Measurement of Temperament in Beef Cattle and its Relationships to Animal Production Characteristics

by

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ABSTRACT

MEASUREMENT OF TEMPERAMENT IN BEEF CATTLE AND ITS RELATIONSHIPS TO ANIMAL PRODUCTION CHARACTERISTICS

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This thesis is an investigation of the outcomes and relevance of three different temperament assessment techniques in beef cattle. In the first study, temperament of feedlot beef cattle (n = 708) was assessed using three techniques, chute temperament score, chute exit speed and exposed eye white percentage (EW), and the resulting outcomes were compared. Repeatability of these techniques was investigated at one farm location; repeated over two consecutive days. Lastly, the accuracy and repeatability of the technique used to determine EW was investigated. Results showed some significant, but low correlations between temperament assessment techniques; chute temperament score and chute exit speed (0.26561; \( P < 0.0001 \)); chute temperament score and EW (0.13660; \( P = 0.0008 \)); and chute exit speed and EW (-0.01443; \( P = 0.7340 \)). The correlations between repeated measures varied depending on the technique used. Chute exit speed measured on day 1 and day 2 had the highest correlation among the 3 techniques (0.6605; \( P < 0.0001 \)), suggesting this may be the most consistent temperament assessment technique. Repeated measures of chute temperament score and exposed EW had low correlations between consecutive days (0.3656; \( P < 0.0001 \)) and (0.1040; \( P = 0.0495 \)), respectively. The correlation between repeated tracings of the same exposed EW image was 0.66129 (\( P < 0.0001 \)) and 0.89157 (\( P < 0.0001 \)) for image 1 and image 2, respectively. In the
second part of the study, the temperament assessments from the three techniques for the same group of cattle were compared to select live animal body composition parameters, production efficiency traits and meat quality characteristics. Results indicated that as exposed EW increased by 1 percent, backfat decreased 0.0284 mm ($P < 0.20$); as chute exit speed increased by 1 m/s, marbling score increased by 0.349 ($P < 0.0001$); as chute temperament score increased by 1, depth of the loin muscle increased 0.742 mm ($P < 0.005$). As chute temperament score increased by 1, ADG increased by 0.181 kg/day ($P < 0.05$); and as exposed EW increased by 1 percent, ADG increased by 0.031 kg/day ($P < 0.05$). There was no significant relationship found between RFI or shear force and any of the three temperament assessment techniques. Overall findings indicate some temperament assessment techniques are related to specific parameters of interest, and in general, more agitated or reactive temperament cattle may take a longer time on feed to achieve desired backfat thickness for finishing, but have higher marbling scores and muscle depth at time of assessment.
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Chapter 1: A review of the literature on beef cattle temperament

INTRODUCTION

An animal’s behavioural response to a stimulus, such as a perceived threat, presence of a conspecific, human, novel sound, smell, object, etc., is of interest to animal scientists, veterinarians, producers, as well as the general public (Réale et al. 2007). An animal’s reaction to different situations is believed to be consistent (Turner et al. 2011) is theorized to be influenced by its temperament (Réale et al. 2007). Due to this consistency across situations, the animal is said to be a certain behavioural type, and this pattern is similar to the concept of personality in humans and non-human animals (Turner et al. 2011). Humans and non-human animals show personality, which is temporal and contextual consistency in behaviour patterns that vary among individuals.

Animal scientists are interested in gaining a better understanding of what temperament encompasses and how it impacts animals responses to various situations. The importance of animal temperament to the human population varies depending on the animal species, and as such, influences research in this area.

The concept of individual differences among cattle is becoming increasingly important in the beef cattle industry. The temperament of cattle and its’ link to a number of valuable aspects within the industry have been investigated for over 25 years. The term temperament reflects a combination of differences in behaviour due to aggressiveness, fearfulness, assertiveness, and exploratory and social motivation (Boissy and Bouissou, 1995).

Beef cattle temperament has been defined in a variety of ways in the scientific literature. Due to the practical implication beef cattle temperament has on routine handling, the definition
considers the behavioural responses of cattle in the presence of humans. Burrow and Corbet (2000) defined temperament of an animal as its behavioural response to handling. Grignard et al. (2000) pointed out that temperament responses are not just in reaction to the presence of a human, but are also influenced by elements of the handling situation, such as social context, physical environment and novel stimuli. The definition of temperament used for this thesis is the nature of the animal as it affects the way it behaves toward human presence or human handling (Burrow and Corbet, 2000; Gauly et al. 2001).

A review of research on beef cattle temperament provides insight into the various methods of assessment and identifies areas where additional temperament research would benefit the beef industry.

**METHODS OF TEMPERAMENT ASSESSMENT IN BEEF CATTLE**

When choosing a technique to assess temperament it is important to consider the equipment, time and experience necessary to successfully perform the assessment. The situation, environment and purpose of temperament assessment can also influence the method selected. Some methods of assessment may be more applicable than others, depending on the circumstances.

There are a number of methods being developed and used to assess beef cattle temperament, both subjective and objective in nature, with varying advantages and disadvantages. It is important that the method chosen be accurate and repeatable, and that different individuals can reliably use the same method at various locations under various conditions. If the ultimate goal is to base management decisions on temperament, it is crucial that the temperament assessment methods are easy to implement and consistent.
In reviewing the methods available, it is necessary to understand the basis they were established, how the technique for assessment is performed, and the strengths and weaknesses. A comparison between methods allows for enhanced comprehension of the science behind temperament assessment in beef cattle. Following, is a description of the most commonly used techniques, and their variations, for assessing temperament in beef cattle.

*Chute temperament score*

Fordyce et al. (1985) was the first to report chute temperament scores while studying temperament of *Bos indicus* cattle and its effects on bruising. Each animal was scored on a 7-point scale by observing their vigour of movement while restrained in a chute. Grandin (1993), while investigating behavioural agitation during handling over time, adapted this temperament assessment method to that which is widely used today. Grandin (1993) utilized the same definitions for scores 1 to 4 as Fordyce et al (1985), however she condensed scores 5 to 7 into a single score of 5. This was done because it was believed to be very difficult for an observer to differentiate between seven different score ratings (Grandin 1993).

The chute temperament score method involves an observer scoring an animal’s behavioural response on a 5-point scale, while the animal is restrained by a head gate in a manually operated squeeze chute (Grandin 1993). The scoring criteria are: 1: calm, no movement; 2: slightly restless; 3: squirming, occasional shaking of chute; 4: continuous vigorous movement of chute; 5: rearing, twisting or violently struggling. Cattle given a score of 4 or 5 are classified as behaviourally agitated and reactive in temperament (Grandin 1993).

A couple of years later, Grandin et al. (1995) proposed a modified chute temperament scoring system for those animals that are restrained in a hydraulic squeeze chute, as this piece of
equipment is able to grip the animal more tightly, further restricting its potential movement. The modified ratings use a 4-point scale: 1: calm, no movement; 2: restless, shifting weight; 3: head throwing, squirming and occasionally shaking the squeeze chute; 4: violently and continually shaking the squeeze chute (Grandin et al. 1995).

The chute temperament scoring method requires only a handling chute, and no additional equipment. This assessment can be done quickly, and can be used across a large majority of beef farms, as most operations have a squeeze chute for handling. However, this method is subjective and could vary between individuals due to their differences in observing the animal and their interpretation of criteria for scoring. The observer’s previous experience can also influence the assessment, and thus consistency and bias among observers is a potential concern. A final concern with using a visual scoring system, such as chute temperament score, is the lack of sensitivity, which results in little variation among resulting scores. A large proportion of individuals end up being assigned the same score, although they may be opposite extremes of the same score.

**Movement measuring device**

Stookey et al. (1994) developed an electronic device they called the Movement Measuring Device (MMD) to quantify the amount of movement made by an animal while restrained in a weigh scale. The MMD is connected to the load cells attached to the electronic weigh scale, and calculates the amount of movement made by the animal during a 1 minute period. Movement is displayed as a peak during this sampling period on an LCD display; the number of peaks increase the more the animal moves, indicating an animal with an agitated response and presumably a more reactive temperament. The lower the number of peaks, the calmer the animal
stood during the test, indicating a more docile temperament in that handling situation. The number of peaks output by the MMD was found to be highly, positively correlated to the amount of movement determined from video analysis of the same animal sample (Stookey et al. 1994).

The benefits of using this method are that it is an objective, quantifiable measure for assessing behavioural response to handling that is not subject to individual interpretation. However, the installation of the MMD to a weigh scale, and maintenance of this equipment, is necessary. To date, this equipment is only available at the University of Saskatchewan feedlot research station and has not been commercialized for routine on-farm use.

**Pen temperament score**

Pen temperament scores (Hammond et al. 1996; Curley et al. 2006) are visual assessments conducted while cattle are confined to a pen, either alone or in small groups (4-5), and the assessor attempts to approach them. This differs from a chute temperament score in that the animal is not confined in a squeeze chute, and has the option to flee from approaching handlers. The individuals response to this approach is then scored on a 5-point scale (Hammond et al., 1996): 1 = nonaggressive, walks slowly, can approach closely, not excited by humans or facilities; 2 = slightly aggressive, runs along fences, will stand in corner if humans stay away, may pace fence; 3 = moderately aggressive, runs along fences, head up and will run if humans move closer, stops before hitting gates and fences, avoids humans; 4 = aggressive, runs, stays in back of group, head high and very aware of humans, may run into fences and gates even with some distance, will likely run into fences if alone in pen; and 5 = very aggressive, excited, runs into fences, runs over humans and anything else in path.
The benefits of using this technique are similar to that of using chute temperament score; in that it does not require any equipment to perform and can be done quickly. However, using this method requires the time to separate larger herds into smaller groups so assessment can be completed on a semi-individual basis. Potential risk to handlers approaching the cattle to perform assessment is also of concern. In addition, the assessment is subject to individual interpretation of animal behaviour and the description of each criterion for the scoring system, which impacts inter-observer reliability. Lack of sensitivity of a scoring system test, resulting in reduced variation between individuals, is also of concern when using pen temperament score.

**Chute exit speed**

Based on the observation that calm animals exit a weigh scale at a slower speed than others, Burrow et al. (1988) developed flight speed or chute exit speed as a method to assess temperament. The chute exit speed test measures the speed at which a released animal covers a measured distance, typically 1.7 to 2.0 m, after exiting a confined area, such as a weigh scale or squeeze chute (Burrow et al. 1988). This was developed as an alternative to the flight distance test (Fordyce et al. 1982), which was believed to be too time-consuming and difficult to perform as a component of routine management procedures. The chute exit speed test incorporates a timing system, composed of two infra-red light beams and corresponding receivers, and a timing display. The animal exits the confined area, triggering the first set of sensors and starting the timer, travels the measured distance, and crosses the second set of sensors, turning off the timer. The time is then recorded and speed is calculated by dividing the measured distance, in meters, by the reported time, in seconds. Cattle that have a slower chute exit speed are considered to be docile in temperament (Burrow et al. 1988).
The benefits of using this method are that it is an objective measure, which involves a quantitative value for assessment and linear comparison. Due to the fact that temperament is assessed by an electronic timing system, it is not subject to individual interpretation or bias. It can also be easily incorporated into routine handling procedures. However, using an electronic timing system to determine chute exit speed requires purchase, set-up and maintenance of the equipment. The technique of assessing the speed at which an animal leaves the handling chute can also be done without the investment in equipment.

A chute exit score is an adaptation of chute exit speed, based on the same assumptions in relation to temperament, used in situations where chute exit speed is not a reasonable measure (Lanier and Grandin, 2002). This adapted version can be used when equipment for obtaining speed is not available or is malfunctioning, or facility design does not allow for proper equipment set-up. The chute exit score classifies the gait movement of the animal as it leaves the chute based on a 4-point scale: 1: walk; 2: trot; 3: run and 4: jumping out of the chute (Lanier and Grandin, 2002). The benefit of this method is that it can be used across all farms, in the absence of equipment, during routine handling. However, assigning a chute exit score requires the observer to be trained and paying close attention to animal movement. The assessment is subject to individual interpretation of gait movements and results in reduced variation between individuals due to the difficulty to detect true differences.

*Exposed eye white percentage*

It has been suggested that the percentage of exposed eye white (EW) (sclera) may be an indicator of cattle emotions, such as frustration, satisfaction, fear or aggression-related (Sandem et al. 2002; Sandem et al. 2006), which are believed to be components of temperament. It is thought
that the sympathetic nervous system is involved in the response to stress-related stimuli, whereby the muscle that lifts the upper eyelid is stimulated, resulting in increased visible eye white (Sandem et al. 2002). It is speculated that exposed EW is in part a response to frustration or fear-inducing stimuli (Sandem et al. 2002; Sandem et al. 2004; Sandem et al. 2006), and thus may have some use in assessing animal welfare and interpreting an animals’ response to specific situations, such as handling (Sandem et al. 2002; Sandem et al. 2004).

Research conducted by Sandem et al. (2002) found a positive correlation between aggressive behaviours in dairy cows and exposed EW; being one of the first to illustrate that exposed EW is a good indicator of undesirable traits. In order to calculate exposed EW, still images captured from video footage taken of the animals’ heads during handling were analyzed (Sandem et al. 2002). A ruler was held up to the picture on the monitor, and diameter measurements were recorded for both the total visible eye (area not covered by eyelids) and the dark iris/pupil (Sandem et al. 2002). From these measurements, the area of the total eye and area of the iris were calculated using the formula for an ellipse, as an approximation of the exact areas. The total exposed EW percentage was calculated from these area approximations by the equation $100\left(\frac{\text{area of total eye} - \text{area of iris}}{\text{area of total eye}}\right)$ (Sandem et al. 2002).

To avoid measuring errors associated with ruler placement, Core et al. (2009) used a computer software program, Sigma Pro 5.0, which calculated the area of a traced portion of an image in terms of pixels. From still computer images, the outer perimeter of the total eye and perimeter of the iris were traced, allowing for the calculation of the area of these respective visible eye components. The equation for calculating exposed EW used by Core et al. (2009) was the same as that used by Sandem et al. (2002). In addition, Core et al. (2009) investigated the relationship between the exposed EW found from tracing and analyzing the same image twice, and the
relationship between the eye white analyses of 2 different images of the same animal. The Pearson correlation coefficients for exposed EW within and between eye images were between 0.77 and 0.96 \((P < 0.0001)\), indicating that this type of testing for temperament is highly repeatable and accurate (Core et al. 2009). This method of assessment is objective in nature, and allows for linear comparison between individual animals’ responses to being handled. However, using this technique does require an investment in equipment, experience using the computer software program, and a substantial time investment for image selection and analysis.

Studies have investigated the correlation between the outcomes of temperament assessment obtained using different techniques. For instance, is an animal identified as docile, using the chute temperament score technique, also docile in terms of a slower chute exit speed? The repeatability of temperament assessment methods over time is also an area of interest. The possibility of habituation to human handling, and how this experience may influence temperament is another area that deserves investigation. The following is a collection of some studies related to these questions and their influence on future work.

Müller and von Keyserlingk (2006) investigated the repeatability of chute exit speed measured three times at 4-week intervals, and a fourth time immediately following the third assessment using a group of 61 Aberdeen Angus heifers. Results indicated there was no significant difference between the first and second assessment of chute exit speed, but a significant \((P < 0.001)\) increase between the second and third assessment was observed. Correlations between the three assessments were all moderately to highly, positively significant \((P < 0.001)\). Within-day repeatability of chute exit speed was determined on the final day of assessment, where chute exit speed assessments were conducted 2 hours apart. Observed results indicated same day repeated chute exit speed measurements were highly significant \((P < 0.001)\). Chute exit speed increased
slightly over time, which agrees with results from Petherick et al. (2002), who hypothesized this may be caused by an increase in their fearfulness. Another explanation is animal growth over the 3-month study period, particularly muscle growth, may enable the animals to move at a faster speed (Müller and von Keyserlingk 2006). Similarly, King et al. (2006) measured temperament using chute exit speed on a group of 144 steers before shipment to feedlot, upon arrival at feedlot and at approximately 70 days on feed. Assessments done using chute exit speed were moderately, positively correlated to each other ($P < 0.10$), indicating somewhat consistent and repeatable measures.

Core et al. (2009) conducted an experiment, using heifers, steers and bulls, to assess the correlation between chute temperament score, flight speed and exposed EW while in the handling chute. Flight speed was measured as the speed at which a segregated animal returned to the herd. Among the three different groups in this study, results suggest that although there is some low to moderate positive correlation between chute temperament score and chute exit speed, this correlation is not strong (Core et al. 2009). This provides evidence that these techniques are not ranking cattle based on temperament in a similar manner. The stronger, positive correlations obtained in this experiment between exposed EW and chute temperament score suggests that these assessment techniques were measuring more closely related aspects of temperament than that of exposed EW and flight speed. As the first study to look at the relationship between these three methods, this initial experiment provides introductory evidence into the relationship between these three techniques. As evident by the moderate values of correlation, it appears that they are not all measuring or assessing the same aspects of cattle temperament.
Schwartzkopf-Genswein et al. (2012) assessed the temperament of steers using five techniques, repeated twice on consecutive days to investigate the relationship between them. In this study, an adaptation of chute temperament score (Grandin, 1993) was used to visually assess cattle temperament as they were moved into a handling chute, while restrained in the chute, and upon release from the chute. Chute flight time and flight distance test were also performed. Strain gauges attached to the handling chute head gate were used to measure the exerted force of cattle movement while restrained. Results indicate a significant negative correlation between chute flight time and chute exit score, suggesting that cattle which left the handling chute at a faster speed also required less time to cover the measured distance of 2.2 m. In addition, chute flight time was significantly correlated with chute temperament score assigned while the animal was moved into the chute and during restraint, indicating that higher scores meant a faster chute exit (Schwartzkopf-Genswein et al. 2012).

In a study conducted on 55 dairy heifers (Holstein-Friesian), Gibbons et al. (2011) reported that there was no significant correlation between the median chute temperament score and mean chute exit speed. In addition, the repeatability of the chute temperament score was low and non-significant, indicating the temperament results were not consistent over the 3 assessments conducted over 4 weeks. Due to the different frequency of human exposure and handling in the dairy industry, it is possible the dairy cattle are more habituated and less reactive or more docile in terms of handling compared to their beef counterparts. Results of this study would support this hypothesis, as there was a low variation in chute temperament score across the group of 55 heifers, and majority were given a score of 1.

Cafe et al. (2011) investigated the relationship between chute temperament score and chute exit speed, measured on 14 separate occasions over the span of 8 months. Results indicated for a
group of Brahman cattle (82 steers, 82 heifers), a moderate, positive relationship between these two measures of temperament assessment \((P < 0.001)\), and for a group of Angus cattle (25 steers, 25 heifers) \((P = 0.006)\). Due to the moderate, positive correlation, some cattle would have been similar temperament assessment outcomes from the different techniques, however overall the outcomes in assessment differed. Correlations between the repeated measures of chute exit speed were greater than for repeated assessments of chute temperament score, and the strength of correlations for both declined over time (Cafe et al. 2011). In general Cafe et al. (2011) noted a decline in the response of the cattle to handling over the duration of the 8 months, with much of the decline occurring in the first 3 assessments. This suggests that the response to handling stabilized after some familiarization with the handlers and facility, and the remaining 11 temperament assessments concluded relatively repeatable results. Similar to previous work (Grandin 1993; Burrow and Dillon 1997), it was suggested that a more accurate assessment of temperament can be obtained from averaging repeated measures using the same technique (Cafe et al. 2011).

Sebastian et al. (2011) investigated the correlation between, and repeatability of, methods of temperament assessment on a group of common beef breed steers at a feedlot. Temperament was assessed using two objective techniques, chute exit time and the MMD, and subjectively, using chute temperament score, and each assessment was performed three times over a period of 4 months. In this study, chute exit time was not converted into speed, therefore a lower chute exit time, in seconds, indicated the animal left the chute at a faster speed. Chute exit time was consistently, slightly to moderately negatively correlated with MMD peaks \((P < 0.0001)\), indicating that in some cases, cattle that took a longer time leaving the chute, moved less while restrained in the chute. When graphing the average MMD peaks and chute temperament scores,
as chute temperament score increased, the number of MMD peaks increased. When graphing chute temperament scores and chute exit times, as chute temperament score increased, a lower average chute exit time was observed (Sebastian et al. 2011). The statistically significant relationships among the objective measures of assessment provide evidence that these techniques are measuring similar attributes of temperament (Sebastian et al. 2011). There was no evidence of habituation occurring over the study period, however chute exit speed decreased significantly from the first to second assessment ($P < 0.05$) and increased from the second to third assessment ($P < 0.001$), and the MMD peaks differed significantly at the first and third assessment ($P < 0.001$). The relationships between chute exit speed and MMD peaks assessed three times over a 4 month period provides evidence that these objective measures are consistent and repeatable.

In contrast to Sebastien et al. (2011) the results of a study by Curley et al. (2006) indicate that habituation to human handling is occurring to some degree. Curley et al. (2006) investigated the relationship between, and repeatability of, two subjective and one objective method of temperament assessment. Chute and pen temperament scores, subjective methods, and chute exit speed, an objective measure, were conducted on Brahman bulls (Curley et al. 2006). Each assessment was performed on each animal at day 0, 60 and 120. Results indicated a low to moderate positive correlation between all temperament measures at the initial day of data collection ($P < 0.005$); however, these relationships did not persist. At day 60, only pen score and chute score were moderately positively correlated ($P < 0.01$). At day 120, there were no significant relationships reported. Initial temperament assessments using chute exit speed were moderately, positively associated with subsequent chute exit speed assessments; initial pen temperament score assessments had a low, positive association with subsequent pen temperament scores; however initial chute temperament score was not significantly associated
with subsequent assessments using this technique. The overall findings of Curley et al. (2006) suggest that chute exit speed is the most valuable tool for temperament assessment as it is a possible indicator of an animals’ temperament throughout its lifetime, and may be more useful than subjective techniques as it has a higher level of repeatability (Curley et al., 2006).

Chute temperament score and chute exit speed are the most frequently used temperament assessment techniques; however studies suggest a slight to moderate positive correlation between resulting assessments. This suggests that these techniques are not measuring the same aspects of temperament, are not being executed properly, or a combination of both. It was hypothesized that if techniques are accurately used, and assessing the same aspects of temperament, that correlations between resulting assessments should be strongly, positively correlated. The development of additional techniques to assess beef cattle temperament, both at the experimental and industry-level is necessary to further understand the different aspects of temperament. In addition, further studies conducted across different breeds and quantity of cattle are necessary to understand if these relationships are greatly dependent on breed, sex, previous experience, facility design, or other environmental or biological influences.

THE ROLE OF GENETICS/BREED, EXPERIENCES AND ENVIRONMENT ON TEMPERAMENT RESPONSES

The internal and external factors that impact the response of an animal in the presence of a human or handling should be considered when observing temperament. Some of the main categories of factors that may relate to temperament responses are genetics, experience and environment at the time of human-animal interaction.
**Genetics and breed**

Temperament differs among beef cattle sexes, breeds and genetic lines (Gauly et al. 2001; Voisinet et al. 1997; Lanier et al., 2001; Hoppe et al. 2010). Gauly et al. (2001) conducted a study over 2 consecutive years on two generations, of five progeny groups of Simmental (n = 23 and 83, respectively) and German Angus cattle (n = 119 and 140, respectively). All animals were tested individually using a restraint and separation test, and behaviour and temperament responses to these situations were observed and recorded. Results indicated that Simmental cattle were more difficult to handle in a restraint and separation test than were the German Angus. This was noted because of the increase in time it took to catch the Simmental cattle for restraint, higher frequency of aggressive behaviours, and higher chute temperament scores prior to and during handing (Gauly et al. 2001).

In general, continental French breeds, such as Charolais or Limousin, are more agitated during restraint than British breeds, such as Angus or Hereford (Hoppe, et al., 2010). Charolais and Limousin cattle seem to be more susceptible to stress in situations where they are isolated from peers or in close contact with humans, which is supported by their agitation during restraint and increased chute exit speed times (Hoppe et al. 2010). It has been suggested that the history of breeding for Charolais and Limousin cattle may be an explanation for their excitable temperament (Hoppe et al. 2010). Historically, these French breeds were raised in a traditional, intense rearing system, which favoured those animals that habituated to humans. The selection for this attribute of habituation could have masked underlying temperament traits, and as such, prevented selection based on temperament itself (Grandin, 1994). Conversely, Angus and Hereford cattle were traditionally reared under pasture conditions, with little human-animal interaction. When these herds were handled, cattle that had more reactive temperaments and
posed a threat to handler safety were culled, resulting in indirect selection for more docile cattle (Hoppe et al. 2010).

Historical selective breeding for common cattle breeds, such as for high muscling, could have resulted in indirect selection for temperament. Identifying these temperament-controlling regions of the genetic code for beef cattle breeds may provide insight as to what is controlling temperament, and how these regions differ across breeds. Gutiérrez-Gil et al. (2008) confirmed previous findings that there are quantitative trait loci regions that control temperament in cattle. Further work is being done to confirm stronger marker-trait associations, so that marker-assisted selection can be used as a genetic tool to select for temperament in beef cattle breeding (Gutiérrez-Gil et al. 2008). The results of this study also determined that no overlapping quantitative trait loci regions were identified for the traits measured by the flight from feeder test or social isolation test. This provides evidence that different genetics factors may influence behavioural responses to different situations (Gutiérrez-Gil et al. 2008). To further this area of research, Glenske et al. (2011) found a candidate gene, DRD4, which plays an important role in the regulation of temperament in a group of 545 German Angus calves of six sires after three behaviour tests. Further quantitative trait loci investigations are needed using standard temperament assessment techniques, on large sample sizes of animals. More studies in this area will provide insight into the genetic control of temperament and how these complex traits and responses are controlled through genetic selection.

Hall et al. (2011) collected DNA tissue samples, and evaluated temperament using chute temperament score and chute exit speed on 183 crossbred feedlot steers. The DNA samples were used for DNA profile testing through IGENITY® for a number of genetic traits including docility or temperament. The profile provided by IGENITY® is an index from 1 (lowest genetic potential
for the given trait) to 10 (highest genetic merit). Results of this genetic test for temperament found no significant relations between the IGENITY® docility index and the measures of chute temperament score and chute exit speed (Hall et al. 2011). This could be due to the range of temperaments observed in this study, a misuse of the techniques, or poor predictive ability of the IGENITY® profile for this trait.

Within each breed, genetic attributes and parental lines also play a role in temperament. The heritability value of temperament has been investigated in a number of breeds and results to date indicate it is a low to moderate value across breeds (Hoppe et al. 2010; Le Neindre et al. 1995; Gauly et al. 2001; Burrow and Corbet, 2000; Morris et al. 1994; Burrow and Dillion, 1997). Heritability refers to the proportion of phenotypic variation that is due to the additive genetic effects, which means a high heritability value indicates the trait has a high genetic component. For the case of temperament, a low to moderate value means that at least a proportion of this attribute is controlled by genetic factors, however other factors are also paying a role. If temperament is low to moderately heritable in beef cattle, this would mean that selection pressure can be exerted in a breeding program to somewhat alter or improve temperament.

However, other factors should also be considered. For instance, the North American Limousin Foundation states one of the current key focus areas for the breed is to place selection pressure on temperament to rapidly improve docility, as this trait was found to be moderately heritable (0.40) in Limousin cattle. This is a key example of where genetic selection is being used to improve temperament in a specific beef breed.

Gauly et al. (2001) investigated traits related to temperament and the genetic variability in German Angus and Simmental cattle. The model to determine heritability of temperament determined by chute temperament score was calculated separately for each breed, and included
the sire as random effect and the sex, year and handler as fixed effects. The estimated heritability for temperament was between 0.11 and 0.61 for the German Angus and 0.17 and 0.55 for Simmental cattle (Gauly et al. 2001). However, these values have relatively high standard errors, presumably due to the small sample size of 206 Simmental and 249 German Angus used to calculate these estimates, and further studies need to be conducted on a larger scale. Although the findings of Gauly et al. (2001) agree with findings by Le Neindre et al. (1995) who calculated heritabilities for chute temperament score between 0.18 and 0.22 for Limousin cattle.

In order to further investigate heritability of temperament on a commercial scale, Hoppe et al. (2010) conducted a study on 3,050 beef cattle over 2 years on commercial farms in Germany of the following breeds: German Angus (n=706), Charolais (n=556), Hereford (n=697), Limousin (n=424), and German Simmental (n=667). Heritability was calculated for each breed, based on chute temperament score and chute exit score, and was found to be small to moderate with significant differences between breeds. The heritability for temperament determined by chute temperament score were reported as follows: German Angus, 0.9 to 0.21; Charolais 0.10 to 0.24; Hereford, 0.23 to 0.43; Limousin, 0.03 to 0.19; and German Simmental, 0.11 to 0.25 (Hoppe et al. 2010). The heritability for temperament determined by chute exit score were reported as follows: German Angus, 0.12 to 0.28; Charolais 0.15 to 0.35; Hereford, 0.33 to 0.42; Limousin, 0.04 to 0.18; and German Simmental, 0.21 to 0.35 (Hoppe et al. 2010). Heritability was generally greater for the chute exit scores than chute temperament score, which could mean this fleeing from restraint or handling area, is a more heritable trait, or that the criteria used to determine chute exit score were more precise than chute temperament score.

On average, females are more excitable or difficult to handle; and heifers have more reactive temperaments than cows, as determined by chute temperament score and chute exit speed, when
compared with steers (Stricklin et al. 1980; Voisinet et al. 1997; Lanier et al. 2001; Gauly et al. 2001; Hoppe et al. 2010). Tőzsér et al. (2003) performed chute temperament score and chute exit speed tests and found that multiparous cows were more docile than primiparous cows, on a test of 67 Holstein-Friesian cows.

**Experience**

The recall of previous experience and the ability to habituate to human handling are important concepts when considering beef cattle temperament. Boissy and Bouissour (1988) demonstrated that intensive, long-term (3 to 6 months) periods of handling effectively improved temperament scores of dairy cattle compared to a non-handled control. Further, Boivin et al. (1994) illustrated that the extent to which calves are in contact with humans affects their subsequent responses later in life to handling tests, such as a fear of humans and restraint test. The quality of their previous experiences, specifically their frequency of contact with humans (range raised versus traditional) and in what context (feeding daily versus castration), will affect their response in the present (Boivin et al. 1994).

Petherick et al. (2009a) conducted one of the first studies investigating whether young beef cattle temperament can be modified through experience. Steers (n=140) were given one of three human handling experiences (classified as good, poor or minimal) on 6 occasions during a 12-month grazing period post-weaning. Good handling was designed to provide cattle with a neutral or positive experience, where cattle were moved by humans into a yard with green grass and exposed to humans in a natural setting. Poor handling was designed to be a negative experience for the animals, where cattle were moved by humans to a bare, earth yard without feed and water and held there for 3-4 hours. The poor group was also moved through a handling chute and
exposed to humans in a negative setting, with a lot of noise, shouting, slapping with open hands and prodding with a plastic pipe. Minimal handling meant these cattle had minimal experience being handled, similar to a range rearing. A fear of humans and temperament assessment was conducted 3 times throughout the experiment. A fear of humans test, based on the Human Approach Test (Hemsworth et al. 1996) was conducted to measure the proximity cattle remained to a stimulus person, the closest they would approach the human and the amount they moved around the test arena. Those cattle that approach the human and remain in close proximity, and move around the arena less, are considered to be less fearful. Chute exit speed was also conducted to assess temperament. Results indicate that quantity and quality of handling imposed on cattle has an impact on fear of humans; in that cattle in the minimal or negative handling group exhibit responses indicating a state of fear in the presence of humans (Petherick et al. 2009a). However, by the second assessment of temperament using chute exit speed, there was no difference between the handling treatments. This may indicate that this particular temperament assessment technique is not measuring fear of humans, but another component of the temperament complex. However, results of this study provide evidence that fearfulness of humans can be modified through experience and learning; cattle that are handled calmly and quietly, and exposed to handlers in a positive situation, such as when they can be associated with food, become less fearful of people (Petherick et al. 2009a). The results of this study are in agreement with those from other studies, which illustrate that repeated exposure to aversive handling procedures can result in cattle and pigs becoming more reactive and fearful of people (Hemsworth et al. 1996).

The ability to habituate to humans and handling procedures to some degree has been documented in the scientific literature (Curley et al. 2006; Petherick et al. 2009a; Hoppe et al. 2010) and it is
thought that this habituation results in the suppression of reactive temperament, and resulting
behavioural responses. This habituation to handling may be evident in a change or decrease in
temperament over time, whereby animals become less reactive, or more docile in their
behavioural responses. This would be evident in repeat instances of temperament assessment
coinciding with repeated handling exposure. The frequency and duration between repeated
exposures appears to affect habituation to human handling (Sebastian et al. 2011).

Environment

Visual stimuli can impact the fearfulness of some cattle, as illustrated by a startle or flight
response (Sandem et al. 2004). Grandin (1998) and Mitchell et al. (2004) suggest that visual
stimuli play a role in the animals’ response, and that blocking the view of humans can play a role
in decreasing undesirable behavioural responses. Beef cattle will balk less and move more
calmly through handling systems with solid sides, which block the animal’s view of the handler
and equipment (Grandin, 1998). Blindfolding may also be of value in an animal production
environment as a means to calm animals and reduce struggling during a task which requires
restraint (Mitchell et al. 2004).

Waynert et al. (1999) conducted a study on 59 yearling beef heifers to evaluate their behavioural
and physiological responses to noise during one minute exposure to either a prerecording of
noise, composed of human shouting and metal clanging, or silence. The MMD was used to
assess temperament, and remote telemetry was used to measure heart rate. Heifers that were
exposed to the noise during handling had significantly higher heart rates, and moved more while
restrained (as determined by the MMD) (Waynert et al. 1999). In a second trial, the results were
separated to determine whether heifers exhibited a greater behavioural and physiological
response to human shouting or metal clanging. Results suggest that when heifers were exposed to a pre-recording of human shouting they had higher heart rates and moved more while restrained. In ruminants, increased heart rate and escape behaviours are the normal components of the fear response (Waynert et al. 1999). The results of this study suggest that noise is a potential source of fear for cattle during handling, which can influence their behavioural responses during this time. This supports the observation by Grandin (1996) that noise generally contributes to difficulty in moving cattle at slaughter plants.

An animal’s temperament can impact the behavioural response exhibited in different social environments. Cattle are gregarious species, and an individual’s response to an aversive situation can be influenced by the presence or absence of conspecifics (Boivin et al. 1992; Grignard et al. 2000). It has been suggested that the reactions of other animals could influence the performance of the animal being tested in a docility test (Boivin et al. 1992). Grandin (1980) suggested that observed aggression or reactive temperament of one of the last animals’ through the handling chute, may be due to separation from the social group for a longer duration. Hoppe et al. (2010) recorded order through the chute, and results indicate that cattle that enter the chute later have faster flight-speed scores, indicating they were more likely to run fast out of the chute and classified as reactive temperament ($P < 0.005$). However, it is important to note that it is also possible that the last animals through the chute are reactive due to the fact they are avoiding the handling area until forced.

Boissy et al. (1998) showed that heifers become more fearful after perceiving the stress of conspecifics mediated by olfactory cues in urine. Visual, auditory and olfactory cues are all aspects of the handling environment that can impact the behavioural responses of cattle. These
components of the handling situation are not fully understood, however it is important to consider these environmental aspects when investigating temperament.

THE IMPACT OF TEMPERAMENT ON KEY ASPECTS OF THE BEEF CATTLE INDUSTRY

Research and experience in the industry suggests that variation in temperament responses of beef cattle impact animal welfare, animal handler safety, production attributes and meat quality.

Animal welfare

According to an emotion- or feeling-based view of animal welfare, good welfare is associated with the maximization of positive emotions and the reduction of negative emotions (Duncan, 1996). Cattle with reactive temperaments can potentially cause stress or fear in the entire herd (Rushen et al. 1999). Stress, fear and frustration are welfare issues that should be considered when handling cattle; these negative affective states may or may not be exhibited through obvious temperament responses. For instance, fear may cause an animal to freeze and reduce movement while restrained, which could in fact appear as docile in terms of the chute temperament score. A greater understanding of what aspect of temperament each technique is assessing is important to avoid inappropriate management decisions.

The importance of fearfulness for understanding individual variability in behaviour is well accepted in humans, laboratory animals and poultry, however is often overlooked when considering cattle (Boissy and Bouissou, 1995). In cattle, like other ruminants, increased heart rate and escape behaviours are considered to be the normal components of the fear response (Waynert et al. 1999). Boissy and Bouissou (1995) showed that some measurements in tests of reaction to novelty, to a startling event or in the open field were strongly correlated and
indicative of the fearfulness of the animal. Petherick et al. (2009a) concluded that the quantity and quality of the handling has an impact on the fear of humans, as determined by a fear of humans test. However, the results of the fear of humans test was not strongly correlated to chute exit speed, suggesting this assessment technique was not accurately assessing this component of temperament in this group of cattle. Chute exit speed was suggested to be measuring general agitation, an innate component of the temperament response, rather than fear of humans (Petherick et al. 2009a). This result suggests that assessing temperament by chute exit speed alone is not a strong enough test to determine welfare in terms of negative affective states, such as fear.

The stress response is one of the body’s major coping mechanisms for environmental disturbance, which is comprised of the sympathetic-adrenal-medullary (SAM) and hypothalamic-pituitary-adrenal (HPA) axis (Hemsworth et al. 2011). The HPA releases corticosteroid hormones, cortisol and corticosterone, as a result of a series of physiological events in these situations. Thus, measuring cortisol concentrations in the serum is a method for assessing the stress response of cattle during handling events (Hemsworth et al. 2011). King et al. (2006) used serum samples to determine cortisol concentrations as an indicator of the stress response occurring in 144 steers involved in the study. Temperament of these steers was assessed using chute exit speed and pen and chute temperament score. Results indicated that the most reactive temperament cattle, as determined by an index composed of results from all 3 assessments, had higher, statistically significant serum cortisol concentrations. Curley et al. (2006) found that serum concentrations of cortisol were significantly positively correlated with chute exit speed. King et al. (2006) and Curley et al. (2006) findings suggests that reactive temperament cattle
have extensive responses to a stimulated stress response and higher basal concentration of glucocorticoids.

Sandem et al. (2002) provided evidence that exposed EW may be a dynamic indicator of emotions in dairy cattle, whereby a high percentage indicates frustration and a low percentage indicates satisfaction. Cattle in a treatment group of food-deprivation showed other accepted stereotypies and vocalizations indicating a state of frustration, and also had significantly greater calculated exposed EW.

In effectively finding ways to measure the fear, stress and frustration responses of cattle, the link between temperament and welfare is being established. These three negative affective states provide insight into the temperament responses of cattle, and how manipulation and improvement of temperament can improve animal welfare.

**Animal handler safety**

Relative to human beings, cattle are large, strong animals and, thus, specific handling techniques and facilities have been designed to ensure human handler safety (Kilgour et al. 2006). However, even when working in properly designed facilities, the handling of cattle is associated with a significant degree of danger, the magnitude of which is not consistent for all animals (Kilgour et al. 2006). Cattle that have a more reactive temperament are often difficult to manage and pose a potential safety threat to their handlers (Grandin, 1993). An animal that is extremely aggressive or agitated in the presence of humans has the potential to direct this behaviour at the handler, which may result in injury. This could mean the animal may charge or seek to kick or pin the handler. Ease of handling is influenced by the dynamic of the human-animal relationship, and it has been recognized that animal temperament plays a role in this interaction (Grandin,
1993). Fearful or aggressive animals are more difficult to work with, which increases the time required for routine tasks and the risk of injury to both animal and handler (Voisinet et al. 1997b; Rushen et al. 1999). Selection for more docile animals could enhance the safety of animal handlers, because injuries to the handler are reduced (Voisinet et al. 1997b).

Production attributes

Numerous scientific studies have investigated the effect of temperament on aspects of economically relevant traits, such as, growth, dry matter intake (DMI), feed conversion ratio, fertility and average daily gain (ADG) (Nkrumah et al. 2007). Results of scientific studies indicate that more reactive cattle will have a reduced intake and slower growth (ADG) (Burrow and Dillon, 1997; Petherick et al. 2009b; Sebastian et al. 2011) and reduced feed conversion efficiency (Petherick et al. 2002) compared to those with a more docile temperament, which will result in a smaller carcass, with less fat cover (Voisinet et al. 1997b; Cafe et al. 2011).

Sebastian et al. (2011) showed significant ($P < 0.05$) relationships between chute temperament score and ADG, in that docile temperament cattle put on 76 g more BW per day. Turner et al. (2011) found similar results in that a docile temperament, determined by chute temperament score, was associated with a greater ADG. Results from Sebastian et al. (2011) showed a positive, significant correlation ($P < 0.001$) between temperament determined by the MMD technique and ADG. However, no relationship was found between chute exit speed and ADG by Sebastien et al. (2011) or Turner et al. (2011). This is in contrast to findings by Petherick et al. (2009b) that showed that cattle with faster chute exit speeds had reduced ADG, indicating chute exit speed has some predictive value of productivity.
In a study looking at *Bos taurus* and *Bos indicus* cross cattle, it was determined that steers with low chute temperament scores, or docile temperament, had 0.19 kg/day greater mean ADG than steers with high chute temperament scores (Voisinet et al. 1997b). In agreement, a study by Gauly et al. (2001) determined a negative genetic correlation between ADG and temperament, as determined by pen temperament score, providing evidence that animals that have a more reactive temperament are less productive.

Burrow and Dillon (1997), conducted research on 2 cohorts (experiment 1 and 2) of *Bos indicus* crossbreeds to determine the relationships that exist between temperament and growth in feedlot cattle. Live weights were recorded weekly for both studies, and temperament, determined by chute exit speed. In experiment 1, chute exit speed was significantly ($P < 0.05$), negatively correlated to ADG, final BW at slaughter and carcass weight. However, these relationships did not persist in experiment 2. In comparing the results of cohort experiments, it was discovered that average chute exit speeds of the cattle in experiment 1 were faster than those in experiment 2. A plausible explanation for these notable differences is the difference in handling exposure, as the cohort in experiment 2 was exposed to an extended period of intense handling before entry into the feedlot. However, this increase in exposure to humans at a young age resulting in more docile temperament later in life, provides evidence for the ability of cattle to habituate to humans.

Results of a study by Cafe et al. (2011) showed that Brahman cattle with faster average chute exit speed had reduced BW ($P \leq 0.046$) and reduced ADG. Furthermore, the greatest decline in ADG occurred in those cattle with a chute exit speed of 2.5 m/s and higher. Increasing chute exit speed was also related to reduced DMI ($P = 0.012$) and less time spent feeding ($P = 0.046$). In these cattle, each meter per second increase in chute exit speed was associated with a reduction
in feed intake of 370 DM/day and a reduction of 4.7 min/day in the amount of time spent eating (Café et al. 2011). The results of this study overall indicate that more reactive cattle (faster chute exit speed and higher chute temperament score) produced smaller carcasses with less fat cover (Café et al. 2011).

Residual feed intake (RFI) is a measure of the feed efficiency, expressed as the difference between the actual feed intake observed and that which is expected given the animal’s performance characteristics, such as BW and ADG (Archer et al. 1999). Cattle with a high RFI value are less feed efficient because they utilize more ingested nutrients to meet maintenance requirements and have less to partition to production. Montanholi et al. (2010) found that a steer with low RFI, consumes smaller meals and at a slower pace and visits the feeder less often than a steer with a higher RFI, indicating poorer feed efficiency. Few studies to date have linked this important efficiency measure to temperament. Nkrumah et al. (2007) sought to investigate the relationship between temperament, as determined by chute exit speed, and its relationship with DMI, RFI, and feed conversion ratio over the span of 3 years. Temperament was negatively correlated with DMI; in that an animal that has a faster chute exit speed, or more reactive temperament, consumes less. However, temperament was not related phenotypically with feed conversion ratio or RFI, although they may not be genetically independent (Nkrumah et al. 2007). Temperament had a weak negative genetic correlation with DMI, a moderate genetic correlation with feed conversion ratio, and a negative genetic correlation with RFI. The results indicate that behaviour traits may contribute to the variation in the efficiency of growth between beef cattle of similar breeds, age and management. In addition, it is possible to select for cattle based on these behaviour traits to meet production goals (Nkrumah et al. 2007).
studies investigating temperament and its link to RFI may provide more evidence as to if selection based on temperament can improve feed efficiency.

**Meat quality**

Meat quality issues, such as dark cutting and tenderness, are of economic importance and a concern to beef producers (Voisinet et al. 1997a). A higher incidence of borderline dark cutting and less tender meat translates into undesirable products for consumers and economic losses in downgrades for producers. Dark cutting can occur if there is stress prior to slaughter as this results in glycogen depletion in the muscle, which will alter the characteristics of the resulting meat (Ashmore et al. 1973). However, absolute causes of the dark cutting condition have not yet been established, so a tool for identifying animals that may be more susceptible to producing these cuts is necessary (Voisinet et al. 1997a).

Voisinet et al. (1997a) investigated the impact of cattle temperament, as determined by chute temperament score, on the incidence of dark cutters and meat tenderness. The results of this study on 306 cattle, indicated that a high proportion of carcasses that exhibited borderline dark cutting were from reactive temperament animals. Of all the carcasses of animals which received a docile temperament rating (lower chute temperament score), only 6.7% of them exhibited borderline dark cutting. In the group of cattle that were determined to have a reactive temperament (chute temperament score ≥ 4), 25% of the carcasses exhibited borderline dark cutting (Voisinet et al. 1997a). In addition, as temperament progressed from docile to reactive, Warner-Bratzler shear force increased, indicating that temperament has an effect on meat toughness (Voisinet et al. 1997a). The threshold value for acceptability of steaks for use in food establishments is Warner-Bratzler shear force values of <3.9kg, as steaks with higher values will
be perceived as tougher meat by consumers (Voisinet et al. 1997a). This analysis by Voisinet et al. (1997a) found that 40% of animals with a reactive temperament produced steaks with Warner-Bratzler shear force values greater than 3.9kg, whereas only 13.7% of animals with a docile temperament produced these Warner-Bratzler shear force values. The results of this study suggest that selecting for cattle with docile temperament (as determined by chute temperament score) may result in benefits in meat quality (Voisinet et al. 1997a).

In agreement, Hall et al. (2011) found that steers with a slow chute exit speed produced more tender rib eye steaks than those steers with a faster chute exit speed (n=183). Behrends et al. (2009) found chute exit speed at weaning to be moderately related to Warner-Bratzler shear force (P < 0.005).

In contrast, a study by King et al. (2006) on 3 contemporary groups of steers, did not find that temperament (as determined by an index comprised of chute temperament score, pen temperament score and chute exit speed) affected the quality grade factors and none of the animals in the study possessed dark cutting characteristics. However, a relationship was observed between temperament and tenderness; in 1 of the 3 contemporary groups, a significant interaction was present in that reactive temperament steers had higher Warner-Bratzler shear force values than the calmer steers (P < 0.05). This pattern was observed in another of the contemporary groups, but was not significant (King et al. 2006).

**DIRECTIONS FOR FUTURE RESEARCH**

As interest in beef cattle temperament continues to grow, there is an apparent need for expanding research. Scientific research to date has provided a knowledge base for understanding this trait;
however, additional research is necessary to understand the mechanisms behind temperament, and the crucial impact it has on welfare, handler safety, production and meat quality.

Practical and repeatable techniques to assess temperament and the associated behaviours need to be identified. These techniques need to have specific, clear definitions of behaviours, to ensure temperament is not misclassified. A clear example of a case like this is the chute temperament score, whereby a 1 means the animal is calm or not moving while restrained, yet this animal could be in tonic state of fear. Is this animal really docile? Research may indicate that a combination of techniques may provide a more well-rounded classification of temperament due to situations such as this. Further research will aid in engaging farmers in the concept of beef cattle temperament, and how consideration of this trait can aid in improving animal welfare, handler safety and profitability.

The concept of the genetic manipulation of temperament through selective breeding continues to be important. Further information about the trait loci influencing temperament needs to be established. As handling of beef cattle is necessary for routine procedures such as vaccination and movement to slaughter facilities, the improvement in temperament must occur. Research findings must first identify the genetic mechanisms that cause an animal to interact with the environment and human presence in the way that it does. Thus far, studies have shown that temperament is only a low to moderately heritable trait (Hoppe et al. 2010; Burrow and Corbet 2000; Morris et al. 1994). However, it is important to further validate this work, and work towards identifying the regions of the genomic code that are linked to temperament. There is very little research into the role individual personality plays, or the behaviours of cattle in the context of no human presence. Are animals that act in a temperamental manner in the presence of humans also more excitable or aggressive while not in the presence of humans? Additionally,
very little research has been done looking at the specific attributes of the handling facility and the
effect the design has on subsequent temperament. Perhaps temperament responses are influenced
to some degree by physical surroundings in combination with an innate genetic response to the
presence of humans or the act of being handled. Due to the moderate heritability of temperament
in beef cattle, it can be assumed that influence of physical surroundings is only partly
contributing to temperament responses, as some level of response is due to genetics.

The majority of the current research about the impact temperament has on aspects of the industry
considers the impacts of temperament on ADG, meat tenderness and other valuable production
characteristics. Further research is needed to understand the role temperament plays in other
important production traits such as marbling scores, feed efficiency and reproduction. The link
between temperament and negative-affective welfare states is a grey area, and needs to become a
more important focus of temperament research. If focus is placed primarily on improving
production and meat quality, animal welfare may suffer if the true link between temperament and
animal emotional states is not understood.

CONCLUSION AND THESIS OBJECTIVES

There are a number of different subjective and objective methods for temperament assessment.
These techniques were established based on different observations of cattle behaviour, and thus it
is not clear to what extent they are measuring the same dimensions of temperament. Statistically
significant, strong positive relationships between temperament assessed by these different
techniques would provide evidence that they are in fact measuring the same components of
temperament; however a review of the literature indicates that is not the case. A combination of
different techniques to assess temperament may provide a more complete evaluation for which selection can be accurately based.

Studies have investigated the effect previous experience, genetics and breeding, and current environment of handling, have on temperament and this impact on behavioural response. Habituation to human handling appears to be probable, and indicates temperament responses can be improved. Conversely, temperament can be negatively impacted with negative handling experiences. Cattle of certain breeds and parental lines may be predisposed to temperament responses of a certain nature. However, further research into the genetic code for beef cattle is necessary to determine which areas are impacting temperament.

Temperament, to some degree, influences the likelihood of fear, stress or frustration in cattle, which can be a welfare concern if these negative affective states are experienced. It is possible that by selecting cattle that are more docile and less affected by the presence of humans, welfare across the industry could be positively affected. Handler safety when dealing with reactive temperament animals is a concern, and thus is important to consider when management and breeding decisions are made regarding these potentially dangerous animals. There is scientific evidence to suggest that docile temperament cattle appear to have increased ADG and more tender meat.

In order to make progress in the industry and increase profits, beef producers are looking for ways to improve animal welfare, ensure animal handler safety, increase the prevalence of beneficial production traits and improve meat quality. Selection based on cattle temperament is being investigated as a way towards accomplishing this goal. There is a need for temperament
measurement tools that can be accurately utilized and standardized to avoid personal bias and facilitate comparisons across the industry.

The overall objective of this thesis is to compare the outcomes and relevance of three different temperament assessment techniques in beef cattle. Specifically, in the second chapter, the objective is to compare the outcomes of the assessment techniques, to compare repeatability of these techniques when performed on 2 consecutive days, and to investigate the accuracy and repeatability of the technique used to determine exposed EW. The objective of the third chapter is to relate the outcomes of the temperament assessment techniques to live animal composition attributes and parameters of production efficiency and meat quality.
Chapter 2: A comparison of three techniques used for assessing beef cattle temperament

ABSTRACT

The study had three objectives; the first was to compare three techniques of temperament assessment: chute temperament score, chute exit speed and exposed eye white percentage (EW). The second was to investigate the repeatability of these three techniques over two consecutive days at one farm location; and third, to examine the repeatability of the technique used to calculate exposed EW. Steers and heifers (n = 582) from 3 commercial feedlots in southwestern Ontario, and steers (n = 126) from Elora Beef Research Centre (Elora, Ontario) were tested at 508 ± 135 kg (mean±SD). Each animal was moved through a handling chute to assess temperament. A chute temperament score from 1 (calm) to 5 (extremely wild) was assigned. The speed each animal exited the chute was calculated. Still eye images captured during animal restraint were analyzed for exposed EW. Results showed some significant, but low correlations between temperament assessment techniques; chute temperament score and chute exit speed (0.26561; \( P < 0.0001 \)); chute temperament score and EW (0.13660; \( P = 0.0008 \)); and chute exit speed and EW (-0.01443; \( P = 0.7340 \)). Mean temperament assessment results were greater on day 2 when compared to day 1, indicating cattle were more reactive on day 2. The correlations between repeated measures varied depending on the technique used. Chute exit speed measured on day 1 and day 2 had the highest correlation among the 3 techniques (0.6605; \( P < 0.0001 \)), suggesting this may be the most consistent temperament assessment technique. Repeated measures of chute temperament score and exposed EW had low correlations between consecutive days that were different from zero (0.3656; \( P < 0.0001 \)) and (0.1040; \( P = 0.0495 \)), respectively. The correlation between repeated tracings of the same image was 0.66129 (\( P < 0.0001 \)) and 0.89157 (\( P < 0.0001 \)) for image 1 and image 2, respectively. A significant, moderate
correlation was found between exposed EW calculated from the two images captured for each animal (0.52427; \( P < 0.0001 \)). The low correlation among temperament methods suggests these tests are measuring different dimensions of temperament. It is possible that a combination of techniques should be used when assessing beef cattle temperament and perhaps one technique is more relevant than another depending on the specific objective for assessing temperament.

**INTRODUCTION**

Beef cattle temperament is defined as the nature of the animal as it affects the way it behaves in response to human presence or handling (Gauly et al. 2001) and is a moderately heritable trait of importance in production (Voisinet et al. 1997b). Cattle that have a more reactive temperament are often difficult to manage and pose a safety threat to their handlers (Grandin, 1993). Reactive temperament animals are presumed to have elevated levels of stress or fear, which negatively impacts their wellbeing (Rushen et al. 1999). Individual cattle with a more reactive temperament, as measured via temperament scores, have lower average daily gain (ADG) (Gauly et al. 2001; Burrow and Dillon, 1997), and produce meat that is less tender (Behrends et al. 2009; King et al. 2006) with a higher incidence of borderline dark cutting (Voisinet et al. 1997a); all of which translates to economic losses for the producer and undesirable product for consumers.

A number of techniques have been used in research to assess cattle temperament, both subjective and objective in nature, with varying positive and negative attributes. At the farm level, if the goal is to base management decisions on temperament, it is crucial that these methods are easy to implement and consistent. Two of the most frequently used techniques for assessing beef cattle temperament, most likely due to their ease of execution, are chute temperament score and chute exit speed. Chute temperament score is a subjective method whereby the individuals behavioural
response to being restrained in a handling chute is assessed and scored (Grandin, 1993). Cattle that are assigned a score of 1 or 2 on this scale are considered to be docile in temperament, and those assigned a 4 or 5 are considered to be reactive (Grandin, 1993). Calculating chute exit speed to assess temperament is based on the observation that docile temperament animals leave the handling area at a slower pace (Burrow et al. 1988). In determining the time it takes an animal to traverse a specified distance, researchers rely on infrared timing systems, with two sensors set up for accurate recording (Curley et al. 2006; Cafe et al. 2011; Sebastian et al. 2011; Hall et al. 2011).

Studies investigating the relationship between temperament assessment techniques (Curley et al. 2006; Core et al. 2009; Cafe et al. 2011; Sebastian et al. 2011) most often look at the correlation between chute temperament score and chute exit speed. In general, results indicate a low to moderate positive correlation between chute temperament score and chute exit speed following a one time assessment (Core et al. 2009; Cafe et al. 2011). However results of other studies suggest this relationship is not consistent over repeated measures (Curley et al. 2006). The relationship between chute temperament score and chute exit speed, and what components of the temperament response each are measuring, is not clear.

Additional tests, including the Movement Measuring Device (MMD) (Stookey et al. 1994; Sebastian et al. 2011) and calculating exposed EW (Sandem et al. 2002; Sandem et al. 2004; Core et al. 2009) are being investigated as potential temperament assessment techniques. The MMD is used to quantify the amount of movement made by an animal while restrained in a weigh scale, and is theorized to provide more information about the force and frequency of movement of restrained cattle (Stookey et al. 1994). Core et al. (2009) conducted one of the first studies looking at exposed EW as a measure of temperament in beef cattle. The authors reported
moderate to high positive correlations between exposed EW percentage and chute temperament score, and low to moderate correlation between exposed EW and a form of chute exit speed. The technique used to determine exposed EW was reported to be highly repeatable and accurate, as multiple images per animal were analyzed twice and found to be highly, positively correlated.

Repetitive temperament assessment provides evidence about the consistency of temperament responses, the ability of cattle to habituate to human handling, and the repeatability of the technique itself. If cattle habituate to human handling, temperament responses over time could be impacted, whereby cattle may become more or less reactive. King et al. (2006) measured chute exit speed 3 times over a period of 70 days and results indicated somewhat consistent and repeatable measures. Findings by Müller and von Keyserlingk (2006) and Petherick et al. (2002) report that chute exit speed of cattle increased over time, which they suggested is either due to an increase in fear of humans or increase in muscle. This is in contrast to chute exit speed findings reported by Curley et al. (2006) and Cafe et al. (2011), in which a notable decline in the response of the cattle to handling occurred, whereby chute exit speed decreased over repeated measures, suggesting cattle habituated to handling.

Beef producers are looking for ways to improve animal welfare, ensure animal handler safety, increase the prevalence of beneficial production traits and improve meat quality. Selection based on cattle temperament is being investigated as a way towards accomplishing this goal. There is a need for further investigation into the relationship between, and repeatability of, assessment techniques in order to further develop the understanding of beef cattle temperament.

There were three objectives of the current study; to assess temperament on farm using three different techniques and to compare their outcome in temperament scoring; to investigate the
MATERIALS AND METHODS

The methods used in this study were conducted in accordance with the Canadian Council on Animal Care regulations and standards, and the study was completed within the guidelines of an approved Animal Utilization Protocol from the University of Guelph Animal Care Committee.

Study farms

This study was conducted from November 2011 to October 2012 on 3 commercial beef cattle feedlots and 1 research farm (Elora Beef Research Centre, Elora, Ontario, Canada) located in the central and western part of Ontario, Canada. Participating commercial herds were enrolled in a larger project managed by Beef Improvement Opportunities, Guelph, Ontario.

Animals

A total of 708 beef cattle of mixed Bos taurus breeds were used in this study. This included steers and heifers (n = 582) from 3 different commercial beef farms, and steers (n = 126) from the research farm. The mean weight (+SD) at assessment was 508 ± 135 kg.

General methods

Each of the 4 farms visited had the same general handling equipment. Cattle were moved from their home pen into a holding pen, through a raceway, into a handling chute and restrained in a head gate. Individual animal identification numbers and weight were recorded. Temperament scores were assessed for the current study. An ultrasound was performed to determine live
carcass performance attributes for body composition, for a subsequent study. A DNA sample from the nostril was also taken during restraint, for a larger initiative to genotype cattle in the industry. Cattle were restrained in the handling chute for 111 ± 55.4 seconds (mean ± SD).

**Temperament assessment**

Individual animal temperament was evaluated using three methods: assigning a 1 to 5 chute temperament score (Grandin, 1993), measuring chute exit speed, and by calculating the exposed EW of cattle while restrained in the chute. All temperament assessments were made by the same individual. The observer stood quietly 1.2 meters away, perpendicular to the middle of the squeeze chute (i.e. caudal to the animals’ point of balance), and did not approach the animal. For all cattle at the 3 commercial feedlots, temperament was assessed on one occasion. At the research farm, temperament was assessed twice, on two consecutive days; October 30, 2012 and October 31, 2012 to satisfy the second objective of this study. Temperament and ultrasound assessment were repeated in the same order and same manner on both day 1 and day 2. Live animal ultrasound was performed on cattle at the research farm once, either on day 1 or day 2. Sham ultrasound was performed on those cattle where ultrasound was not actually performed in order to keep exposure to procedures consistent across the two days, to ensure temperament responses could be accurately compared. This sham handling consisted of the technician following the same procedures used when an ultrasound was performed; however an image was not taken. These procedures included oil applied and an ultrasound probe held against the animals’ back.

**Chute temperament score.** After the ultrasound assessment was completed and while no handlers were in contact with the animal, a chute temperament score was assigned based on 10
seconds of observation. The chute temperament score was based on a 1 to 5 scale as described by Grandin (1993); 1: calm, no movement; 2: restless shifting; 3: squirming, occasional shaking of chute; 4: continuous vigorous movement of chute; 5: rearing, twisting or violently struggling.

**Chute exit speed.** An electronic timing system (Trackmate Racing, Surrey, British Columbia, Canada) consisting of 2 pairs of infrared transmitters, and a timing display, was used to determine the time it took each animal to traverse a measured distance of 1.9 ± 0.14 m after leaving the chute. The minimum and maximum distance used to measure chute exit speed was 1.7 m and 2.0 m, respectively. The first pair of infrared transmitters was placed 0.2 m in front of the squeeze chute exit. As the animal left the chute, this first infrared transmitter was triggered, starting the timer. As the animal crossed the second infrared transmitter and receiver, the timer was stopped and the time it took the animal to pass between the two beams was displayed on a monitor. Figure 2.1 is a schematic of this equipment setup. The chute exit speed was later calculated by dividing the distance travelled (specific to each farm), by the time it took for the animal to pass between the two sets of infrared sensors.

**Exposed EW: 1. EW video recording.** For the entire duration that the animal was restrained in the squeeze chute, a colour Panasonic HD camera (Panasonic TN-900, Panasonic Canada Inc., Mississauga, Ontario, Canada), recorded the front quarter of the chute. The camera was mounted on a tripod and positioned 1.5 meters away, perpendicular to the side of the chute.

**Exposed EW: 2. EW data extraction and calculation.** All of the video clips were watched and 2 still images were selected for EW analysis from the animals with video data in the study (n = 605). For the remaining animals involved in the study, (n = 103), either the video camera malfunctioned at the feedlot or appropriate still images could not be selected from the video clips.
for analysis. Similar to the procedure used by Core et al. (2009), each still image was selected from video frames when the animal was not being touched by a human, when the animal’s head was parallel to the camera, and when head, neck and eye movements were minimal (i.e., a relatively calm period). The videos were paused and still images were extracted and saved using the program Video ReDo (DRD Systems, Inc, Mendham, New Jersey, USA). The first image was selected just after the animal was restrained in the handling chute, and the second image was selected just prior to release from the handling chute. During image selection, every effort was made to keep the observer blind to the animals’ other temperament assessment results, to avoid bias in image selection. To ensure this, the observer extracted and analyzed the images at least one month after the on-farm visit and did not have the results of the chute temperament score or chute exit speed assessment in front of them.

The method of exposed EW calculation used was based on the methods used by Core et al (2009). EW percentage was calculated from each of the 2 selected images for each animal, using the computing program Image J (U.S. National Institutes of Health, Bethesda, Maryland, USA) which evaluates the area of an image in pixels. The outer edge of the iris of the eye was traced and the area was calculated, then the iris was traced and the area was calculated. The following formula: EW percent = (1 – [area of the iris/area of the total eye]) × 100%, was used to calculate exposed EW percentage. Figure 2.2 illustrates the steps in this procedure. Each image was traced twice to determine correlation and accuracy of this technique to satisfy objective three. Repeated tracings of the same image were performed two weeks apart. A total of 4 EW percentages were calculated for each animal. The exposed EW for image 1 was calculated from averaging the percentage of EW calculated from trace 1 and trace 2. The same was done to determine exposed EW from image 2. An exposed EW for each animal was determined by averaging the 4 EW
percentages calculated for each animal. This average exposed EW for each animal was used in analysis.

**Statistical analysis**

The computing program SAS version 9.3 (Statistical Analysis System, 2003), was used to analyze the data. Due to equipment difficulties or inability to assess an animal based on farm conditions, there were not always equal numbers of observations for every outcome of interest, on every farm. EW video recording was not available on one commercial feedlot, due to recording equipment failure.

Negative exposed EW percentage values were removed and replaced with a zero prior to analysis due to biological relevance. These values were replaced with a zero based on the assumption that a negative value was calculated because there was no exposed EW to trace. Out of 2404 EW images, a total of 22 negative exposed EW values were identified and replaced with a zero.

Using the CORR procedure, Pearson partial correlation coefficients between order through the chute, BW at time of assessment and temperament assessment techniques were identified, adjusting for the farm and herd. Due to the fact that the cattle at the research farm had two measures of temperament for each of the three techniques, the assessment taken on the same day the ultrasound was performed was used in this procedure, to be consistent with methods from the commercial farms visited.

The CORR procedure was used to determine Pearson correlation coefficients between two repeated measures of weight, chute temperament score, chute exit speed and exposed EW for cattle at the research farm.
The CORR procedure was used to determine Pearson partial correlation coefficients among exposed EW calculated from 2 images of the same animal and among duplicate tracings of each of the 2 images.

RESULTS

A summary of the data used in analysis for the current study is presented in Table 2.1.

Correlations between three temperament assessment techniques

A summary of the correlations resulting from comparing order through the chute, weight and the three temperament assessment techniques can be found in Table 2.2. Correlations between order of cattle through the chute (Table 2.2) were statistically significant for BW, chute exit speed and exposed EW. Cattle that were first through the chute had a slight tendency to be lighter in BW, but this correlation is very low (-0.08258, \( P = 0.0281 \)). Cattle that were moved through the chute later in the order were more likely to have faster chute exit speeds (0.14640; \( P = 0.0002 \)), but lower exposed EW (-0.13045; \( P = 0.0013 \)). There was no significant relationship between order through the chute and chute temperament score. The BW of cattle was correlated to all three temperament assessment techniques, but the correlations were low. As BW increased, chute temperament score (0.11941; \( P = 0.0015 \)) and exposed EW (0.14684; \( P = 0.0003 \)) also increased. However a negative correlation was found between BW and chute exit speed (-0.21548; \( P < 0.0001 \)), indicating heavier cattle had slower chute exit times. The Pearson partial correlation coefficient between chute temperament score and chute exit speed was 0.26561 (\( P < 0.0001 \)), between chute temperament score and exposed EW was 0.13660 (\( P < 0.005 \)) and between chute exit speed and exposed EW was -0.01443 (\( P > 0.20 \)). Statistically significant correlations were found between chute temperament score and chute exit speed, and chute temperament score and
exposed EW, however these correlations were low. There was no statistically significant relationship found between chute exit speed and exposed EW.

**Correlations between subsequent assessments of temperament at research farm**

A summary of the data for objective two is presented in Table 2.3, and Table 2.4 displays a summary of the correlations between these repeated weight and temperament assessments. Mean chute temperament score, chute exit speed and average exposed EW percentage was higher on day 2 when compared to day 1 (Table 2.4). All correlations were statistically significant, indicating each these techniques are repeatable over consecutive days. The Pearson correlation coefficient between the repeated measure of weight on day 1 and the following day (day 2), was 0.9738 ($P < 0.0001$). The correlation between repeated measures of temperament assessment techniques on day 1 and day 2 was 0.3656 ($P < 0.0001$) for chute temperament score, 0.6605 ($P < 0.0001$) for chute exit speed and 0.1940 ($P < 0.05$) for exposed EW.

**Repeatability of exposed EW calculation**

A summary of the correlations resulting from comparing repeated tracings of still images to satisfy objective three can be found in Table 2.5. The Pearson partial correlation coefficient between repeated exposed EW tracings (trace 1 and trace 2) of image 1 was 0.66129 ($P < 0.0001$) and between repeated tracings of image 2 was 0.89157 ($P < 0.0001$). These moderate to high statistically significant correlations indicate that when the same image was traced twice, a similar exposed EW value was calculated. The correlation between exposed EW calculated from image 1 and image 2 is 0.52427 ($P < 0.0001$).
**DICUSSION**

The statistically significant, low correlations between chute temperament score, chute exit speed and exposed EW provide evidence that when different techniques are used for temperament assessment the outcomes differed. This means that individual cattle classified as reactive temperament in terms of chute temperament score, were not necessarily classified as reactive temperament by chute exit speed or exposed EW techniques. The results suggest that these techniques are not measuring the same aspects of temperament. High correlations between the three techniques would indicate they had similar temperament assessment outcomes. The findings of this study suggest that cattle with faster chute exit speeds are more likely to enter the chute later in terms of herd order, which are similar findings to Hoppe et al. (2010). However, Hoppe et al. (2010) also reported that cattle entering the chute earlier in terms of order had lower chute temperament scores, whereas this correlation was not noted in the current study. Investigating the relationship between order through the chute and temperament assessment while restrained may provide more information into if cattle are sorting themselves based on apprehension to enter the chute.

The correlation between chute temperament score and chute exit speed in the current study is lower in comparison to the findings of previous studies (Curley et al. 2006; Core et al. 2009; Cafe et al. 2011). Previous studies report a moderate correlation; 0.35 ($P < 0.005$) (Curley et al. 2006); 0.378 ($P < 0.005$), 0.680 ($P < 0.001$), and 0.460 ($P < 0.001$) for heifers, bulls and steers, respectively (Core et al. 2009); and 0.41 ($P < 0.001$) for a group of Brahman cattle and 0.39 ($P < 0.05$) for a group of Angus cattle (Cafe et al. 2011). However, in agreement with these previous studies, it seems chute temperament score and chute exit speed are measuring some similar components of cattle temperament.
The correlation between chute temperament score and exposed EW from the current study is in contrast with previous findings, which reported much higher correlations (Core et al. 2009). In the study by Core et al. (2009), the correlations between these two techniques were 0.674 ($P < 0.0001$), 0.95 ($P < 0.0001$) and 0.696 ($P < 0.0001$), for heifers, bulls and steers, respectively.

There was no significant correlation found between chute exit speed and exposed EW in the current study. This contradicts the findings from Core et al. (2009), who reported correlations of 0.378 ($P < 0.005$), 0.680 ($P < 0.001$), and 0.460 ($P < 0.001$) between these two methods when tested on heifers, bulls and steers, respectively.

The correlations between chute temperament score and exposed EW, and chute exit speed and exposed EW were determined for 601 and 554 animals, respectively. In contrast, Core et al. (2009) reported findings on a much smaller number of cattle (48 heifers, 39 bulls and 60 steers). It is possible that the correlations reported by Core et al. (2009) were impacted by the study size.

In addition, flight speed was used by Core et al. (2009), which is a slightly different technique than chute exit speed. Core et al. (2009) measured flight speed independently of handling and the handling chute. The current study used an electronic timing system, set up at the exact same distance for each animal, to prevent human error from impacting chute exit speed assessments.

There are a number of possible variables that can impact the resulting temperament assessment using these techniques, and thus impact the correlation between them. Chute temperament score is subjective in nature, which means human bias or error can impact the results (Boivin et al. 1992). The time during handling when chute temperament score was assigned or the point at which a still image of the eye was extracted, can impact the resulting temperament assessment. For instance, if the chute temperament score was assigned while the animal was having an ear
tag inserted, the resulting behavioural response may have been due to the process of inserting the ear tag, not necessarily handling in general. The equation used to calculate exposed EW in the current study was the same as that used by Core et al. (2009), however the software program differed. During still eye image selection process, it was difficult to regulate the time during the handling period that these images were selected. Every effort was made to select an image at the beginning and end of the handling period, and at a time when the animals’ head was perpendicular to the camera, so the eye was easily visible.

Although temperament assessment techniques are based on observations attempting to quantify temperament, they may in fact be measuring different components of the temperament response and it may be inappropriate to directly compare the results. For instance, an animal not moving while restrained in the chute would be assigned a 1 on the chute temperament score, indicating a docile temperament; however it is possible they are not moving because they are in a state of fear. This animal may leave the handling area at a very fast speed, motivated by this fear to escape the situation. In this case, the temperament of the animal would be classified differently using these techniques, and thus temperament results from the two methods would not be in agreement.

Repeatability of temperament assessment outcomes from different techniques has been investigated in previous studies (Petherick et al. 2002; Curley et al. 2006; Müller and von Keyserlingk, 2006; Cafe et al. 2011; Sebastian et al. 2011). These studies investigated repeated measures ranging from the same day, conducted hours apart, to measures taken days apart, to repeated on a monthly basis. In the current study, chute temperament score, chute exit speed and average exposed EW were higher on day 2 relative to day 1. Previous studies’ have also noted an increase in chute exit speed over time when this test has been conducted over longer time
intervals (Petherick et al. 2002; Müller and von Keyserlingk, 2006; Schwartzkopf-Genswein et al. 2012). These previous studies have attributed these findings to either an increased fear response or increase in speed ability due to increased muscle mass (Petherick et al. 2002; Müller and von Keyserlingk, 2006). Due to the consecutive day assessment in the current study, it is unlikely an increase in muscle mass can be used to explain the increase in chute exit speed. The group of cattle at the research farm originated from a large feedlot in western Canada where they were among a larger herd of 3000 cattle that had minimal interaction with humans. At the end of backgrounding feeding phase, the group was transported to the research farm, where they had been handled only 3 times through the weigh scale, before involved in the current study. Based on their minimal previous human handling experience it is likely they were experiencing some level of fear or frustration in response to being handled, as it is still a novel experience.

The correlation between repeated measures of temperament assessment techniques on day 1 and day 2 was the highest for chute exit speed (0.6605; \( P < 0.0001 \)). This provides some evidence that chute exit speed was the most consistent component of the temperament response in this study. The lower correlations between repeated measures of chute temperament score and exposed EW mean there was more scatter around the line of best fit when comparing the results of these assessments over the 2 consecutive day test period. These results could be partly due to the inability to measure chute temperament score and exposed EW in a consistent way, due to both animal response and human error in performing the technique. These findings are in agreement with previous studies, which suggest that chute exit speed is the most repeatable technique for assessing temperament (Curley et al. 2006; Cafe et al. 2011). This may be attributed to the more objective nature of this technique, whereby an electronic timing system is used and human error or bias is minimized. Chute exit speed appears to be a consistent and reliable measure of a
component of the temperament response, specifically the speed at which a segregated animal flees the handling area to return to the herd. If temperament is considered to be consistent over time, only minimally impacted by both positive and negative experience, then this robust response should be evident in highly correlated repeated assessments indicating minimal changes in resulting temperament assessment.

This is the first study reporting on the repeatability of exposed EW over a multiple day test period. The results of this study suggest this repeatability is quite low (0.1040; \( P = 0.0495 \)), when measured on two consecutive days. This could be due to the lack of consistency in image selection for EW analysis or can indicate that exposed EW is not consistent from day to day.

Correlations between both images of exposed EW for the same animal provides evidence as to whether exposed EW is consistent across the handling period, and thus, if more or fewer images might be required to get an accurate measure. The correlation between image 1 and image 2 in the current study was lower than findings from Core et al. (2009), who reported a correlation of 0.96 (\( P < 0.0001 \)). This difference may be due to a larger sample size in the current study, a different computer software program, use of a high definition camera in the current study and potential for human error in both image selection and analysis. In addition, the average exposed EW percentage for the cattle in the study by Core et al. (2009) was approximately 30%. This is a larger percentage, more than double, the exposed EW percentage for the cattle in the current study, which was around 12%. When more EW is visible it becomes easier to have an accurate trace; as the exposed EW decreases, it becomes more difficult to observe, and thus trace. The moderate correlation between average exposed EW obtained from the two different images from each animal suggests that exposed EW is not consistent across the handling period or that more images would have provided a more accurate measure. It may also be the change in exposed EW
over the handling period, or extreme values of EW, would provide the best situation for temperament assessment.

The results of the current study indicate that the correlation between repeated tracings of the same EW image were moderate to high, positive and statistically significant, $0.66129 (P < 0.0001)$ and $0.89157 (P < 0.0001)$, for image 1 and image 2, respectively. These values were lower than the correlations reported by Core et al. (2009) (image 1: $0.94, P < 0.0001$ and image 2: $0.96, P < 0.0001$). The correlation between image 1 and image 2 in the current study was lower than findings from Core et al. (2009) ($0.96 (P < 0.0001$). Similar to mentioned above, these differences could be due to image selection, sample size, tracing error, and differences in computer software programs used to analyze the images. The results of the current study, in combination with the results from Core et al. (2009) suggest that repeatability of tracing the exposed EW image is high. This suggests the tracing procedure is suitable for use in calculating exposed EW for temperament assessment if exposed EW in fact has some value in understanding temperament.

The results of this study provide evidence for the use of exposed EW in terms of temperament and behavioural assessment. In the current study, every effort was made to select the first image for analysis just after the animal was restrained in the handling chute, and the second image just prior to release from the handling chute. A standardized procedure involving EW analysis is necessary to ensure images are selected and analyzed using the same process. The change in exposed EW throughout the duration of handling or the peak exposed EW may be the most relevant for temperament classification. Establishing a baseline exposed EW for each animal prior to a handling situation would be beneficial. Some cattle may have more exposed EW than others naturally, and this may alter the interpretation of results. Investigating the exposed EW at
different points during the handling period may provide more insight into whether exposed EW could be a valuable tool for temperament assessment or identification of a fear response. Measuring exposed EW at the point when a health or management procedure is being performed, such as castration or ear tagging, may provide evidence as to how that animal is reacting as a direct result. If exposed EW at this point is at its’ maximum, an argument could be made that at this point, the animal had the most extreme behavioural response to handling. Other techniques for assessment of temperament may provide more consistent results, particularly those that are more objective and standardized. For example, the MMD (Stookey et al. 1994) may provide a more precise measure of chute temperament score, whereby the number and force of movements while restrained in the chute can be obtained in terms of peaks of movement and amplitude or force of each movement. Results of Sebastian et al. (2011) suggest a relationship between chute temperament score and the peaks reported by the MMD. The MMD was not used in the current study because this equipment is only available at the University of Saskatchewan feedlot research station. An additional tool used in research is the mounting of strain gauges to each bar of the head gate (Schwartzkopf-Genswein et al. 1997, 1998) which are sensitive to the forces acting in the front to rear direction exerted on this part of the chute. Schwartzkopf-Genswein et al. 2012 found measures of animal activity derived from head gate strain gauges were significantly correlated with chute temperament scores. These techniques further enhance the information obtained from a chute temperament score assessment allowing for a more accurate and possibly consistent temperament assessment outcome.

**CONCLUSIONS**

Beef cattle temperament is a broad label term invoked to explain the behavioural responses of cattle to handling and the presence of humans. It is evident that temperament is complex and
difficult to accurately assess with just one test. The three temperament assessment techniques used in this study were not highly correlated which suggests they are measuring different aspects of the temperament complex. From a practical perspective, different aspects of the temperament response, measured by different assessment techniques, may relate more to one area of production interest than others. For instance, one of the three techniques used in the current study may relate primarily to aspects of animal welfare, handler safety, or meat quality. Using one standard temperament assessment technique across the industry will not provide enough reliable information about the scope of the behavioural response of cattle. The specific assessment selected for use will depend on the aspect of practical importance being investigated, and the goal of the temperament assessment itself.

The development and implementation of additional techniques to assess beef cattle temperament, both at the experimental and industry-level, is necessary to further understand the different aspects of temperament. In addition, further studies conducted across different breeds and quantity of cattle are necessary to understand if these relationships are greatly dependent on breed, sex, previous experience, facility design, or other environmental or biological influences. When techniques are understood and accurately implemented, resulting temperament assessments can be used to make management based decisions to improve animal welfare and animal handler safety, while considering production aspects of interest.
Table 2.1. Description of body weight (BW), chute temperament score, chute exit speed and average exposed EW percentage, regardless of farm, for all cattle in the study.

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
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<tbody>
<tr>
<td>BW (kg)</td>
<td>708</td>
<td>508</td>
<td>135</td>
<td>5</td>
<td>165</td>
<td>888</td>
</tr>
<tr>
<td>Chute Temperament Score</td>
<td>708</td>
<td>2</td>
<td>1</td>
<td>0.034</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Chute Exit Speed (m/s)</td>
<td>652</td>
<td>1.843</td>
<td>0.682</td>
<td>0.026</td>
<td>0.201</td>
<td>3.932</td>
</tr>
<tr>
<td>Exposed EW (%)</td>
<td>605</td>
<td>12.176</td>
<td>5.847</td>
<td>0.238</td>
<td>0.574</td>
<td>35.606</td>
</tr>
</tbody>
</table>
Table 2.2. Pearson partial correlation coefficients among order cattle moved through the chute, BW and three techniques for assessing temperament for all cattle in the study.

<table>
<thead>
<tr>
<th></th>
<th>Order through chute</th>
<th>BW</th>
<th>Chute Temperament Score</th>
<th>Chute Exit Speed (m/s)</th>
<th>Exposed EW (%)</th>
</tr>
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<tr>
<td>Order through chute</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BW</td>
<td>-0.082*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$P = 0.0281$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$n = 708$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chute Temperament</td>
<td>0.042</td>
<td>0.119*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Score</td>
<td>$P = 0.2588$</td>
<td>$P = 0.0015$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$n = 708$</td>
<td>$n = 708$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chute Exit Speed (m/s)</td>
<td>0.146*</td>
<td>-0.215*</td>
<td>0.265*</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$P = 0.0002$</td>
<td>$P &lt; 0.0001$</td>
<td>$P &lt; 0.0001$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$n = 652$</td>
<td>$n = 652$</td>
<td>$n = 652$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposed EW (%)</td>
<td>-0.130*</td>
<td>0.146*</td>
<td>0.136*</td>
<td>-0.014</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>$P = 0.0013$</td>
<td>$P = 0.0003$</td>
<td>$P = 0.0008$</td>
<td>$P = 0.7340$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$n = 605$</td>
<td>$n = 605$</td>
<td>$n = 605$</td>
<td>$n = 558$</td>
<td></td>
</tr>
</tbody>
</table>

*statistically significant
Table 2.3. Description of weight, chute temperament score, chute exit speed and average exposed eye white (EW) percentage, for EBRC cattle assessed twice (day 1 and day 2).

*October 30, 2012*

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW (kg)</td>
<td>86</td>
<td>720</td>
<td>63</td>
<td>7</td>
<td>543</td>
<td>868</td>
</tr>
<tr>
<td>Chute Temperament Score</td>
<td>126</td>
<td>2.357</td>
<td>0.983</td>
<td>0.087</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Chute Exit Speed (m/s)</td>
<td>120</td>
<td>1.778</td>
<td>0.561</td>
<td>0.051</td>
<td>0.797</td>
<td>4.595</td>
</tr>
<tr>
<td>Exposed EW (%)</td>
<td>115</td>
<td>12.972</td>
<td>3.310</td>
<td>0.309</td>
<td>4.346</td>
<td>19.670</td>
</tr>
</tbody>
</table>

*October 31, 2012*

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW (kg)</td>
<td>126</td>
<td>721</td>
<td>59</td>
<td>5</td>
<td>543</td>
<td>888</td>
</tr>
<tr>
<td>Chute Temperament Score</td>
<td>126</td>
<td>2.460</td>
<td>1</td>
<td>0.088</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Chute Exit Speed (m/s)</td>
<td>125</td>
<td>1.955</td>
<td>0.581</td>
<td>0.052</td>
<td>0.857</td>
<td>3.560</td>
</tr>
<tr>
<td>Exposed EW (%)</td>
<td>113</td>
<td>15.060</td>
<td>3.654</td>
<td>0.344</td>
<td>4.860</td>
<td>26.250</td>
</tr>
</tbody>
</table>
**Table 2.4.** Pearson partial correlation coefficients among repeated measures of weight and three techniques for assessing temperament over two consecutive days.

<table>
<thead>
<tr>
<th></th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>0.974*</td>
</tr>
<tr>
<td></td>
<td>$(P &lt; 0.0001)$</td>
</tr>
<tr>
<td></td>
<td>$n = 86$</td>
</tr>
<tr>
<td>Chute Temperament Score</td>
<td>0.365*</td>
</tr>
<tr>
<td></td>
<td>$(P &lt; 0.0001)$</td>
</tr>
<tr>
<td></td>
<td>$n = 126$</td>
</tr>
<tr>
<td>Chute Exit Speed (m/s)</td>
<td>0.660*</td>
</tr>
<tr>
<td></td>
<td>$(P &lt; 0.0001)$</td>
</tr>
<tr>
<td></td>
<td>$n = 120$</td>
</tr>
<tr>
<td>Animal Average EW (%)</td>
<td>0.194*</td>
</tr>
<tr>
<td></td>
<td>$(P = 0.0495)$</td>
</tr>
<tr>
<td></td>
<td>$n = 103$</td>
</tr>
</tbody>
</table>

*statistically significant*
Table 2.5. Pearson partial correlation coefficients among repeat exposed EW tracings of the same image, and second image, from the same animal.

<table>
<thead>
<tr>
<th>Trace 1</th>
<th>Trace 2</th>
<th>Average</th>
<th>Trace 1</th>
<th>Trace 2</th>
<th>Average</th>
<th>Animal</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picture 1 Trace 1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Picture 1 Trace 2</td>
<td>0.661*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Picture 1 Average</td>
<td>0.915*</td>
<td>0.907*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Picture 2 Trace 1</td>
<td>0.493*</td>
<td>0.476*</td>
<td>0.531*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Picture 2 Trace 2</td>
<td>0.537*</td>
<td>0.527*</td>
<td>0.583*</td>
<td>0.891*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Picture 2 Average</td>
<td>0.529*</td>
<td>0.515*</td>
<td>0.572*</td>
<td>0.974*</td>
<td>0.970*</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Animal Average</td>
<td>0.812*</td>
<td>0.801*</td>
<td>0.885*</td>
<td>0.846*</td>
<td>0.873*</td>
<td>0.883*</td>
<td>1</td>
</tr>
</tbody>
</table>

*statistically significant
**Figure 2.1.** Set up of electronic timing system for determining the duration of time (in seconds) it took each animal to traverse a measured distance of 2m after exiting the squeeze chute. This time was then divided by 2m to determine chute exit speed (m/s).

A: First set of infra-red transmitter and receiver

B: Second set of infra-red transmitter and receiver
**Step 1:** Select image for analysis.

**Step 2:** Trace outer perimeter of the eye. Determine area of this traced area with the computer software program ImageJ.

**Step 3:** Trace iris/pupil. Determine area of this traced area with the computer software program ImageJ. Input the value for the area of the iris (Step 2) and the area of the perimeter of the eye (Step 3) into the equation: Eye white percent = \((1 - \frac{\text{area of the iris}}{\text{area of the total eye}}) \times 100\%\). Repeat Steps 2 – 3 for each image, and repeat Steps 1 -3 for each animal. (Total of 2 images per animal, each image to have 2 eye white percent values)

**Figure 2.2.** Schematic of steps to trace and calculate exposed EW using a still eye image.
Figure 2.3. Distribution of cattle in the study across the 5 chute temperament scores. N = 708.
Chapter 3: The relationship between temperament and production and meat quality characteristics of beef cattle

ABSTRACT

Studies show that cattle with more reactive temperaments have less desirable production attributes (e.g., decreased average daily gain (ADG)) and meat quality (e.g., lower tenderness). Temperament is also considered to impact human safety and animal welfare. Our study objectives were to test three methods for assessing beef cattle temperament on farms, and to relate those outcomes to production parameters from ultrasound assessment (backfat thickness, marbling and muscle depth), growth efficiency parameters (ADG and residual feed intake, RFI) and meat quality parameters (shear force). Steers and heifers (n = 582) from 3 commercial feedlots in southwestern Ontario were assessed at an average weight (±SD) of 508 ± 135 kg. Each animal was put through a handling chute to perform ultrasound and assess temperament. A chute temperament score from 1 (calm) to 5 (extremely wild) was assigned. Exit speed was calculated using an electronic timing system placed 2m past the exit chute. Each animal’s head was video recorded while restrained and 2 still images per animal were selected for analysis of exposed eye white percentage (EW). A GLM procedure in SAS was used to model each ultrasound, growth efficiency and meat quality parameter, controlling for farm group, weight and including the temperament assessment measures as covariates. Weight was significant ($P < 0.05$) in each model. As exposed EW increased by 1 percent, backfat decreased 0.0284 mm ($P < 0.20$); as chute exit speed increased by 1 m/s, marbling score increased by 0.349 ($P < 0.0001$); as chute temperament score increased by 1, depth of the loin muscle increased 0.742 mm ($P < 0.005$). As chute temperament score increased by 1, ADG increased by 0.181 kg/day ($P < 0.05$); and as exposed EW increased by 1 percent, ADG increased by 0.031 kg/day ($P < 0.05$). There was no significant relationship found between RFI or shear force and any of the three temperament
assessment techniques. The results of this study suggest that chute temperament score, chute exit speed and exposed EW may not be useful predictors of live animal ultrasound measures, ADG or RFI. However, these assessment techniques may be important when considering animal welfare and handler safety, or other production or meat quality parameters of interest to the industry.

**INTRODUCTION**

Beef cattle temperament, practically defined as the nature of the animal as it affects the way it behaves towards human presence or handling (Gauly et al. 2001) is a moderately heritable trait of importance in production (Voisinet et al. 1997b). Beef cattle temperament affects handler safety and animal welfare, and in addition this behavioural response to the act of being handled has also been shown to influence production traits of interest. Evidence from previous studies suggest that temperament impacts dry matter intake (DMI) and average daily gain (ADG); in that docile temperament cattle put on more BW per day (Sebastian, et al. 2011; Turner et al. 2011) and that more reactive temperament cattle have decreased ADG (Burrow and Dillon, 1997; Gauly et al. 2001). Cattle with reactive temperaments are suggested to produce less tender meat (Behrends et al. 2009; King et al. 2006) with a higher incidence of borderline dark cutting (Voisinet et al. 1997a); which translates to an economic loss for the producer and undesirable consumer product.

Most research investigating the link between temperament and production traits of interest in the live animal includes traits relating to efficiency, specifically ADG and DMI (Nkrumah et al. 2007). Residual feed intake (RFI) is another measure of feed efficiency, expressed as the difference between the actual feed intake observed and that which is expected given the animal’s performance characteristics, such as BW and ADG (Archer et al. 1999). One of the first studies
investigating the link between temperament and RFI suggested temperament was not related phenotypically with RFI; however behavioural traits in general may contribute to variation in growth efficiency between beef cattle of similar breeds, age and management (Nkrumah et al. 2007). Additional studies investigating temperament and its link to RFI may provide evidence regarding the potential for selection based on temperament to improve feed efficiency. Understanding the relationship between temperament and live animal production parameters provides insight into variation in economically important aspects of the carcass post-slaughter.

Ultrasound technology is used in the beef cattle industry to measure live-carcass characteristics and make predictions about the number of days an animal should remain on feed in order to be slaughtered at the optimal carcass composition (Brethour, 2000). Ultrasound technology provides an opportunity to quickly and economically estimate carcass attributes on the live animal (Brethour, 2000). Greiner et al. (2003) found a high correlation between live animal ultrasound measures and post-slaughter measures of rib fat thickness and muscle area. Houghton and Turlington (1992) also reported high levels of accuracy, with average correlations of 0.86 and 0.73 between carcass and ultrasound measurements of 12th-rib fat thickness and longissimus muscle area, respectively. Linking temperament to these economically important factors of body composition provides opportunities for management based decisions to be made on both behaviour and economic potential.

The three objectives of the current study were to compare temperament measures to different production and product quality attributes of feedlot cattle including; live animal ultrasound assessment for body composition; growth and feed efficiency traits, and lastly important meat quality parameters. It is hypothesized that docile temperament cattle have more desired body composition parameters. However not all temperament assessment techniques are related to all
live-animal body composition parameters. It is also proposed that there is a correlation between an animal’s performance, and its temperament, as evaluated by both subjective and objective techniques.

**MATERIALS AND METHODS**

The methods used in this study were conducted in accordance with the Canadian Council on Animal Care regulations and standards, and the study was completed within the guidelines of an approved Animal Utilization Protocol from the University of Guelph Animal Care Committee.

**Experimental location and animals**

The locations and animals involved in this study were outlined in Chapter 2, as data were collected for both studies at the same time. The same 708 beef cattle of mixed *Bos taurus* beef breeds were used in this study.

**General methods**

Each animal’s temperament was assessed and an ultrasound was performed to determine live carcass performance attributes for body composition for the current study. ADG and RFI were calculated for the group of cattle at EBRC. In addition, Warner-Bratzler shear force was used to determine steak tenderness. This data was collected for ongoing studies conducted at this research facility.

**Ultrasound assessment**

Ultrasound measurements were obtained on the left side of each animal. Vegetable oil (15 mL) was placed on the back of the animal where the ultrasound image was to be taken. The experienced technician performing this assessment used an Aloka SSD-500 ultrasound unit, long
probe (model 5044; 172 mm; 3.5 MHz; Corometrics Medical Systems, Wallingford, CT), and stand-off block, to scan the 12th/13th rib interface. Images were captured using a USB 2800 capture card (Hi-Speed USB Revision 2.0 Style 2725, Item No.; VC-211V, Serial No.; 000372A). Minimum subcutaneous fat depth over the longissimus muscle in the fourth quadrant distal to the spine was measured from this image, as well as longissimus muscle area. Four to six sagittal scans across the 11th to 13th ribs were also collected using the long probe, and marbling score was estimated using CPEC software (Bergen et al. 2005). From the ultrasound assessment output, backfat thickness (mm), marbling (score) and depth of the loin muscle (mm) were recorded.

Temperament assessment

Individual animal temperament was evaluated using three methods: assigning a 1 to 5 chute temperament score (Grandin, 1993), measuring chute exit speed, and by calculating the exposed eye white percentage (exposed EW) of cattle while restrained in the chute. The specific methods for temperament assessment were outlined in Chapter 2, as this data was collected for a parallel study. At the research farm, temperament was assessed twice, on two consecutive days; October 30, 2012 and October 31, 2012 to satisfy an objective in Chapter 2. All techniques were repeated in the same order and same manner on both day 1 and day 2. Ultrasound assessment was only performed once on research farm cattle, either on day 1 or day 2. For the purpose of the current study, only the temperament assessed on the day the ultrasound was performed was included in the analysis.
Average daily gain and residual feed intake calculations

ADG and RFI were calculated for the group of cattle at the research farm. ADG was determined by a regression of BW on days on test, with 5 observations per animal at intervals of 28 d. The feed intake to gain ratio (F: G) was also calculated. The mid-trial metabolic body weight (MBW) was calculated by computing the animals’ intercept plus the ADG times 56 d (half of the whole testing period) at ¾ power.

Residual feed intake (RFI) was initially calculated from the model of Koch et al. (1963):

\[
\text{ADMI} = \beta_0 + \beta_1(\text{ADG}) + \beta_2(\text{ABW}) + \text{RFI}
\]

Where ADMI is the average dry matter intake, \(\beta_0\) is the regression intercept, and \(\beta_1\) and \(\beta_2\) are coefficients of the linear regression of ADMI on trial ADG and trial average metabolic body weight (ABW). The residual portion of the model is the RFI (Koch et al. 1963). RFI and ADG was calculated for the 126 cattle at the research farm.

Shear force calculation

Steak tenderness was determined using Warner-Bratzler shear force to measure the amount of force (kg) required to cut through cooked longissimus dorsi that had been aged for 7 days post-mortem. Steaks were thawed for 48 hours at 1.5°C, trimmed of external fat and epimysium, and weighed prior to cooking. Steaks were cooked to an internal temperature of 70°C on a Garland Grill (ED-30B broiler, Garland Commercial Range Ltd., Mississauga, ON). Cooking temperatures were monitored via a thermocouple placed in the geometric centre of each steak with initial and final temperatures recorded. Steaks were turned after reaching an internal temperature of approximately 35°C. Once the steak was cooked to 70°C, the cooked weight of
each steak was recorded; steaks were placed in individual bags, and immediately chilled in ice water. Steaks were stored at 1.5°C for 24 hours before extracting a core for sampling. Before coring, steaks were allowed to equilibrate to room temperature. Approximately 8 cores of 1.5 cm were removed parallel to the muscle fibers from each steak using a drill press mounted corer. Cores were sheared using a Warner-Bratzler blade on a TA-XT Plus texture analyzer (Texture Technologies Corp., Scarsdale, NY) with crosshead speed set at 3.3 mm s^{-1}. Peak shear force was determined using a custom macro program in Stable Microsystems Exponent software, with the average of the 8 peak force values used in data analysis as the shear force value for each animal, reported in kg.

**Statistical analysis**

The computing program SAS version 9.3 (Statistical Analysis System, 2003), was used to analyze temperament, ultrasound assessment, growth efficiency and meat quality data. Due to equipment difficulties or inability to assess an animal based on farm conditions, there were not always equal numbers of observations for every outcome of interest, on every farm. EW video recording was not available on one commercial feedlot, due to recording equipment failure.

The normality of distributions of all three temperament assessment techniques was assessed with the UNIVARIATE procedure in SAS. Negative exposed EW values were removed and replaced with a zero prior to analysis due to biological significance. These values were replaced with a zero based on the assumption that a negative value was calculated because there was no exposed EW to observe while completing the trace. Out of 2404 EW images, a total of 22 negative exposed EW values were identified and replaced with a zero. The UNIVARIATE procedure was performed again after removing negative exposed eye white percentages. The Shapiro-Wilk test
was performed to investigate linearity of the temperament assessment technique variables. From the cattle at EBRC, temperament assessment results collected on the same day the ultrasound assessment was performed were used in analysis. This was done to remain consistent with the commercial farms, as temperament was only assessed once at those locations.

To satisfy the objectives of this study, the following traits were modeled separately using a General Linear Model (GLM): each ultrasound parameter of interest (backfat thickness, marbling score and muscle depth), growth and feed efficiency traits (ADG and RFI) and a meat quality parameter (shear force). Weight was included in each model due to its statistical and biological significance. Models with significant temperament assessment techniques were further analyzed to determine an estimate of impact on the parameter of interest. The fit of all models was investigated using residual plots.

The final models are as follows:

\[ BF = \text{group} + \text{wt} + \text{EW} + e \]

\[ MB = \text{group} + \text{wt} + \text{wt} \times \text{speed} + \text{speed} + e \]

\[ MSC = \text{group} + \text{wt} + \text{CTS} + e \]

\[ ADG = \text{group} + \text{CTS} + \text{CTS} \times \text{EW} + \text{EW} + e \]

Where the parameters of interest represent y, including BF = backfat thickness (mm); MB = marbling score; MSC = muscle depth of the loin muscle (mm); and ADG = average daily gain (kg/d). Where group = specific farm and group; wt = animal weight at time of ultrasound assessment (kg); EW = average exposed eye white (%); speed = chute exit speed (m/s); CTS = chute temperament score; wt*speed = interaction between weight (lb) and chute exit speed (m/s);
CTS*EW = interaction between chute temperament score and average exposed eye white (%); and e = residual error associated with observation y. All effects other than residual error were considered fixed.

Animals were assumed unrelated with no repeated records. All animals were assumed to be mixed common beef cattle breeds. Cattle with higher chute temperament scores, faster chute exit speeds and greater exposed EW were assumed to be more reactive in temperament. All animals were assumed to be steers or heifers. Limitations included lack of birth date information and varying stage of growth, impacting the remaining number of days to slaughter, both among and between farms.

No models with significant factors of interest were found for RFI or shear force.

**RESULTS**

A summary of the number of animal records for the outcomes of interest used in analysis for the current study is presented in Table 3.1 with summary statistics in Table 3.2.

The results of the UNIVARIATE procedure suggest that chute exit speed and exposed EW are more normally distributed than chute temperament score. The skewness and kurtosis values calculated for chute exit speed and exposed EW did not differ significantly. However these values for chute temperament score were greater (Table 3.3). Greater kurtosis values mean that more of the variance is due to infrequent extreme deviations. The result of the Shapiro-Wilk test was statistically significant, indicating that chute temperament score, chute exit speed and exposed EW were not normally distributed. However, upon examination of the box plots for both chute exit speed and exposed EW percentage, in combination with low skewness and kurtosis values, these variables were assumed to be normally distributed.
The three objectives of the current study were to compare temperament measures to different production and product quality attributes of feedlot cattle including; live animal ultrasound assessment for body composition; growth and feed efficiency traits, and lastly an important meat quality parameter.

A summary of the final models for the ultrasound, growth and efficiency and meat quality parameters can be found in Table 3.4. To satisfy the first objective, comparing temperament and live animal ultrasound assessment for body composition; as exposed EW increased by 1 percent, backfat thickness decreased by 0.0284 mm ($P < 0.20$). As chute exit speed increased by 1 m/s, marbling score increased by 0.349 ($P < 0.05$). As chute temperament score increased by 1, loin muscle depth increased by 0.724 mm ($P < 0.005$).

To satisfy the second objective, comparing temperament measures with growth and feed efficiency traits; as chute temperament score increased by 1, ADG increased by 0.181 kg/day ($P < 0.05$). As exposed EW increased by 1 percent, ADG increased by 0.031 kg/day ($P < 0.05$). There was no statistically significant relationship found between temperament assessment measures and RFI.

To satisfy the third objective, temperament measures and shear force, a meat quality parameter was investigated, but no significant effects were determined.

**DISCUSSION**

The significant relationships between temperament assessment techniques and the live animal ultrasound parameters, suggest that more reactive temperament cattle have slightly more desirable parameter outcomes at time of assessment, in terms of backfat thickness, marbling.
score and muscle depth. It is plausible that cattle with a greater muscle depth are more reactive, and thus have less backfat.

Ultrasound assessment of the live animal results in body composition parameters of the animal at the time it is performed. The stage of growth and therefore remaining days on feed to slaughter, impact the results of the ultrasound assessment and the findings of this study. Older cattle that have been on feed longer, have more muscle, and are most likely closer to slaughter. Body composition of younger and older cattle will differ due to age and days on feed. Although the effect for farm was controlled in analysis, the age of the cattle at time of ultrasound assessment was not, as this information was not known. It was evident from the range in body composition parameters both across and within farm locations, that age of cattle involved in the current study varied. Temperament responses may differ between young and mature cattle, given the difference in frequency of handling exposure. Live animal body composition and temperament should be assessed across cattle of the same age, or at least on cattle where age is known to allow for control of this variable.

There are no studies to date, which investigated the relationship between temperament assessments conducted at the same time a live animal ultrasound for body composition is performed. Given the suggested accuracy between outcomes of live animal ultrasound for body composition and body composition post slaughter (Greiner et al. 2003), it can be assumed that to some degree, the results of this study should be comparable with studies investigating temperament and meat quality parameters obtained post slaughter. Cattle were not assessed at the same time pre-slaughter; it is possible that the assessment for those cattle closer to slaughter was more accurate then the assessment for cattle who still had a significant amount of time on feed. This would suggest that the accuracy between ultrasound assessment and post-slaughter
body composition could be quite different for those animals that had more days left on feed. This is a limitation to the current study and resulting models.

Backfat thickness of the carcass is used to calculate the yield grade of a carcass. As fat thickness increases, yield grade becomes less desirable as external fat is generally considered waste product, but the presence of at least some external fat is important for meat quality. Findings of the current study suggest that as temperament becomes more reactive, in terms of an increase in 1 percent of exposed EW, backfat thickness decreased. However, the impact of this change is very minimal, and the difference in backfat thickness between a docile and reactive temperament animal is almost insignificant. These reactive temperament cattle may require more time on feed prior to slaughter to ensure backfat thickness is appropriate for slaughter. Just under half of the variation in backfat thickness from cattle involved in the current study is explained by differences in exposed EW and weight, with the majority being explained by weight. Within the model for backfat thickness, weight is accounting for 41% of the variation in backfat thickness, whereas exposed EW is only explaining 2%. This provides evidence that other factors not accounted for in this study are impacting backfat thickness.

Marbling score is based on a scale of traces to very abundant, of intramuscular fat in the loin muscle. The greater the marbling score, the more abundant the marbling, which means a positive impact on quality grade. Results of the current study suggest that as chute exit speed increased by 1 m/s, marbling score increased by a third of a point. This would suggest more reactive temperament cattle have higher marbling scores. Similar to backfat thickness, the change in marbling score from a docile to reactive temperament animal is minimal, as it is not a greater difference then 1 point. King et al. (2006) in a study conducted on a group of steers, found that temperament (as determined by an index comprised of chute temperament score, pen
temperament score and chute exit speed) did not affect quality grade factors, specifically marbling score. A small proportion of the variation in marbling score for the cattle in this study is explained by the analysis of this trait. It is plausible that other genetic and behaviour traits, such as breeding and feeding behaviour, have a greater impact marbling score.

Loin muscle depth translates into the amount of marketable meat post-slaughter; thus a greater depth is more profitable. Results of the current study suggest that as chute temperament score increases, classifying the animal as more reactive, muscle depth increases; indicating reactive temperament cattle in this study have greater muscle depth. Similar to the other ultrasound parameters, this impact on muscle depth is quite low. The model explaining muscle depth is explaining 47% of the variation in this parameter; however, weight alone is accounting for 46% of the variation. Similar to backfat thickness, this suggests that other factors are affecting this trait in addition to weight, with little explanation due to temperament.

Due to the overall minimal impact of the extremes of temperament as classified by chute temperament score, chute exit speed and exposed EW, the results of this study indicate temperament does not greatly influence body composition parameters. In addition, the low to moderate model explanation of the variance in these body composition parameters suggest that unaccounted variables are having a larger impact in these differences. Specifically, age and breed might be important for further modeling of these traits.

In modeling each of the body composition ultrasound parameters, there was not one technique that was significantly related to each of the three ultrasound parameters. These results suggest that different temperament assessment techniques may need to be used when investigating a specific outcome of importance. Temperament, as defined by any combination of techniques,
may be too broad and not give an accurate representation of this characteristics impact on production outcomes of important.

Chute temperament score and exposed EW were found to be significantly related to ADG. The results of the current study indicate that as cattle temperament is classified as reactive, in terms of these two techniques, ADG is found to be higher. These results suggest that of the cattle evaluated at EBRC, those that are more reactive in temperament have greater ADG. These findings do not agree with previous findings, which suggested that docile temperament cattle have greater ADG (Voisinet et al. 1997b; Sebastian et al. 2011; Turner et al. 2011). It is possible that breed is confounding the current results. The cattle at EBRC used for this portion of the current study are European in origin, and have been found to be more reactive in temperament (Gauly et al. 2001), but perhaps this breed also has better ADG. The time at which ADG was measured and calculated could explain the results found in this study. Calculating lifetime ADG, rather then a short period of time of ADG, will encompass the different age periods when cattle may interact with human handlers on a more frequent basis. This type of ADG information, with repeated temperament assessments over the same time period, may provide a deeper understanding into the relationship between the different temperament assessment techniques and ADG.

The findings of the current study agree with that of Nkrumah et al. (2007), in that no relationship was evident between the three temperament assessment techniques tested and RFI for the cattle at EBRC. It is highly plausible that RFI is inherently related to feeding behaviour rather then behaviour in response to human handling.
No significant factors in the model for Warner-Bratzler shear force was found in the current study. This is in contrast to work by Voisinet et al. (1997a) which reported that as temperament progressed from docile to reactive, Warner-Bratzler shear force increased, indicating that temperament has a significant effect on meat toughness. Although the range in temperament assessment for this group of cattle ranges, the temperament may not be extreme enough to greatly impact shear force over the impact of other significant traits that were unaccounted for in the current study.

**CONCLUSIONS**

It is apparent beef cattle temperament is a complex concept, encompassing many different dimensions of behavioural response, which may be better understood with the use of variations of different assessment techniques. The results of the current study suggest that from a practical perspective, relationships exist between the different assessment techniques themselves and specific parameters of interest, rather than an overarching link with a general trait ‘temperament’. Further investigation is necessary to determine which specific techniques, if any, are related to production parameters of interest. The results of this study suggest that chute temperament score, chute exit speed and exposed EW may not be overwhelming predictors of live animal ultrasound measures, ADG, RFI, or shear force. However, these techniques may be important when considering animal welfare and handler safety. Although there is no evident production benefit from performing temperament assessment using these three techniques, this does not mean temperament or the response of cattle to the presence of humans, is not an important characteristic of beef cattle and thus the industry.
Table 3.1. A summary of the number of animals involved in this study with records for weight, temperament assessment, ultrasound parameters, growth efficiency parameters and meat quality characteristics.

<table>
<thead>
<tr>
<th></th>
<th>Farm 1 Group 1</th>
<th>Farm 2 Group 1</th>
<th>Farm 1 Group 2</th>
<th>Farm 3</th>
<th>Farm 2 Group 2</th>
<th>EBRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>50</td>
<td>65</td>
<td>153</td>
<td>120</td>
<td>194</td>
<td>126</td>
</tr>
<tr>
<td>Chute temperament score</td>
<td>50</td>
<td>65</td>
<td>153</td>
<td>120</td>
<td>194</td>
<td>126</td>
</tr>
<tr>
<td>Chute exit speed</td>
<td>40</td>
<td>59</td>
<td>140</td>
<td>116</td>
<td>177</td>
<td>120</td>
</tr>
<tr>
<td>Average EW</td>
<td>49</td>
<td>0</td>
<td>150</td>
<td>114</td>
<td>176</td>
<td>116</td>
</tr>
<tr>
<td>Backfat</td>
<td>50</td>
<td>65</td>
<td>149</td>
<td>120</td>
<td>194</td>
<td>126</td>
</tr>
<tr>
<td>Marbling</td>
<td>50</td>
<td>65</td>
<td>149</td>
<td>120</td>
<td>194</td>
<td>0</td>
</tr>
<tr>
<td>Muscle Depth</td>
<td>50</td>
<td>65</td>
<td>149</td>
<td>120</td>
<td>194</td>
<td>126</td>
</tr>
<tr>
<td>ADG</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>119</td>
</tr>
<tr>
<td>RFI</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>119</td>
</tr>
<tr>
<td>Shear Force</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>122</td>
</tr>
</tbody>
</table>

Total number of cattle per farm location:

Farm 1 Group 1 = 50; Farm 2 Group 1 = 65; Farm 1 Group 2 = 153; Farm 3 = 120; Farm 2 Group 2 = 196; EBRC = 126
Table 3.2. Description of BW, chute temperament score, chute exit speed and exposed EW, backfat thickness, marbling, muscle depth, ADG, RFI and shear force, regardless of farm, for all cattle in the study.

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW (kg)</td>
<td>708</td>
<td>508</td>
<td>135</td>
<td>5</td>
<td>165</td>
<td>888</td>
</tr>
<tr>
<td>Chute Temperament Score</td>
<td>708</td>
<td>2.00</td>
<td>1</td>
<td>0.0342</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Chute Exit Speed (m/s)</td>
<td>652</td>
<td>1.843</td>
<td>0.682</td>
<td>0.026</td>
<td>0.201</td>
<td>3.932</td>
</tr>
<tr>
<td>Exposed EW (%)</td>
<td>605</td>
<td>12.176</td>
<td>5.847</td>
<td>0.238</td>
<td>0.574</td>
<td>35.606</td>
</tr>
<tr>
<td>Backfat</td>
<td>704</td>
<td>7.257</td>
<td>3.033</td>
<td>0.114</td>
<td>2.00</td>
<td>16.670</td>
</tr>
<tr>
<td>Marbling</td>
<td>578</td>
<td>4.100</td>
<td>0.601</td>
<td>0.0250</td>
<td>3.00</td>
<td>6.650</td>
</tr>
<tr>
<td>Muscle Depth</td>
<td>704</td>
<td>57.160</td>
<td>8.325</td>
<td>0.314</td>
<td>31.00</td>
<td>82.330</td>
</tr>
<tr>
<td>ADG</td>
<td>119</td>
<td>1.851</td>
<td>0.319</td>
<td>0.029</td>
<td>0.989</td>
<td>2.667</td>
</tr>
<tr>
<td>RFI</td>
<td>119</td>
<td>-0.029</td>
<td>0.950</td>
<td>0.087</td>
<td>-2.243</td>
<td>3.195</td>
</tr>
<tr>
<td>Shear Force</td>
<td>122</td>
<td>4.977</td>
<td>1.415</td>
<td>0.128</td>
<td>3.063</td>
<td>10.828</td>
</tr>
</tbody>
</table>
Table 3.3. Skewness and kurtosis values calculated using the Proc UNIVARIATE method for the temperament assessment distributions of chute temperament score, chute exit speed and exposed EW.

<table>
<thead>
<tr>
<th></th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chute Temperament Score</td>
<td>0.784</td>
<td>0.479</td>
</tr>
<tr>
<td>Chute Exit Speed</td>
<td>0.285</td>
<td>-0.394</td>
</tr>
<tr>
<td>Exposed EW</td>
<td>0.284</td>
<td>-0.422</td>
</tr>
</tbody>
</table>
Table 3.4. A summary of the estimates, standard error, t value and P value for each of the final models for backfat thickness (BF), marbling score (MB), muscle depth (MSC) and ADG.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>t Value</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BF (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-1.388</td>
<td>1.327</td>
<td>-1.05</td>
<td>0.2961</td>
</tr>
<tr>
<td>Farm 1 Group 1</td>
<td>0.904</td>
<td>0.529</td>
<td>1.71</td>
<td>0.0878</td>
</tr>
<tr>
<td>Farm 3</td>
<td>0.785</td>
<td>0.776</td>
<td>1.01</td>
<td>0.3118</td>
</tr>
<tr>
<td>Farm 1 Group 2</td>
<td>-0.421</td>
<td>0.406</td>
<td>-1.04</td>
<td>0.2999</td>
</tr>
<tr>
<td>Farm 2 Group 2</td>
<td>1.675</td>
<td>0.581</td>
<td>2.88</td>
<td>0.0041</td>
</tr>
<tr>
<td>EBRC</td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>0.007</td>
<td>0.000</td>
<td>9.00</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Exposed EW (%)</td>
<td>-0.028</td>
<td>0.019</td>
<td>-1.50</td>
<td>0.1349</td>
</tr>
<tr>
<td>MB (score)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>3.284</td>
<td>0.410</td>
<td>8.02</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Farm 1 Group 1</td>
<td>-0.190</td>
<td>0.111</td>
<td>-1.71</td>
<td>0.0871</td>
</tr>
<tr>
<td>Farm 2 Group 1</td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farm 3</td>
<td>-0.504</td>
<td>0.130</td>
<td>-3.87</td>
<td>0.0001</td>
</tr>
<tr>
<td>Farm 1 Group 2</td>
<td>-0.659</td>
<td>0.094</td>
<td>-7.01</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Farm 2 Group 2</td>
<td>-0.578</td>
<td>0.091</td>
<td>-6.38</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>0.001</td>
<td>0.000</td>
<td>3.86</td>
<td>0.0001</td>
</tr>
<tr>
<td>Weight*Chute exit speed (m/s)</td>
<td>-0.0001</td>
<td>0.000</td>
<td>-2.57</td>
<td>0.0104</td>
</tr>
<tr>
<td>MSC (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>29.905</td>
<td>3.436</td>
<td>8.70</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Farm 1 Group 1</td>
<td>8.806</td>
<td>1.380</td>
<td>6.38</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Farm 2 Group 1</td>
<td>6.386</td>
<td>1.325</td>
<td>4.82</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Farm 3</td>
<td>3.405</td>
<td>1.986</td>
<td>1.71</td>
<td>0.0869</td>
</tr>
<tr>
<td>Farm 1 Group 2</td>
<td>11.179</td>
<td>1.050</td>
<td>10.64</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Farm 2 Group 2</td>
<td>8.053</td>
<td>1.475</td>
<td>5.46</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>EBRC</td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>0.017</td>
<td>0.002</td>
<td>8.35</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Chute temperament score</td>
<td>0.742</td>
<td>0.261</td>
<td>2.84</td>
<td>0.0047</td>
</tr>
<tr>
<td>ADG (kg/day)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-1.830</td>
<td>0.338</td>
<td>-5.41</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>0.004</td>
<td>0.000</td>
<td>12.89</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Chute temperament score</td>
<td>0.181</td>
<td>0.077</td>
<td>2.32</td>
<td>0.0221</td>
</tr>
<tr>
<td>Chute temperament score*Exposed EW (%)</td>
<td>-0.010</td>
<td>0.005</td>
<td>-1.84</td>
<td>0.0687</td>
</tr>
<tr>
<td>Exposed EW (%)</td>
<td>0.031</td>
<td>0.013</td>
<td>2.30</td>
<td>0.0234</td>
</tr>
</tbody>
</table>
Chapter 4: General Summary and Conclusions

The literature review and two studies in this thesis facilitated exploration into the assessment of beef cattle temperament, and the resulting impact of this on relevant production parameters. The concept of beef cattle temperament is complex, and assumed to be a component of an individual animal's personality. As such, this trait is believed to be impacted by a number of different genetic and environmental conditions. Temperament research in applied ethology is based on the development of a theory to explain the behaviour of cattle in response to handling. A comprehensive literature review of beef cattle temperament research provided a summary of evidence established by previous literature, while identifying gaps in this knowledge base. From this literature review, key subjective and objective methods for assessing temperament were identified, along with the negative and positive aspects of each of these tools. A summary of the impact of genetics, environment and experience on temperament, provides evidence that temperament is impacted by a wide range of factors, explaining the difference in temperament responses observed across the industry. Temperament is believed to impact key areas in production, specifically animal welfare, animal handler safety, growth attributes and meat quality characteristics.

There were three objectives of Chapter 2; to assess temperament using three different techniques and to compare their ranking outcomes; to investigate the repeatability of the three techniques when used on the same animals two consecutive days at one farm location; and lastly, to investigate repeatability and accuracy of the technique used to determine exposed EW from still images. Chute temperament score, a subjective tool, chute exit speed, an objective tool, and exposed EW, a tool with both subjective and objective aspects, were tested and resulting assessments were compared. Repeatability of the technique used to calculate exposed EW and
repeatability of the three techniques over a two-day period was also investigated. Results of this study suggest that the correlation between the three temperament assessment techniques is low to moderate, which suggests the three techniques are not resulting in the same outcomes. It is possible that these tools are measuring different components of the individual animals. Like human personality, which is varied and complex it is theoretical interpretation (Eysenck, 1967), cattle personality and individual differences create assumed dimensions of cattle temperament which require further investigation.

Findings related to the second objective of Chapter 2 suggest that a moderate correlation exists between exposed EW calculated from two different images of the same animal taken at different time points during handling, as well as repeated tracings of the same image. Further standardization of this technique is necessary to fully understand its value in temperament assessment. Perhaps human bias and specificity of the image, affects when images are captured and how exposed EW is traced. To eliminate some of these limitations, a computer software program that captures an EW image every second the animal is restrained and calculates an average over duration of handling would provide a more accurate representation. The maximum change in exposed EW may provide more insight into temperament, rather then an average of exposed EW over handling duration. Determining the basal exposed EW of cattle is a necessity in order to understand the change in exposed EW that occurs during handling. A limitation to using this tool is the lack of understanding into whether an animal usually has more exposed EW or if the exposed portion is strictly due to handling. In order for this tool to be economically feasible, both in terms of equipment and time necessary, additional tools need to be developed. Currently using this technique is very labour intensive in terms of image selection and analysis, and the procedure itself needs to be standardized.
The moderate consistency of chute exit speed when repeated over two days provides evidence that this assessment technique may be the best at measuring the overarching trait of temperament. Although other techniques are most likely measuring different components of a behavioral response to handling, if only one test is to be used, chute exit speed may be appropriate. The speed at which an animal leaves the chute appears to be the most consistent over time, based on the findings of the current study and previous work (Cafe et al. 2011). Chute exit speed may be the most reliable tool to use because it is objective, is even more precise with the use of electronic equipment, and reduces the subjectivity and potential for human bias and error, which is evident in different techniques. This technique is formed on the basis that reactive temperament cattle flee the handling area at a faster pace (Burrow et al. 1988) presumably to return to the herd and escape from handling.

However, this does not mean other temperament assessment techniques do not hold value, or contribute to the overall understanding of the temperament concept. Potential exists for new techniques to become popular in this area of research. The MMD allows for an enhanced understanding of what is occurring while the animal is restrained in the chute, providing a more precise measure than chute temperament score. An assessment using the MMD eliminates the issues of subjectivity and allows for the animals’ behaviour to be assessed throughout the duration of handling. Chute temperament score is assigned based on animal movements while restrained, such as shaking the chute or violently struggling. The MMD captures these same movements, but provides even more precise information about number and force of movements. Further identification of objective tools which incorporate sound behavioural knowledge with scientific equipment should be completed.
The objectives of Chapter 3 were to compare temperament measures to different production and product quality attributes of feedlot cattle including; live animal ultrasound assessment for body composition; growth and feed efficiency traits, and lastly important meat quality parameters. The findings of Chapter 3 suggest that the more agitated or reactive temperament cattle had less backfat at time of assessment, suggesting they may require more time on feed to be ready for slaughter. Reactive temperament cattle had higher marbling scores and muscle depth, as determined from live animal ultrasound measures. Specifically, as exposed EW increased, backfat decreased; as chute exit speed increased marbling score increased; as chute temperament score increased the loin muscle increased; and as chute temperament score and exposed EW increased, ADG increased. There was no significant relationship found between RFI or shear force and any of the three temperament assessment techniques. Different temperament assessment techniques related to different production parameters of interest, further suggesting that temperament is complex, and cannot be easily assessed with one technique alone.

Limitations of this thesis are human error in implementation of techniques and lack of animal information. Human error was most likely to occur while performing chute temperament score assessments and during calculation of exposed EW. Previous cattle experience and interpretation of the difference between scores may have influenced the resulting assigned chute temperament score. Image selection and tracing for exposed EW are steps in the process where personal bias can arise. Additional animal information such as age, breed and days on feed would have provided additional factors to explain some of the variation noticed in the different production parameters investigated in Chapter 3. Having this additional information would have explained some of the variation in body composition parameters, and could have been included in the models for further control.
Investigation into different techniques for assessing temperament will provide insight into which tools are best used when considering different aspects of interest to the industry. From a practical perspective, producers may care more about assessing temperament and identifying reactive animals based on their potential to damage equipment and threaten the safety of herd mates and handlers. For instance, one assessment technique relates more to human handler safety. If cattle that have high chute temperament scores are the cattle more likely to injure a handler, then this assessment tool will be useful when identifying cattle to remove from the herd due to potential safety risk.

Further research should focus also on identifying the stress or fear response exhibited by cattle while being handled. The fight or flight response may be influencing the response of cattle when they are being handled or restrained. Cattle that appear to be docile may actually have high levels of cortisol, indicative of a stress or fear response. These cattle, although calm in appearance, may be experiencing a negative welfare state, which also may impact aspects of meat production and quality. Assessment techniques may be inaccurately classifying temperament if they are based on behavioural response alone. A combination of internal and external factors may provide the best evidence for a comprehensive understanding of the temperament complex.

The findings of this thesis do not provide strong evidence of a correlation between chute temperament score, chute exit speed or exposed EW. There was not an overwhelming link between these tools and production parameters of interest found. All three methods were reasonable to complete on-farm, with exposed EW requiring the most time after the on-farm visit, in terms of image selection and analysis. Chute temperament score and chute exit speed are two techniques in particular that are easy for producers to add to their regular handling routine in order to gain further understanding about the cattle in their herds.
The lack of significant relationships between the three temperament assessment techniques used and important body composition and growth parameters does not mean temperament is not an important characteristic in the beef cattle industry. This evidence contributes to the overall knowledge of this trait, and provides direction for future work. Further research can be aimed at other aspects of importance in the industry, specifically animal welfare and human handler safety.
Chapter 5: References


