 (0.06)	13 (0.03)	10 (0.03)
27	Fan	27,205	24,001 (88.22)	3,168 (11.64)	18 (0.07)	8 (0.03)	7 (0.03)	3 (0.01)	0 (0)
28	Fan	28,083	25,200 (89.73)	2,855 (10.17)	18 (0.06)	6 (0.02)	4 (0.01)	0 (0)	0 (0)
17	No Fan	35,163	31,410 (89.33)	3,637 (10.34)	29 (0.08)	18 (0.05)	10 (0.03)	4 (0.01)	2 (0.01)
18	No Fan	34,593	30,227 (87.38)	4,256 (12.3)	38 (0.11)	44 (0.13)	30 (0.09)	20 (0.06)	14 (0.04)
24	No Fan	31,819	28,972 (91.05)	2,798 (8.79)	15 (0.05)	12 (0.04)	14 (0.04)	8 (0.03)	1 (0)
25	No Fan	35,689	32,037 (89.77)	3,608 (10.11)	16 (0.04)	17 (0.05)	6 (0.02)	5 (0.01)	1 (0)

As it can be seen from the model output summarized in Table 12. Breed Type and AHLU for breed type 4 (AHL4) were statistically significant predictors of higher panting scores. Treatment with Fan was not statistically different (P=0.3050) to No Fan. Breed Type 4 was less likely to show higher panting scores. The odds of higher panting score were up to 38% (OR = 0.62, 95% CI: 0.43, 0.87) lower in BT4. An increase in AHL4 was accompanied with increased odds of higher panting scores. Odds of higher panting score increases by 20% (OR = 1.20, 95% CI: 1.15, 1.24) for a unit increase in AHL4.

Table 12. Random effects logistic regression model output.

	PS Outcome		
Predictors	Odds Ratios	CI	p-value
(Intercept)	0.01	0.01 – 0.02	<0.001
BT4	0.62	0.43 – 0.87	0.006
AHLU 4	1.20	1.15 – 1.24	<0.001
Fan	*0.80*	*0.52 – 1.22*	*0.305*
Random Effects			
Var_{animal}	3.29		
Var_{wave}	4.86		
ICC_{wave}	0.60		
N_{wave}	1,472		
Observations	6,463		
Marginal R^2 / Conditional R^2	0.097 / 0.636		

Var_{animal} = Variance at animal level,
Var_{wave} = Variance due to day and time fluctuations,
ICC_{animal} = Intra Class Correlation Coefficient.
N_{wave} = The number of date and day hour combinations

To help explain the above model results, an illustrative example is given to aid interpretation of Figure 2. An AHLU level of 30 was associated with a predicted probability of elevated panting score of 72% with a 95% confidence interval ranging from about 55% to 84% representing an average 72% of cattle observed across all days and hours with panting scores of 2 or greater.

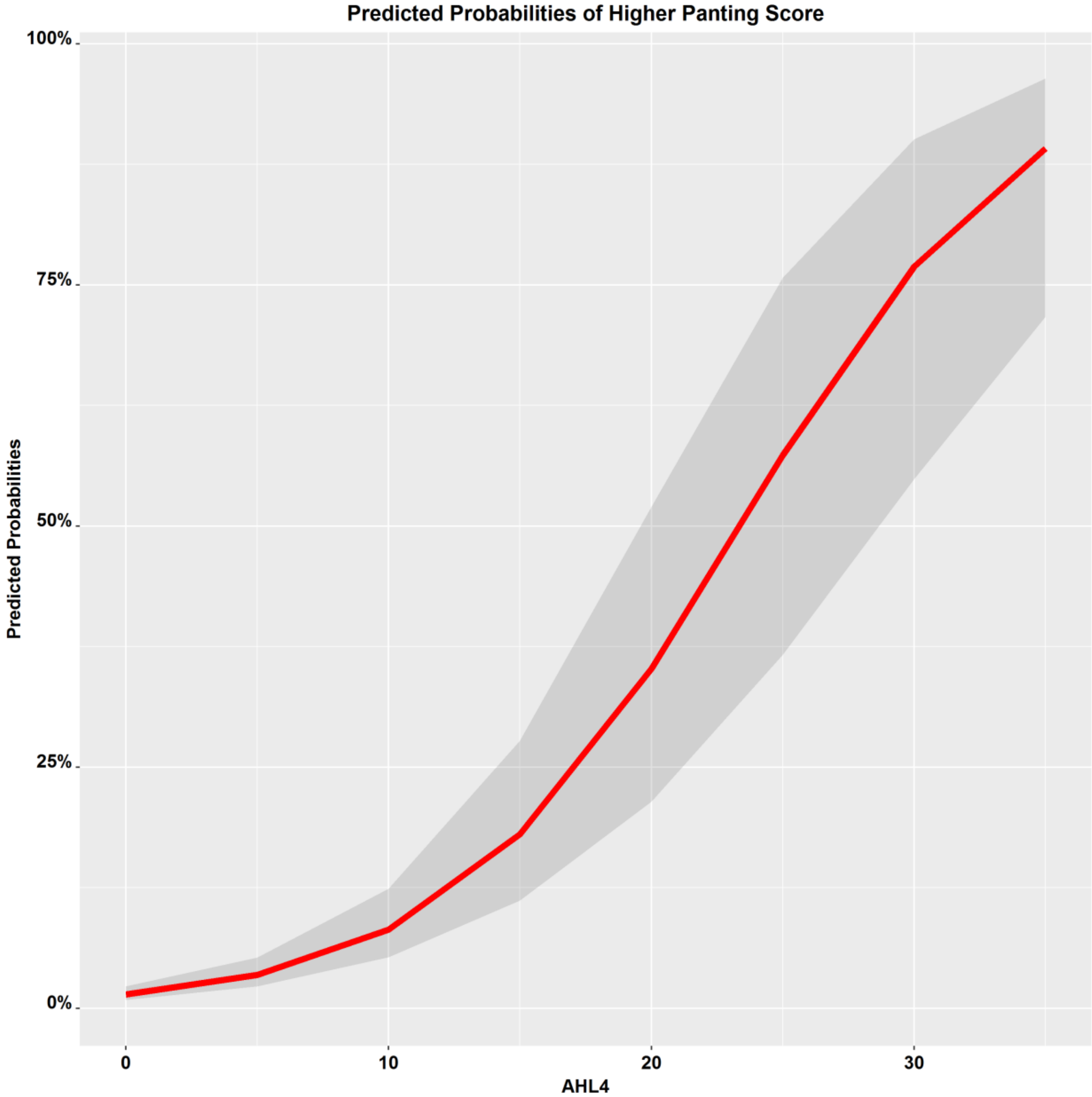

Figure 2. Predicted probability of elevated panting score (PS ≥2) for "AHL" levels. The shaded bands represent 95% confidence intervals. Predicted probabilities derived from a multivariable mixed effects logistic regression model.

The intra class correlation coefficient (ICC) measures unexplained or residual variance in the outcome of interest (proportion of animals with elevated panting score), derived from the multivariable random effect model. Explained variance is the variance in the outcome of interest that has been explained by the addition of fixed effects (BT, AHL4 and treatment) to the model. At a conceptual level we assume that the total variance in the outcome (for a dataset) is constant. When fixed effects are added to a multilevel model they will be expected to explain some of the variance in the outcome and the residual (or unexplained) variance will be reduced. In a mythical, perfect model where fixed effects explain almost all of the variance in the outcome, there would be almost zero unexplained (residual) variance. In most models, fixed effects explain some of the variance and the remaining variance is then distributed amongst the random effects.

Inspecting the statistical model output, the random effect (variance estimate) is statistical different to zero, i.e., showing presence of date and time level variance. The statistical model output indicated a variance for the date and time level effect of 0.60. Looking at Figure 3, where the confidence intervals for the plotted variance cross the zero line, the unexplained variance for that individual date and hour combination is not different to the unexplained variance averaged over all days and time combinations. Where the entire confidence interval is below the zero line, the proportion of animals with elevated panting score in that date and hour combination is expected to be significantly lower than the average across all days and hours combinations. Where the entire confidence interval for a date and hour combination is above the zero line (at the right end of Figure 3), the date and hour combination has a significantly higher proportion of animals with elevated panting score compared to the average across days and hours combination.

Some inferences can be drawn from Figure 3. Most of the individual date and hour combination estimates shown in Figure 3 have confidence intervals that cross the zero line, meaning that for these date and hour combinations there is no significant variation in proportion of animals with elevated panting score – they are all within the confidence limits of the overall average. However, there are some date and hour combinations that have significantly higher proportions of animals with elevated panting scores. This suggests that there is some degree of significant date and hour-level variation in probability of elevated panting score and that further work may be needed to understand what characteristics of individual pens might explain reduced or elevated risk of elevated panting score.

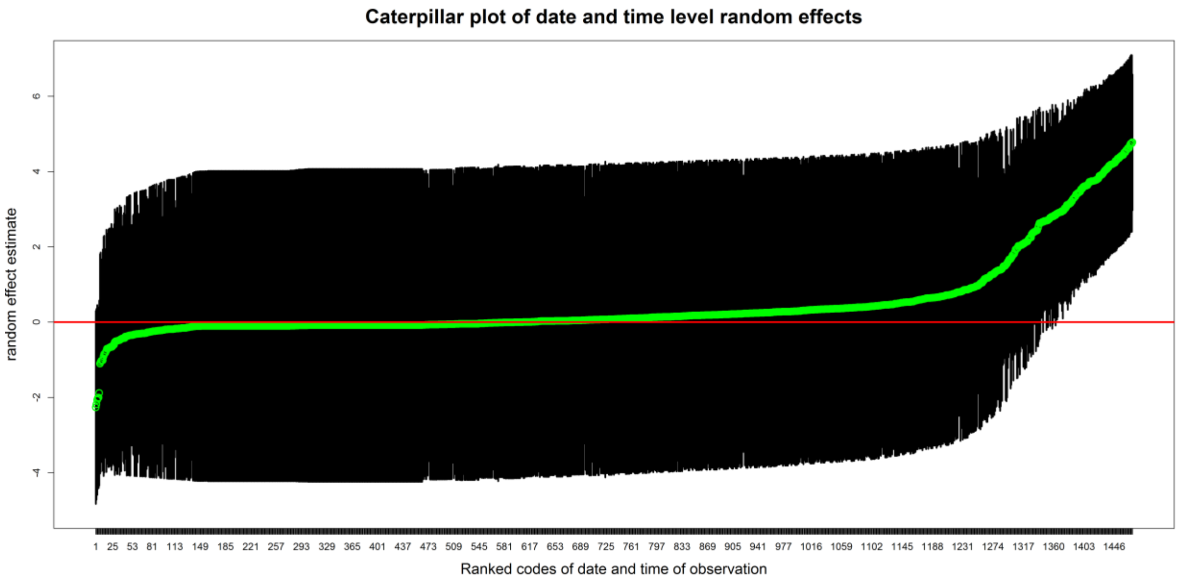

Figure 3. Caterpillar plot of the date and time level random effects. It represents the unobserved variance that could be attributed to variation between day and time.

In the multinomial model which compares PS 0&1 with PS 2 and PS 0&1 with PS 2.5 to 4.5, BT and AHL4 were found to be statistically significant predictors of higher panting scores (Table 13). In this model, a unit increase in AHL4 is followed by 13.2% increase in the odds of higher PS when comparing PS 0&1 against PS 2. In addition, the odds of higher PS increase by 25.5% for a unit increase in AHL4 when comparing PS 0&1 against PS 2.5 through 4.5. In general, BT4 had a lower risk of higher panting score compared with BT3. In the model comparing PS 0&1 against PS 2, BT4 had 31.3% (OR = 0.687, 95% CI: 0.665, 0.708) lower odds of higher panting score than BT3. Similarly, in the model comparing PS 0&1 against PS 2.5 through PS 4.5, BT4 had significantly lower odds of higher panting scores. The odds of an elevated panting score (PS 2.5-4.5) compared to baseline panting score (PS 0&1) in 50%

Bos indicus were 0.141 compared to 25% *Bos indicus* (95% CI 0.111 to 0.178). This represents an 86% reduction in the odds of elevated panting scores for the 50% *Bos indicus* category (BT4) compared to the 25% *Bos indicus* category (BT3).

Table 13. Baseline category multinomial model comparing PS 0&1 against PS 2 and PS 2.5 to PS 4.5.

						95% CI		
		Coef	SE	Z	P-value	OR	LL	UL
PS 0&1 vs PS 2	(Intercept)	-2.304	0.014	-164.571	<0.001	0.1	0.097	0.103
	AHL4	0.124	0.001	124	<0.001	1.132	1.13	1.134
	Treatment NF	-0.008	0.017	-0.471	0.638	0.992	0.96	1.026
	Breed 2 (50% Bos i)	-0.376	0.016	-23.5	<0.001	0.687	0.665	0.708
PS 0&1 vs PS 2.5-4.5	(Intercept)	-6.336	0.095	-66.695	<0.001	0.002	0.001	0.002
	AHL4	0.227	0.006	37.833	<0.001	1.255	1.24	1.27
	Treatment NF	-0.053	0.121	-0.438	0.661	0.948	0.748	1.202
	Breed 2 (50% Bos i)	-1.959	0.12	-16.325	<0.001	0.141	0.111	0.178

CI = Confidence Interval, Coef = model coefficient on the log scale, SE = Standard Error, Z = Calculated Standard Normal Score, P-value = probability of getting the observed result by chance, OR = Odds Ratio, LL = Lower Limit of the 95% CI and UL = Upper Limit of the 95% CI.

Predicted probabilities of higher PS are shown in Figure 4 from the baseline category multinomial logistic regression. Predicted probability of PS 2 was higher in BT3 (25% *Bos indicus*) for AHL4 ranging from 0 to about 26. Beyond AHL4 26, this probability becomes higher for BT4 (50% *Bos indicus*). However, predicted probability of PS 2.5 through 4.5 is higher for BT3 (25% *Bos indicus*) for each value of AHL4 above 15 units and very big differences were observed for higher values of AHL4 (Figure 12). The reduction in the probability of PS2 for BT3 when AHL4 exceeds 25 units is a reflection of their shift to PS≥2.5, and not a reduction in PS.

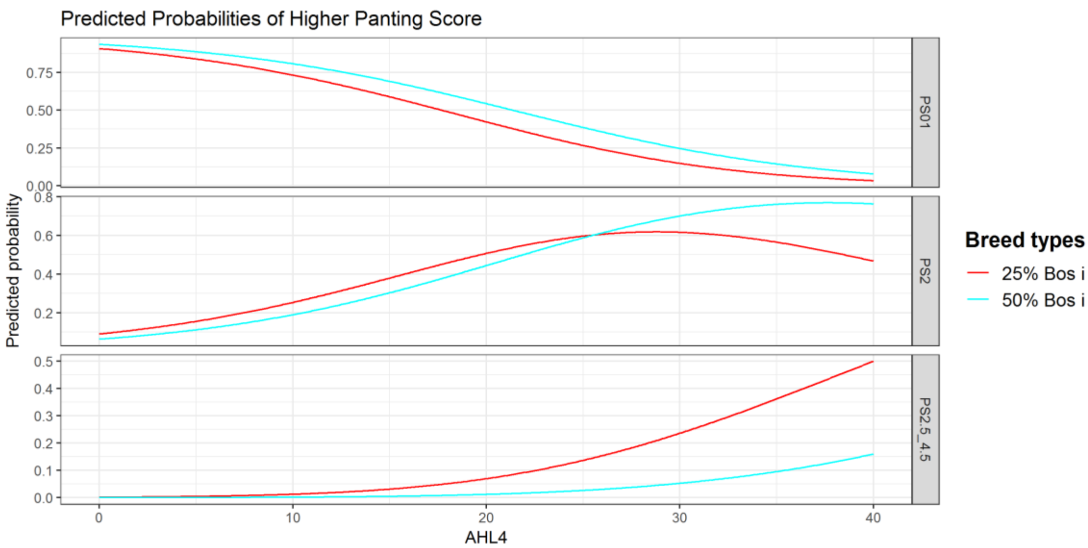

Figure 4. Predicted probability of elevated panting score (PS ≥2) for “AHL” levels by breed types. Predicted probabilities derived from a baseline category multinomial multivariable logistic regression model.

5 Cost comparison Fans vs No Fans

Cattle purchase, induction, feed and transport were similar between treatments (Table 14). Labour costs associated with each treatment have not been itemised but the assumption is that labour costs were also similar between treatments.

Overall the fans added an additional $45,522.29 in costs over the duration of the study. This equates to $11,103.73 per pen. As there were no production benefits from the use of the fans the Fans treatment returned a net loss of $45,522.29.

Table 14. Cost breakdown between the No Fan and Fan treatments.

Item	No Fans	Fans
Cattle Purchase	$685,019.65	$686,310.00
Induction	$935.44	$932.44
Feed	$236,127.29	$236,692.28
Transport	$7,086.75	$7,086.70
Health	2,100.00	$2,500.00
Fan Items		
Labour	-	$267.48
Fuel	-	$4,145.25
R&M	-	$202.33
Fan Hire	-	$37,263.38
Total Cost	$929,926.75	$974,341.68
Carcass value	$1,020,261.87	$1,019,153.80
Difference in return	-	-$45,522.99

The total cost of using the fans was $45,522.99, which equates to approximately $69.30 per animal exposed to the fans or $0.95 per day per exposed animal.

6 Discussion

6.1 Impact of Fan Use

6.1.1 Accumulated heat load

There were enough hot days over the duration of the study to see a heat load response in the cattle (e.g. increased panting scores) and reductions in DMI. There were 28 days when the HLI ≥ 93 at or after 1200 h which was the trigger for fan usage from 1800 h on that day until 0600 h the following day. Fans increased the airflow across the pens during operation but they did not appear to have a major influence on reducing AHLU within a pen.

6.1.2 DMI

Dry matter intake (pen level intakes) was affected by hot conditions, and this was not ameliorated by fan use i.e. there were no treatment effects. There were also no treatment effects for feed:gain.

6.1.3 Growth and Carcass

Average daily gain (ADG) and carcass traits were examined on a pen basis (pens within treatment). Overall growth performance and carcass characteristics were in the expected range. Health of the cattle was generally very good (3.5% morbidity). There were no treatment effects for ADG, HSCW, dressing percentage, eye muscle area, MSA marbling score and MSA Grade were not affected by treatment. Rib Fat Depth was greater in the Fans treatment compared with the No Fans. The difference in rib fat could be confounded by slight differences in sex ratio and BT ratios between treatments, and therefor may not be a treatment effect *per se*.

6.1.4 Rumen Temperature

Although there was a significant difference between treatments for rumen temperature the difference was only 0.1 ^{o}C – it is doubtful that this is of any biological significance. It is likely that the statistical difference is a reflection of the large data set rather than a 'real' treatment effect. One notable outcome was that rumen temperature decreased as heat load increased. We speculate that this is due to reduced DMI and increased water intake during the hotter periods.

6.1.5 Panting Score – Predictive Model

More than 265,000 panting scores were collected across the two breed types. There were no treatment differences for panting score. Only breed type and accumulated heat load thresholds for BT4 (HLI=96) were significant and used in the predictive model. As was presented in Figure 12 the panting score probability model predicted that the probability of PS 2 was higher in BT3 for an AHL4 ranging from 0 to about 26. Beyond AHL4 26, this probability becomes higher for BT4 (50% *Bos indicus*). However, predicted probability of PS 2.5 through 4.5 is higher for BT3 (25% *Bos indicus*) for each value of AHL4 above 15 units and very big differences were observed for higher values of AHL4. The reduction in the probability of PS2 for BT3 when AHL4 exceeds 25 units is a reflection of their shift to PS≥2.5, and not a reduction in PS. This makes biological sense and although based on some limited data (1 feedlot) it does suggest that the model is robust. More data has been collected (B.FLT.4006) and these new data plus the data from the current study will be used to further refine the model.

6.1.6 Cost Comparison

There appears to be no production benefits of using fans compared to the No Fans treatment. At $11,103.73 per pen ($69.40/animal) there is no financial justification for using the fans as they were used in the current study.

7 Conclusions/recommendations

7.1 Conclusions

While there is no financial justification for using the fans as they were used in the study, however the timing of the use of the fans could be further investigated. It also needs to be remembered that the cattle used in the current study were 25% to 75% *Bos indicus*. It is possible that a different result would be obtained if 100% *Bos taurus* cattle were used. One of the identified issues was that fans may have run for a number of hours during early morning (0200 to 0600 h) when they were not needed e.g. cattle returned to 0 AHLU. Being able to link fans to an environment measure such as AHLU or HLI for automated on/off could substantially reduce running costs. Another factor was natural wind. It was evident that natural wind flow could negate the effect of the fans. The fans appeared to be most beneficial on hot days (HLI>93) when there was little or no air movement.

The predictive probability model appears to be useful in predicting the impact of hot conditions on panting score, at least for the two breed types used. The data does show that some cattle even with 50 to 75% *Bos indicus* content will respond to hot conditions by panting.

7.2 Recommendations

- As there were no real objective animal welfare or production responses and no financial gain from using the fans we would not recommend that work with these type of fans continue without a re-think of the use strategies.
- If work in the area of fan use at feedlots were to continue, then the type of fans and strategies for optimal use would need to be considered.
- Amelioration of heat load by other means such as use of shades, pen cleaning and nutritional management may be a better option.

8 Key messages

Based on the findings from this study it is unlikely that Orchard Fans will be of economic value in ameliorating heat load in un-shaded feedlot cattle with 25 to 75% *Bos indicus* content.