TEMPERAMENT IN BEEF CATTLE:
METHODS OF MEASUREMENT,
CONSISTENCY AND RELATIONSHIP
TO PRODUCTION

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ABSTRACT

Two behavioural studies were conducted at the University of Saskatchewan beef feedlot. In the first study, the temperament of 400 steers was determined using both objective and subjective measures. The consistency of temperament, over repeated tests and between different measures, was also tested. The objective behavioural tests were conducted during the individual restraint of the steers using strain gauges and an MMD (movement-measuring-device). The time required for the steers to exit the area was also recorded. Subjective assessment of animals' responsiveness during restraint was recorded on a scale of 1-5 (calm to wild). The consistency of individual differences in a steer's response within the evaluation series and across repetitions, shows that this trait may represent a stable 'personality' of the animal. The significant relationship between objective and subjective measures demonstrates that objective measures of temperament can be used to replace the traditional subjective scale as it has the added advantage of reducing inter- and intra-observer variability. The positive relationship of subjective scores and MMD values with the steers performance (average daily weight gain) shows not only that a calm temperament is conducive to productivity, but also that objective measures can replace subjective techniques for assessing temperament for performance evaluation. In the second study the reactivity of a subset of the original 400 steers (262 animals from 8 pens) to a novel stimulus was assessed. The purpose of this experiment was to determine if a steers' behavioural response in the novel test was correlated to its' temperament assessment determined in the first study. A remote controlled ball was dropped from the ceiling of a salt feeder while a steer licked the salt. Two overhead cameras connected to a monitor through a VCR and time lapse recorder permitted us to observe and document the response. A lack of correlation between measures of handling and novelty measures show that reactivity of animals in the handling chute and their responsiveness to the novel stimulus do not represent one and the same trait.

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LIST OF ABBREVIATIONS

ADG	Average Daily Gain
AV.	Average
g	Gram
h	Hour
Hz	Hertz
IQR	Interquartile range
kg	Kilogram
m	Metre
MMD	Movement measuring device
min	Minutes
mV	Millivolt
No. / no.	Number
P	Probability
PCA	Principal component analysis
s	Second
SAS	Statistical analysis software
SD	Standard deviation
S.E	Standard error
SG	Strain gauge
vs	Versus
n	Number

1 INTRODUCTION

Temperament has been an important contribution to the domestication process of our livestock species, in that our ancestors certainly took advantage of selecting animals with calmer dispositions. Under the present livestock production scenario, temperament is also extremely important due to its welfare implications, since calmer animals are likely less stressed and less prone to injury than wilder animals during handling and restraint. Research studies linking productivity to temperament also show that this is another area where producers benefit from selecting calmer animals. Though there remains some debate on the ways to measure and define temperament of animals, temperament is generally viewed as an animal's response to being handled. Measuring temperament via subjective assessments has been predominantly used in the past and temperament is often ranked on a continuous scale. Though some of the past studies tried to incorporate objectivity in temperament assessment, most studies invariably had some elements of subjectivity. An attempt was made to measure temperament in an objective manner by using mechanical devices such as strain gauges which measures the animal's exertion force during restraint, a MMD (movement-measuring-device) which measures animal movement during isolation on a weigh scale and the time required for the animal to leave the handling area (exit time). These devices afforded the opportunity to obtain objective behavioural data, which is believed to yield more reliable and repeatable results than subjective measures. Multiple measures were used in hope of providing a better assessment of temperament and to assess habituation effects.

If temperament is an inherent property of an animal, it was also hypothesized that this property would linger or "show itself" even in the absence of human handlers. Therefore, a test was devised to determine an animal's response to novelty, while in the comfort of its own pen and in the presence of its penmates. Previous studies have recorded the reaction of animals to novelty tests in an arena with or without a discrete stimulus. This method to evaluate temperament has been criticized as the outcome variable (i.e. the animal's reaction) may not have been the result of the treatment imposed alone, as there were several independent variables in the study such as handling, isolation and unfamiliar surroundings that could have confounded the results. In order to eliminate the confounding effects of handling, novelty of surroundings and effect of absence of pen mates, a test was designed to assess their responsiveness in their normal environment with their group-mates.

1.1 Thesis objectives

There have been limited attempts to quantify temperament (Burrow et al., 1988; Curley et al., 2006) though there have been many studies designed to qualify or characterize the attribute of temperament in beef cattle (Ewbank, 1961; Shrode and Hammack, 1971; Holmes et al., 1972; Vanderwert et al., 1985; Grandin, 1993; Kilgour et al., 2006). Chapter 2 of the thesis presents a review of important literature on the concept of temperament, discusses the different definitions of temperament and the suitability of developing an integrated concept of temperament. The review also focuses on the methods used in the past to measure temperament and contrasts objective and subjective techniques. Past research on heritable aspects of temperament and applications of research on temperament in realms of production and welfare are also discussed. Chapter 2 also reviews the importance of an animal's reaction to novelty as a measure of temperament.

The principal goal of the research, to objectively quantify temperament, is described in Chapter 3. The study looked at the correlations of different objective measures, over repeated evaluations, in order to discern the consistency of the attribute of temperament. The coefficients of correlation between objective methods were also calculated to assess whether these tools measure the same attribute of the animals. Because the traditional tool of assessment of temperament has been to subjectively score it, the study also examined the relationship between the subjective and objective evaluations to determine whether the objective tools are as reliable as or better than the subjective assessments. Another goal of the study was to examine how the temperament (as assessed by subjective and objective methods) was related to the animal's performance (i.e., weight gain) during the early backgrounding period in the University feedlot and later in the finishing period in a commercial feedlot.

After the first study (described in Chapter 3) an attempt was made to determine whether or not an animal's reactivity in their home pen, when no human was visible would correlate to measures which were obtained during handling and restraint. These results are presented in Chapter 4. The animal's reactions to a novelty test were compared with the measures of handling to determine whether both represent the same attribute of the animal. Not all animals participated in the novelty test due to the voluntary nature of the test. The test involved dropping a ball from the ceiling of a salt feeder and measuring both the distance the animal moved away from the salt feeder after the drop and the number of times the animal returned to the salt feeder after the sudden drop. In order to assess the variability in the reactivity, the relationship between the animals that participated in novelty test from those that did not participate was tested. The differences between the groups of animals that visited the salt feeder once and those that visited it at least 10 times were also examined and compared those groups to their previous temperament scores. The relationship between different measures of novelty was also tested. Another objective was to study the habituation effect of animal's reactivity to a novel stimulus. Comparisons were also made between novelty measures and production parameters.

2 LITERATURE REVIEW

2.1 Temperament

2.1.1 Definitions

Temperament is often described as an individual trait influencing an animal's behavioural response to handling. In an early study, Tulloh (1961a) used the term temperament to describe the 'behaviour of cattle in the bail'. In normal use, "good" temperament is often equated to calm behaviour of the animal while "poor" temperament describes an animal that appears more agitated. Therefore, temperament seems to have much to do with the degree of fearfulness shown by animals in handling situations, and the different tests used to assess temperament measures the different aspects of an animal's fear response (Petherick et al., 2002). Others consider the ease with which we can carry out the routine handling of animals and their flight distance as predictors of their temperament (Morris et al., 1994). But these definitions exclude the general reactions of animals in the absence of their human handlers. Kilgour (1975) stressed that individual variability in an animals' physical, hormonal and neuronal characteristics is the reason for their differences in temperament. The importance of behavioural variability in other animals has also been investigated (cats: Lowe and Bradshaw, 2001; dogs: Svartberg et al., 2005). Lyons (1989) described temperament as an enduring characteristic of an individual's overall behavioural style, emotional tone, reactivity or responsiveness which is a "dynamic attribute of an individual that modulates environmental influences on behavioural and physiological systems". This means that temperament is not merely the response to handling or restraint. Their "divergences in emotional reactivity" i.e., temperament (Grignard et al., 2001) depend not only on their reactions to people, but also on social and environmental situations, and novelty (Grignard et al., 2000). Conversely, some other researchers (Kerr and Wood-Gush, 1987) used the term behavioural pattern to describe most behaviours and 'temperament' to indicate exclusively how reactive or docile they are to the challenge by humans. But Manteca and Deag (1993) suggested that the term 'temperament' is not exclusive and it gives a broad understanding of animal behaviour.

Hall (1941) defined temperament as “consisting of the emotional nature, the basic-needs structure, and the activity level of an organism” which when fine-tuned by social and environmental factors becomes individuality. Hall preferred to use the term individuality in animals instead of personality. The author gave such examples as timidity, aggressiveness, sexuality, spontaneity, variability, speed of reaction and activity to describe different areas of animal temperament. Plomin (1981) suggested that temperament includes those personality characteristics that are stable, continuous and constitutional. McDevitt (1986) suggested that temperament can be viewed as a foundation for development of more intricate traits of personality. Eysenck (1967) suggested that individual differences in behaviour should also be accounted before drawing conclusion on personality studies that failed to obtain matching results. The term ‘temperament’ has been used traditionally in animals to describe behavioural differences and the term ‘personality’ tended to be used in human beings to describe the same character trait. Jones and Gosling (2005) suggested that, instead of using the words interchangeably, the word 'personality' tended not to be used in animals just because of its anthropomorphic connotations. But throughout this manuscript the terms ‘temperament’ and ‘personality’ are interchangeably used.

2.1.2 Assessment of temperament

Many tests have been used in the past to assess cattle temperament. Most researchers have developed their own methods to assess temperament depending on the situation. However, to date there has been no generally agreed upon criteria to assess temperament. Open-field tests were used to assess temperament in dairy (Kilgour, 1975; Boissy and Bouissou, 1995) and beef cattle (Boivin et al., 1992b; Kilgour et al., 2006). Boivin et al. (1992a) used parameters such as the number of squares within a pen the animal crossed, running time in the pen and time spent aiming towards the handler as criteria to assess temperament. Bovin et al. (1992a) concluded that in beef calves, handling at weaning was more effective in improving temperament than pre-weaning handling. Le Neindre et al. (1995) handled Limousin heifers in a pen, and measured the amount of aggression, the time spent in the corner of the pen as well as escape reactions, in order to assign a 'docility score'. The study found that animals that were maintained indoors were more docile than those reared outside.

A number of researchers have used a subjective scale to assess the temperament of cattle. Grandin (1993) relied on an observer to rank steer temperament based on their movements in the squeeze chute on a 5 point scale. Another criteria used by the author to grade temperament was whether they 'balked or not' when entering the squeeze chute. The movement score assigned on beef cattle by Kilgour et al. (2006) was on a subjective 1-7 scale. Based on reactivity during restraint Ewbank (1961) classified animals as docile, alarmed, greatly alarmed and submissive. Holmes et al. (1972) used an observer grading of temperament from 1 to 5 ('quiet to unmanageable') during restraint in the squeeze. Shrode and Hammack (1971) also used a 1 to 5 scale and termed animals with a score of 5 as 'most rebellious'. Similarly a 1 to 5 scale of 'quietude' to 'nervousness' was used by Vanderwert et al. (1985). The study also used flight distance as a measure of temperament. Kabuga and Appiah (1992) used flight distance from the investigator and temperament score (1-5 scale) as measures of their reactivity.

Murphey et al. (1980) measured the distance up to which an observer could approach an animal before it moved away. The author suggested that 'approachability' was a stable trait. Behaviours such as ambulation, vocalization and elimination shown by the dairy animals in an open-field were also used as the criteria of their temperament (Kilgour, 1975). The ‘open-field test’ has been extensively used in laboratory animals, how far it is efficacious in a farm animal temperament study is not known (Manteca and Deag, 1993). Walsh and Cummins (1976) criticized open-field tests for their lack of construct validity and suggested that the entire testing scenario is the independent variable instead of any specific stimulus. Kilgour (1975) could not find any correlation between temperament ratings of dairy animals (based on a scale) by different people, and felt that temperament assessment may be prejudiced by personal preference. Kilgour (1975) also could not find correlations between subjective temperament ratings and objective measures of temperament such as ambulation score, vocalization score and elimination score. Ease of sorting (Boivin et al., 1992b; Kilgour et al., 2006) and confinement of the animal to a particular location in the test arena (Boivin et al., 1992b; Gringnard et al., 2001; Kilgour et al., 2006) were also used as a measure of beef cattle reactivity. Though the terms used for the tests to measure temperament varied from author to author, most of these tests predominantly relied on a scale system and observer rating.

Objective techniques such as time taken to move a measured distance after release from restraint have also been used in a limited number of experiments with beef cattle (Burrow et al., 1988; Kilgour et al., 2006; Muller and Von Keyserlingk, 2006; Curley et al., 2006). Kilgour et al. (2006) also assessed the distance up to which an animal could tolerate the presence of an observer. In addition to behavioural measures, physiological parameters such as heart rate (cattle: Le Neindre, 1989; Gringnard et al., 2001; Kilgour et al., 2006; goats: Lyons and Price, 1987) and cortisol levels (cattle: Munksgaard and Simonsen, 1996; pig: Von Borell and Ladewig, 1992; Mendl et al., 1992; goats: Lyons et al., 1988b; sheep: Moberg and Wood, 1982) have been used to assess reactivity. Manteca and Deag (1993) highlighted the importance of using a variety of tests or measures in assessing temperament as we may miss many facets of temperament if we stick to a single test or measure. Plomin (1981) distinguished between the 'molecular' (specific) versus 'molar' (broad) nature of objective and subjective temperament measures respectively. Burrow (1997) did a comprehensive review of the different tests used in the past to measure temperament in different species of animals. The tests were classified based on the amount of restraint received (restrained tests vs. non-restrained tests), ease of movement, dominance, maternal behaviour, etc. Table 2.1 adapted from the review gives examples of the tests used to assess temperament in different species.

2.1.3 Habituation

Habituation is a learning process in which there is "waning of a response to repeated stimuli" (Whittaker and Knight, 1998). Gentle handling has been shown to reduce fear and neophobia of beef cattle (Hemsworth et al., 1996), pigs (Gonyou et al., 1986; Hemsworth et al., 1996) and sheep (Mateo et al., 1991) towards humans. However results of the studies in rabbits (Kersten et al., 1989) showed that handling reduced fear of humans, but resulted in general fearfulness across a wider spectrum. Hemsworth et al. (1986b) also observed that handling in pigs reduced fearfulness towards humans but did not reduce general fearfulness. Boissy and Bouissou (1988) found that protracted handling (9 months) is required to habituate dairy heifers towards humans. Habituation and learning helps the farm animals to put up with the routine husbandry procedures (Mateo et al., 1991). Jones (1994) demonstrated not only that handling of birds reduced fear but birds habituated to one person will also show reduced reactivity to other people. Jones and Waddington (1993) stressed the importance of handling in reducing fear and

Table 2.1. Examples of tests used to assess temperament in different species of animals (adapted from Burrow, 1997)

Measurement	Reference	Brief description of test	Species
		Non-restrained tests	
Approachability	Murphey et al. (1980)	Closest distance an observer could approach at a set rate to the animal in an open yard (metres)	Beef / dairy cattle
Approach/ Avoidance behaviour	Murphey et al. (1981)	Responses of groups of animals to an observer lying on the ground near the mob (video record)	Beef / dairy cattle
Approach behaviour	Gonyou et al. (1986)	Time taken for animal to interact with observer + number of interactions	Pigs
Approach behaviour	Tilbrook et al. (1989)	Time taken for animal to interact with observer + number of interactions	Dairy cattle
Approach behaviour	Hemsworth et al. (1990)	Time taken for animal to interact with observer + number of interactions	Pigs
Arena test	Fell and Shutt (1989)	Position of individual animals and their movement in a marked yard is recorded	Wool sheep
Arena test	Hohenboken et al. (1986)	Position of individual animals and their movement in a marked yard is recorded	Wool sheep
Behavioural tests	Boissy and Bouissou (1988)	Count of number and type of reactions to a variety of novel situations	Dairy cattle
Behavioural tests	Boivin et al. (1992a)	Sorting, following and restraint tests, based on video records (different variates)	Beef cattle

Table 2.1. continued

Docility score	Le Neindre et al. (1995)	Stepwise scoring system of behaviours of animals in an open pen (scores from 6.5 to 17.0)	Beef cattle
Flight distance	Murphey et al. (1981)	Closest distance an observer could approach at set rate to the animal in an open yard (metres)	Dairy / beef cattle
Flight distance	Fordyce et al. (1982)	Closest distance an observer could approach to the animal in an open yard (paces)	Beef cattle
Flight distance	Hutson (1982)	Closest distance an observer could approach at set rate to the animal in an open yard (metres)	Wool sheep
Flight distance	Hargreaves and Hutson (1990 a, b)	Closest distance an observer could approach head-on to the animal in an open yard (metres)	Wool sheep
Flight distance	Kabuga and Appiah (1992)	Closest distance an observer could approach at set rate to the animal in an open yard (metres)	Beef cattle
Flight speed	Burrow et al. (1988)	Electronic measures of time taken to cover a set distance when animal is released into an open yard	Beef cattle
Goat-human encounter	Lyons et al. (1988a)	Changes in mean scores on five behavioural measures monitored in goat-human encounters	Dairy goats
Open-field test	Beilharz and Cox (1967)	Count of number of squares over which animal moves in a fixed time period	Pigs

Table 2.1. continued

Open-field test	Kilgour (1975)	Animals scored for vocalization, elimination and general period for 3 X 5 minute periods	Dairy cattle
Open-field test	Torres-Hernandez and Hohenboken (1979)	Count of vocalization, elimination and movements + scores (1-5) for emotional and investigative behaviour	Meat sheep
Pound test	Fordyce et al. (1982)	No. of times animal crossed a line in an open yard + speed of movement (1-5 scale)	Beef cattle
		Restrained tests	
Bail test (movement score)	Fordyce et al. (1982)	Subjective assessment of behaviour while restrained (1-8 scale from stands still to struggles violently)	Beef cattle
Bail test (audible respiration)	Fordyce et al. (1982)	Subjective assessment of behaviour while restrained (1-4 scale; no audible respiration to frequent blowing)	Beef cattle
Baulking rating	Grandin (1993)	Classified as baulkers or non-baulkers when entering a crush and headbail	Beef cattle
Behaviour test	Tulloh (1961a)	Subjective assessment of behaviour of animal entering scales and bail (1-4 scale, 1 = most desirable)	Beef cattle
Behaviour score	Shrode and Hammack (1971)	Subjective assessment of behaviour of animals in a crush (1-5 with score 5 being most rebellious)	Beef cattle

Table 2.1. continued

Crush test	Ewbank (1961)	Subjective assessment (1-4 scale of docile, alarmed, greatly alarmed and submissive)	Beef cattle
Crush test(movement score)	Fordyce et al. (1982)	Subjective assessment (1-8 scale from stands still to struggle violently)	Beef cattle
Crush test (audible respiration)	Fordyce et al. (1982)	Subjective assessment (1-4 scale from no audible respiration to blowing frequently)	Beef cattle
Chute (crush) score	Vanderwert et al. (1985)	Subjective assessment (1-5 scale from quiet to extremely nervous or wild)	Beef cattle
Chute (crush) score	Grandin (1993)	Subjective assessment (1-5 scale from calm to struggling violently)	Beef cattle
Temperament score	Tulloh (1961 b)	Subjective assessment of animal restrained in a crush (1-6 scale from docile to aggressive)	Beef cattle
Temperament score	Holmes et al. (1972)	Subjective assessment (1-5 scale from quiet and tractable to unmanageable)	Beef cattle
Temperament score	Hearnshaw et al. (1979)	Summation of scores of behavioural responses in a bail to seven tests scored on a 1-5 scale	Beef cattle
Temperament score	Sato (1981)	Subjective assessment of behaviour in a weighing scale (1-4 scale from mild to nervous)	Beef cattle
Temperament score	Fordyce et al. (1982)	Summation of scores from five separate tests (restrained and non-restrained tests)	Beef cattle

Table 2.1. continued

Temperament score	Kabuga and Appiah (1992)	Subjective assessment of behaviour in a weighing scale (1-5 scale from docile to wild)	Beef cattle
		Dairy temperament score	
Disposition	Aitchison et al. (1972)	Subjective assessment (1-5 scale, with 1 most desirable)	Dairy cattle
Disposition	Thompson et al. (1981)	Subjective assessment by farmers (3-1 scale from excellent to problem cow)	Dairy cattle
Disposition	Agyemang et al. (1982)	Subjective assessment (1-3 scale from quiet to mean or very nervous)	Dairy cattle
Temperament score	O'Bleness et al. (1960)	Subjective rating by herd manager (no detail provided)	Dairy cattle
Temperament score	Van Vleck (1964)	Subjective assessment (1-3 scale of quiet, nervous, dull)	Dairy cattle
Temperament score	Dickson et al. (1970)	Subjective assessment (1-4 scale from very quiet to very restless)	Dairy cattle
Temperament score	Mishra et al. (1975)	Subjective assessment (1-5 scale from docile to very restless and aggressive)	Dairy cattle
Temperament score	Gupta and Mishra (1978)	Subjective assessment (1-5 scale, with 1 most desirable)	Dairy cattle
Temperament score	Gupta and Mishra (1979)	Subjective assessment (1-5 scale from docile to aggressive)	Dairy cattle
Temperament score	Wickham (1979)	Subjective assessment (1-3 scale from satisfactory to often unsatisfactory)	Dairy cattle
Temperament score	Sharma and Khanna (1980)	Subjective assessment (1-4 scale of docile, restless, nervous, aggressive)	Dairy cattle

Table 2.1. continued

Temperament score	Arave and Kilgour (1982)	No. of kicks X 2 + number of leg lifts during milking time	Dairy cattle
Temperament score	Fimland (1984)	1-5 scale (no other details provided)	Dairy cattle
Temperament score	Khanna and Sharma (1988)	Subjective assessment (1-4 scale of docile, restless, nervous, aggressive)	Dairy cattle
Temperament score	Lawstuen et al. (1988)	Subjective rating by dairy farmers (50-1 scale from docile to excitable)	Dairy cattle
		Dominance tests	
Behaviour score	Blackshaw et al. (1987)	Descriptive (e.g., agonistic, investigation, resting, panic, fight)	Beef cattle
Dominance value	Beilharz et al. (1966)	Repeated subjective assessments by three pairs of observers for 25 minute per assessment	Dairy cattle
Dominance value	Wagnon et al. (1966)	Subjective assessment of behaviours during feeding over 2 x 50 day periods (six times per week)	Beef cattle
Dominance value	Blockey and Lade (1974)	No. of interactions /no. of contests over three test periods (total test time, 9.5 h)	Beef cattle
Dominance value	Brown (1974)	Subjective assessment of dominance, aggression and submission	Beef cattle
Dominance value	Kabuga et al. (1991)	Behaviour recorded during scan sampling at 5-min intervals for 12 h/day over 10-day period	Beef cattle

Table 2.1. continued

Ease of movement tests			
Ease of movement	Hinch and Lynch (1987)	Repeated measures of time taken to move groups of animals through a series of yards and a race	Beef cattle
Ease of movement	Tilbrook et al. (1989)	Time taken to move an animal through a race system + number of baulks or negative interactions needed	Dairy cattle
Ease of handling	Kabuga and Appiah (1992)	Time taken for groups of animals to enter and exit scales and dip	Beef cattle
Maternal temperament			
Maternal protective temperament	Brown (1974)	Subjective score of attentiveness of calf at birth (scale not specified)	Beef cattle

welfare implications of fear of humans in poultry. Bovin et al. (1992) proposed that tameness in cattle can be achieved through habituation and that early handling is more effective in habituating beef and dairy cattle to humans. Mal and McCall (1996) found that early handling during the first 42 days improved future temperament in horses. Frequent exposure to sound stimuli in beef cattle cause habituation; but under routine husbandry conditions exposure to stimuli may not be frequent enough to cause habituation and hence cause fear (Waynert et al., 1999). Talling et al. (1996) found that sound stimuli are stressful to pigs and complete habituation to the stimuli does not occur. Heird et al. (1986) reported that accidental deaths due to perils such as holes, worn out tracts, etc., on the ranch can occur if the emotionality of horses is not tempered by habituation to human presence. Hargreaves and Hutson (1990a) suggested that the extent of habituation to repeated stimuli can be used as predictors of harshness of the stimuli.

2.1.4 Temperament and genetics

The steers used in my studies were part of a larger project investigating the effect of genetics on temperament. Though temperament and genetics was the topic of detailed investigation by another research student working with these animals, I think it is expedient to review literature that link 'temperament' to genetics.

Depending upon the type of temperament test conducted researchers have found varying levels of heritability for this trait. Subjective assessment of chute behaviour (temperament) of Angus cattle shows that the behaviour is heritable (0.40 ± 0.30) (Shrode and Hammack, 1971). Le Neindre et al. (1995) found that temperament measured as docility score had a heritability of 0.22. Lyons et al. (1988a) observed that 29% of variability in behavioural responses (approach-avoidance) towards human in dairy goats was due to difference in temperament. Medium to high heritability of flight speed score was reported in tropical beef cattle (Burrow, 2001). Hearnshaw and Morris (1984) tested the breed differences in temperament and obtained a higher heritability (0.46 ± 0.37 vs. 0.03 ± 0.28) for temperament scores of *Bos indicus* calves compared to *Bos taurus* calves. Moderate heritability of 'fearfulness towards humans' was also reported in pigs (Hemsworth et al., 1990). Morris et al. (1994) also proposed that manipulation of temperament is possible through breeding. Schmutz et al. (2001) detected six loci on cattle chromosomes related to temperament. Kersten et al. (1989) found that genetic effects dictate rabbit temperament more than handling effects. Sire influence on cattle temperament has been observed in the studies of Watts et al. (2001), Grignard et al. (2001) and Le Neindre et al. (1995). Prayaga (2003) suggested that selection can be made for temperament. Gosling and John (1999) suggested that some of the elements of personality may be common between animals and man and that like physical traits, they are also subject to selection. All the above studies emphasize the effect of genetics on temperament.

Grignard et al. (2001) observed that elicitation of response of beef cattle is partly attributable to genetics. An earlier study (Tulloh, 1961a) found that cattle of the Hereford breed was more excitable than Angus and Shorthorns, where as Fordyce et al. (1988) reported that Shorthorns were less temperamental than cattle with Brahman bloodlines. In another study, it was observed that Brahman cattle were the most excitable followed by Africander followed by British breeds which were the calmest (Fordyce et al., 1982). A French study found that Salers were more reactive than Friesians irrespective of the rearing conditions (Le Neindre, 1989). Stricklin et al. (1980) found that the other British breeds were more agitated than Herefords. Lanier et al. (2001) also showed that beef cattle were more temperamental than Holsteins, but one has to wonder whether the amount of handling Holsteins receive as calves and throughout their lives plays some role in the scores they received by the researchers. Fordyce et al. (1982) suggested that selection based on temperament scores would improve temperament. Stricklin et al. (1980) also recommended that temperament should be considered as a selection criteria as it is heritable. Hereditary and non-hereditary aspects of temperament should be further explored before including it as a criterion in conventional breeding plans (Burrow and Corbet, 2000). Grandin (1997) warns that reckless selection for temperament may be prejudicial to other traits.

2.1.5 Applicability

2.1.5.1 Welfare

The study of beef cattle temperament is important for several reasons. The most important is to ensure animal and handler safety through careful selection for calmer temperament (Le Neindre et al., 1996). It is also important to understand the extent to which such behaviours are, in fact, heritable (Schmutz et al., 2001). Restraint, handling or exposure to novelty cause ‘psychological stress’ in farm animals and risk of injury is greater in case of temperamentally difficult animals when they are exposed to challenging situations (Grandin, 1997). Burrow (1997) suggested that improvement of temperament in farm animals will reduce the amount of stress experienced during husbandry procedures. An animal's ability to adapt to environmental challenges is also dictated by their difference in temperament (Ruis et al., 2002; Manteca and Deag, 1993). Research aimed at improving animal temperament should indirectly help in improving welfare. Kilgour et al. (2006) also felt that as individual cattle differ in their reactivity to handling, it is important to measure/assess this variability in order to understand the level of threat to handlers and its possible link with productivity and to reduce welfare problems. It is important to study the consistency of temperament in order to predict future behaviours (Svartberg et al., 2005) and contextual differences in behavioural expression (Lawrence et al., 1991). Such a study may also find application in devising handling methods (Svartberg et al., 2005). Beef cattle temperament with focus on its welfare has not been extensively researched.

2.1.5.2 Production

Many authors have highlighted the importance of temperament from an economic standpoint. Cattle with 'poor' temperament have been shown to have lower weight gain (Tulloh, 1961a; Burrow and Dillon, 1997; Voisinet et al., 1997b; Petherick et al., 2002), poorer feed conversion efficiencies and lower dressing percentages (Petherick et al., 2002) than those with a calm temperament. The reduced performance has been speculated to be due to their high state of 'arousal and fearfulness' (Petherick et al., 2002). Temperamentally difficult feeder cattle have been shown to yield tough and dark cutting beef (Voisinet et al., 1997a) due to stress and the associated depletion of glycogen stores (Ashmore et al., 1973).

2.2 Reaction to novelty: A measure of beef cattle temperament

2.2.1 Stimulus novelty and temperament

"Individual differences in behavioural reactions are the rule rather than an exception" (Bekoff, 1977). But when compared to companion animals, this area has not received much attention in livestock species. Routine husbandry practices expose animals to fearful novel stimuli and animals with heightened reactivity to stimuli may undergo more fear (Munksgaard and Jensen, 1996). Hence it is important to study such individual differences in an animal's reactivity in order to reduce stress (Burrow, 1997) and improve welfare. Archer (1973) suggested that reaction to novelty is a reliable measure of ‘emotionality’ or ‘fearfulness’ in rats. Lanier et al. (2000) observed that an animal’s response to an abrupt stimulus may be a predictor of its temperament. Stimuli provided should be biologically relevant to test animal reactions (Herskin and Munksgaard, 2000). Response to a novel stimulus depends on stimulus complexity (Russel, 1983) and a heterogenous stimulus has been reported to evoke more response in rats (Taylor, 1974). This preference shown by animals to complex novel stimuli may be due to the fact that such an environment provides the animal with more knowledge (Russel, 1983). Boissy and Bouissou (1995) devised two tests to assess dairy cattle reaction to novelty and termed them as 'exploration test' and 'surprise test'. In the exploration test the reactions (such as sniffing of the object) of the animal to a novel iron pyramid placed in an arena was observed and in the 'surprise test' reaction (feeding latency) to a sudden 'blast of air' into their face during their feeding time was noted and the author suggested that these variables measured an animal’s fear reactions. Nielsen and Luescher (1988) also suggested that there is a significant effect of stimulus novelty on an animal’s investigatory behaviour. Consistent with this concept Grandin and Deesing (1998) observed that an animal can react to a novel stimulus in two different ways. An event or stimuli that is surprisingly novel is usually aversive (fear inducing). However, when an animal is given an opportunity to investigate a novel object or situation it may be attracted to it. Wood-Gush and Vestergaard (1991) showed that this second type of behaviour is gratifying to the animal. Torres-Hernandez and Hohenboken (1979) have shown that investigatory behaviour can be used as a measure of ‘emotionality’ in sheep. The ‘surprise test' and 'novel object test' used in sheep by Romeyer and Bouissou (1992) comes under the fear inducing category where as the 'novelty test' employed by Kilgour et al. (2006) was more suited to study beef cattle's investigatory behaviour. Investigatory behaviour is particularly important for wild animals to obtain knowledge about their living environments and their domestic counterparts still retain this behaviour in their repertoire (Wood-Gush and Vestergaard, 1989). Adaptive significance of exploratory behaviour has also been stressed by Russel (1983). Berlyne (1960) distinguished between extrinsic exploration, behaviour directed towards ‘conventional reinforcers’ (for e.g., food) and intrinsic exploration, interest shown by animals to stimuli of ‘no biological importance’ (e.g., novel object). Negative effects of exposure to novelty (e.g., fear) have been proposed by Boissy (1995). Romeyer and Bouissou (1992) placed near the feeding trough of sheep an electric fan fitted with streamers, and feeding time and latency were used as the dependent variables to measure reaction to novelty (fear). Christensen et al. (2005) used a traffic cone to measure novelty responses in horses. Boissy (1995) suggested that, whether the animals experienced the stimulus in past or not is the determinant of ‘novelty’ of stimulus and hence it can be called a ‘collative variable’. When there is commonality in the situations, an animal that showed a heightened response to one stimulus might show a similar response to some other stimulus (Boissy, 1995).

Exposure to novelty has been used in the past to assess animal reactivity (temperament). Russel (1983) suggested that studying reaction to novelty using a distinct localized stimulus makes evolutionary sense, as wild animals often get exposed to such stimuli. Researchers provided novel stimulus in different ways. Lawrence et al. (1991) individually tested the reaction of pigs to novel object (plastic bucket) by instantaneous sampling of their exploratory behaviour. Rasmussen (1991) studied the reactivity of pigs to a novel object (long stick) and found that reactivity was inversely related to productivity. Stephens and Toner (1975) proposed that emotionality in a calf is a function of the degree of novelty it encounters in its life. Moberg and Wood (1982) used a hobby horse as a novel stimulus and found that previous experience did influence lambs reaction to novelty. This study demonstrated that lambs reared in isolation interacted less with, and withdrew more from the novel stimulus than peer/mother-reared ones. Schrader (2002) measured dairy animal’s reactivity by puffing air into their muzzle and obtained correlated responses across repetitions. Latency to contact with the novel object (tambourine and plastic ball lowered from above the test arena), time in contact with the novel object and vocalizations were the dependant variables measured by Reenen et al. (2004) to test the reactivity of heifer calves to novel object (tested alone). The study also found consistency in an animal’s reactivity towards the novel object. Munksgaard and Simonsen (1996) tested dairy animals in a novel arena using a human-dummy and measured the latency to contact and number of contacts with the novel object. The study found that previous experience (deprivation of lying and social isolation) influenced an animal’s response to novelty. Table 2.2 gives examples of the tests used by authors to assess reactions to novelty in different species of animals.

Table 2.2**.** Examples of tests which assessed reactions to novel stimulus

Name of the test	**Reference**	**Description**	**Behaviours observed**	**Species**
Reactivity in novel environment	Veissier and Le Neindre, (1992)	Reaction of animal to cube, bucket and man present in the enclosure	Latency to enter and come out of enclosure, ambulation, sniffing at enclosure, man or bucket and eating from bucket	Beef cattle
Fear of humans	Kilgour et al. (2006)	Reaction to a human sitting on a stool in a novel arena	Whether interacted to human or not, time spent and latency to enter within different distances of human	Beef cattle
Novel object	,,	Reaction to a metal cube at the center of an arena	Time spent within a specified distance from cube	,,
Startle	,,	Reaction to a metal cylinder that has been suddenly taken up and down in an arena	Time spent within a specified distance of cylinder	,,
Reaction to sudden environmental stimuli	Lanier et al. (2000)	Response to sudden sounds that naturally happen at livestock auctions such as shouting of ring man, etc.	Flinching, jumping, quivering, orientation of head and ear towards the stimulus	Beef/ dairy cattle

Table 2.2. continued

Novel enclosure test	Le Neindre, (1989)	8 X 8-m indoor pen divided into 9 squares	Squares crossed, time spent near the entrance and centre, sniffing, moos, defecation, urination, entrance and exit latencies, etc.	Beef/ dairy cattle
Novel object approach test	Hemsworth et al. (1996)	Animals presented with black tire, plastic bucket or 2 m steel chain alternatively	Time to approach within specified distance of stimulus, time spent within specified distance of stimulus, etc.	Beef cattle/pig
Air puff	Schrader (2002)	Air blown to the muzzle during feeding	Time taken by the animal to resume feeding	Dairy cattle
Novel object test	Boissy and Bouissou (1995)	Painted iron pyramid placed in the test room	Latency to approach, time spent away, sniffing, vocalizations	Dairy cattle
Conflict test	,,	Familiar food placed in an unfamiliar room	Feeding time, latency, attempts, duration, latency to exit, time spent away	,,

Table 2.2. continued

Surprise test	Boissy and Bouissou (1995)	A current of air blown towards the muzzle during feeding	Latency to return to eat, time spent away, feeding time	Dairy cattle
Open-field test	,,	Unfamiliar arena	Latency to enter, exit, duration of immobility, head in upright position, number of squares crossed, vocalizations	,,
Response to human test	Reenen et al. (2004)	Individually tested for response to a stationary human in the test arena	Latency to approach within 1m, whether not contacted and time in contact with the human	Dairy cattle
Open-field test	,,	10 minute recording of behaviour in the open-field	Time in contact with floor or wall (nose or tongue), locomotion and vocalizations	,,
Novel object test	,,	Reactivity to tambourine and ball descended at the centre of test arena	Latency to contact and time in contact with the novel object, vocalizations	,,
Novel arena test	Munksgaard and Simonsen, (1996)	Reaction to a human-dummy in a novel arena	Latency to contact, number of contacts	Dairy cattle

Table 2.2. continued

Vigilance test	Welp et al. (2004)	Novel enclosure (150m^2)	Head in the feeder	Dairy cattle
Novel food	Herskin et al. (2004)	Carrots	Latency, duration and frequency of sniffing and eating, etc.	Dairy cattle
Novel object	,,	White plastic container filled with sand brought down at the edge of feeding receptacle	Latency, duration and frequency of sniffing and being away from the object, etc.	,,
Unfamiliar person	,,	Motionless female in white clothing at the edge of feeding trough	Latency, duration and frequency of physical contact, etc.	,,
Novel food test	Herskin and Munksgaard, (2000)	Behaviours towards novel food (carrot)	Eating, sniffing, self-grooming, drinking and disturbance from neighbors observed	Dairy cattle

Table 2.2. continued

Surprise test	Romeyer and Bouissou, (1992)	Ball dropped above the feeding bowl 1min after the animal moved into the pen	Latency to enter the test room, feeding latency, feeding time, time spent away from stimulus, immobilization, defecation, vocalization, number of squares crossed (open-field), escape attempts, etc.	Sheep
Human test	,,	Reaction of sheep to a person sitting inside the test pen		,,
Novel object test	,,	Electric fan with pennants placed near the manger		,,
Open-field test	,,	Reaction in a novel open-field		,,
'Stimuli' test	Moberg and Wood, (1982)	Reaction to a 'hobby horse' descended from above in the open-field	Latency to contact the stimulus, time spent near stimulus, number of lines crossed in the open-field, vocalizations, etc.	sheep

Table 2.2. continued

Novel environm-ent test	Hillmann et al. (2003)	2 X 2m arena marked with 0.5 X 0.5m squares. Arena also contained double T shaped wooden structure and a ball	Vocalization, latency to leave the start box, duration of sniffing at the objects, jumping, call frequency and squares entered	Pig
Novel object test	Lawrence et al. (1991)	A plastic bin was let to descend in a pen and the response of individual pig observed	Instantaneous sampling of contact, attention and exploration	Pig
Novel object test	Rasmussen, (1991)	Response to 1.5m orange stick in the home pen	Exploration	Pig
'Response of pigs to sound'	Talling et al. (1996)	Pigs exposed to artificial sound in a familiar arena with a companion pig	Heart rate and ambulation sore	Pig
Open-field test	Von Borell and Ladewig, (1992)	Novel room (3m X 7m) divided into 21 one m^2 sections	Latency to enter the room, ambulation score, vocalizations and defecation	Pig

Table 2.2. continued

Visual, auditory and olfactory test	Christensen et al. (2005)	Novel stimuli to which animals were exposed to, were either a traffic cone, white noise or eucalyptus oil smeared on the inside of feed receptacle	Time spent eating, locomotion, heart rate, number of eating bouts, vigilance, distance backed up from the stimuli, etc.	Horse
Novel object test	Scolan et al. (1997)	Inflated ball inside a metallic cage kept in the arena	Standing, exploration, walk, trot, gallop, vigilance, etc.	Horse
Novel object test	Visser et al. (2001)	Reaction to a colored umbrella that has been caused to descend from the ceiling	Latency to approach the novel object, locomotion, posture, vocalizations, etc.	Horse
Hole-in-the-wall box	Jones and Mills, (1983)	The apparatus consisted of two compartments, start box and goal compartment containing a hole in the partition between compartments. Start box was darker than goal compartment	Latency to peep, put head through the hole and emerge into the goal compartment	Poultry

Table 2.2. continued

Open-field	Jones and Mills, (1983)	Wooden box	Latency to step, peep, duration of freezing, number of step, peep, pecks at the environment, preens and jumps	Poultry
Response to a bell	,,	Response to electric door bell observed for 5 min	Freezing duration, latency to first peep and step	,,
Tonic immobility	,,	Restrained on table for 15 s	Latency to first head movement and duration of tonic immobility	,,
'Looming human stimulus'	Jones et al. (1981)	Behaviour of bird during approach by a person and holding for 2 minute recorded	Cessation of feeding, step back, head shaking, withdrawal, startle, crouching, calling, panic and escape behaviours observed	,,
Novel object test	King et al. (2003)	Dog exposed to a moving remote control toy car	Withdrawal distance, time spent within and number of entries within a specified distance from toy, etc.	Dog

Table 2.2. continued

Startling test	King et al. (2003)	Brightly colored umbrella opened near the dog	Withdrawal distance, time spent within and number of entries within a specified distance from umbrella, heart rate, salivary cortisol, etc.	Dog
Sudden appearance	Svartberg et al. (2005)	Human like dummy hauled up in front of dog	Aggression, exploration, avoidance, approaches, etc.	Dog
Metallic noise	,,	Chain dragged over metal sheet	,,	,,
'Ghosts'	,,	People dressed like 'ghosts' moving towards the dog	,,	,,
Open-field test	Morisse et al. (1999)	Individually placed in the central square of open-field (150 cm X 150 cm). Total nine squares (50 cm X 50 cm)	Freezing, number of lines crossed, duration of freezing and displacement	Rabbit
Open-field test	Rauw , (2006)	Open-field (70 cm X 112 cm) divided into square (14 cm X 14 cm)	Positions of mouse every 5 s and number of squares crossed	Mice
Run way test	,,	200 cm X 10 cm X 10 cm- run way used	Latency to reach different targets on the run way	,,

Though there has been no consensus definition of 'temperament', reaction to a novel stimuli has been proposed to be a predictor of temperament in horses by Heird and Deesing (1998), who concluded that, by testing an animal's response to novelty, we are essentially measuring their fearfulness. Christensen et al. (2005) observed heightened responses to visual and auditory stimuli compared to olfactory stimuli when all these were used to assess horses' reaction to novelty. Most of the researchers used visual stimuli to measure an animal's response to novelty. But Christensen et al. (2005) used sound stimuli (white sound) and olfactory stimuli (eucalyptus oil) to assess horses' reaction to novelty in addition to visual stimuli. Though novelty effects on animals have been tested by different methods by different authors, it is argued that this trait (reaction to novelty) also influences the spontaneous activities and interactions of cattle in situations where they are not being handled by people. Therefore studies of such interactions are crucial to a more complete understanding of the concept of temperament. Le Neindre (1989) opined that novelty test can be used as complement to other tests in interpreting the reactivity of animals. When compared to open-field studies, exposure to a distinct novel stimulus is more suitable to study investigatory behaviour (Russel, 1983).

2.2.2 Impact of novelty on stress, animal welfare and production

'Fearfulness' has been proposed to be an individual personality trait (Boissy, 1998) where as 'fear' is regarded as a negative emotional state borne out of realization of danger and is a "basic characteristic of the individual that predisposes it to react in a similar manner to a large number of potentially challenging events" (Boissy, 1995). Romeyer and Bouissou (1992) proposed that fear is a "unitary phenomenon" as they could obtain significant inter-test correlations of behavioural measures from tests that involved a fear inducing stimuli. But Ramos and Mormède (1998) proposed that fear is 'multidimensional'. Wilson (1998) stressed the importance of environmental context in the expression of an animal's fear (reviewed by Reenen et al., 2004). Though fear is not amenable to direct measurement, its presence can be extrapolated from behavioural and physiological measures (Jones and Mills, 1983). It is evident from the literature that fearfulness is a component of an animal's behaviour repertoire (temperament). But a narrow-sense use of the term 'temperament' indicates response of an animal to any stimuli or situation that generates fear in an animal (Boissy and Bouissou, 1995).

The negative effects of fear in animals are generally agreed upon. Welfare is not far removed from productivity (Craig and Adams, 1984). Though certain levels of fear and anxiety were necessary for animal survival in the wild, excessive fear and stress may impinge on welfare and productivity in domestic animals (Boissy, 1998). The study of Breuer et al. (2000) found that a 19% difference in milk yield in dairy cattle can be accounted by their difference in the fear of humans. Fear has also shown to reduce let- down in dairy animals (Rushen et al., 1999). Fearfulness towards humans have been shown to result in diminished reproductive function (Hemsworth et al., 1981; Hemsworth et al., 1986a), less weight gain and increased adrenal response suggestive of stress (Gonyou et al., 1986) in pigs. Studies have linked the presence of stress to diminished welfare in animals. The animals with a heightened response to the novel stimuli will be more at risk of being startled (Herskin et al., 2004) and hence their welfare will be compromised more than that of those with minimal reactivity, as welfare being a function of an animal's ability to reconcile with the environment (Broom, 1988). Instead of sudden exposure, a bit-by-bit exposure reduces stress due to novelty and this principle can be applied in routine husbandry practices (Grandin, 1997). Tests designed to assess the response to novel stimuli give valuable information about animals' coping capacity in farming situations where animals are exposed to a variety of novel stimuli and environments (Boissy and Bouissou, 1995). So these tests can be used as valuable tools in assessing their welfare.

3 MEASUREMENT OF TEMPERAMENT

3.1 Introduction

In spite of different researchers developing different tests to assess temperament, subjective assessment tools were most commonly used in the past for the 'qualification' of temperament (reviewed by Burrow, 1997). As the subjective scores vary from observer to observer and even within observer between scorings it is very difficult to get reliable data. Manteca and Deag (1993) suggested that it is difficult to compare subjective score- results across studies because of its 'relative' nature. Burrow and Corbet (2000) suggested that, instead of subjective measures objective flight speed should be used as the test of choice to assess temperament in zebu and zebu-cross beef cattle whereas Kilgour et al. (2006) used exit time as a measure of temperament in Angus beef cattle. To eliminate the 'human factor' in rating temperament, Stookey et al. (1994) developed a movement-measuring-device (MMD) to objectively quantify movement. Watts et al. (2001) found that animals' MMD scores were well correlated between observations and suggested that this could represent a stable inherited personality trait. Past studies in rodents have linked individual differences in behaviour (personality) to their respective coping strategies (active vs. passive) (Benus et al., 1991). Schmutz et al. (2001) used MMD to measure the animal's response to handling and isolation and found a heritability of 0.36.

Schwartzkopf-Genswein et al. (1998) measured the force exerted by steers on the headgate during branding using strain gauges and found these measures were correlated with the measurements of load cells (another objective tool used for measuring force) attached to the headgate and squeeze chute. Prayaga (2003) used chute exit speed as a measure of temperament and showed that there were significant differences in the exit speed of different breeds. Burrow and Corbet (2000) showed that exit speed is heritable and can be used in genetic selection programs for *Bos indicus* animals. Burrow et al. (1998) used exit speed as a measure of temperament in *Bos indicus* crossbreds and the results show that slower moving animals grow faster in a feedlot. Curley et al. (2003) argues that exit speed may be more valuable than subjective methods as it is objective and continuous.

The aims of this study were to assess temperament using both objective and subjective methods and to determine if there is any correlation among different objective measurements and between subjective and objective methods and to assess correlations within objective and subjective measures between evaluations. It is hypothesized that there is consistency of objective and subjective measures within the evaluation series and across repetitions. It is also proposed that there is a correlation between an animal's performance, and its temperament as evaluated by both subjective and objective measures.

3.2 Animals, materials and methods

The study was carried out between November 2005 and March 2006. Four hundred weaned steers (5-8 months old; 243 ± 19 kg) were procured in late November 2005 from Saskatoon Livestock Sales. They were housed at the University of Saskatchewan Beef Cattle Research Station. The animals were apparently healthy and free from any visible abnormalities. The calves appeared to be crosses of a number of common beef breeds including: Hereford, Angus, Charolais, Simmental, and Limousin. Typically calves purchased from cow-calf herds in Western Canada would have been pasture reared. Under pasture-rearing conditions, pre-sale handling for most of these calves would have been similar with very little previous experience with humans and restraint. The animals that were tested for temperament were part of a larger project, which was investigating the impact of genes on beef cattle temperament. Blood was sampled from each animal one month before the second behavioural evaluation for genotyping. So, from a broader perspective the aim of the experiment was to correlate genotype of these animals with temperament.

Most animals were processed on the day of their arrival. Animals that arrived late in the evening were processed on the following day. The handling complex consisted of a curved chute outdoors that led indoors to a straight chute, with a headgate and scale. For processing, the animals were moved single file though the chute by the staff and were individually restrained in the headgate. At the headgate they were ear tagged, implanted with Zeranol (Ralgro, Schering Canada Inc), a hormonal growth promoter; had prophylactic administration of oxytetracycline

(Liquamycin LA-200, Pfizer Canada Inc), were vaccinated against Clostridial and respiratory diseases, treated with Ivermectin (Ivomec Pour-On, Merial), and had their mandatory federal ear tags scanned. The animals were then weighed on an electronic weigh scale and randomly placed in pens.

The 12 pens that were set apart for housing the steers had 3-sided shelters for protection from extreme weather conditions. Steers were held in groups of approximately 33 in adjacent pens during their backgrounding period (149 ± 3 days) before being transported to another feedlot for finishing. The "backgrounding ration" constituted a mixture of grain and silage. The animals were fed *ad libitum* from the feed bunks lining the front of the pen. They also had free access to water. In addition to the weighing of animals during the processing time they were also weighed at the time of blood collection, after the second and third behavioural evaluation, at the end of backgrounding period and again at the end of the finishing period.

The animals were subjected to three series of evaluations. Factors such as voice, presence of people, environment and handling methods were kept as similar as possible within and between sets of tests, using the same number of people, stationed in the same positions for each evaluation. The first evaluation was made within 48 hours of their arrival at the facility. The second and third evaluations, spaced two months apart, were run to study the consistency in reactivity and habituation effects. Three objective tools were used to assess temperament: strain gauges, MMD and exit time. They are designed to give quantitative measures of temperament. Such methods of temperament measurement may give more precision and reliability, and hence more power to the study when compared to subjective measures. Also, there are only relatively few studies that looked at the consistency of behavioural reactivity in beef cattle. Complete data from 16 animals could not be obtained due to technical problems.

3.2.1 Strain gauges

A pair of strain gauges mounted on the headgate (Fig. 3.1), measured the amount of force exerted by the steer on the headgate due to struggle (Schwartzkopf-Genswein et al., 1997). Output signals were measured in millivolts (mV). Strain gauges were connected to a data logger (Campbell Scientific Inc. 21X Micro logger) which digitizes and temporarily stores the data. The

Fig. 3.1. Photo showing a pair of strain gauges mounted on a headgate bar

data logger was programmed to sample the voltage in the strain gauge circuit every 50 ms. The computer retrieved the information from the data logger and stored it as a single data file (software program used : PC208W). The variables in the file that were of interest were the sampling time and voltages. Average, minimum, maximum and SG SD were calculated for each animal. Because animals could pull or push against the headgate and generate negative values, the absolute strain forces were also recorded for each animal. Absolute strain force is calculated by summing the absolute values of all the 200 data points in the strain gauge output for 10s. Standard deviation represents the fluctuation of the force about a mean whereas absolute strain force describes the variation of force about the baseline (i.e., zero). The number of shifts of the strain gauge force about a mean (i.e., when the animal modifies its escape behaviour from pulling to pushing the headgate) was recorded as the number of Runs. Fig. 3.2 shows an example of the strain gauge output from a restrained animal.

3.2.2 Movement-measuring-device

The MMD (Stookey et al., 1994) was connected to the load cells of an electronic weigh scale. The MMD passes an electrical signal through the load cell circuit that is normally used to weigh an animal, and measures the returning voltage 122 times per second for a period of one min. The returning voltage fluctuates as the animal moves about on the scale platform. When the animal is placed on the scale for 1 minute, three values are obtained from the MMD in succession. These are the number of peaks, mean value and the standard deviation (MMD SD). The number of peaks represents the frequency or number of body movements. The mean is proportional to the animal's weight, and the standard deviation is representative of the magnitude of movements.

3.2.3 Exit time

Exit time was measured as per the protocol used by Burrow et al. (1988). The measuring device consisted of two sets of laser beam generators, reflectors on a stand and a timer. Calm animals were observed to leave the chute at a slower rate than more agitated ones (Burrow et al., 1988). Hence the temperaments of animals were assessed by recording the time taken to move a measured distance (2.9 m) after vacating a confined area.

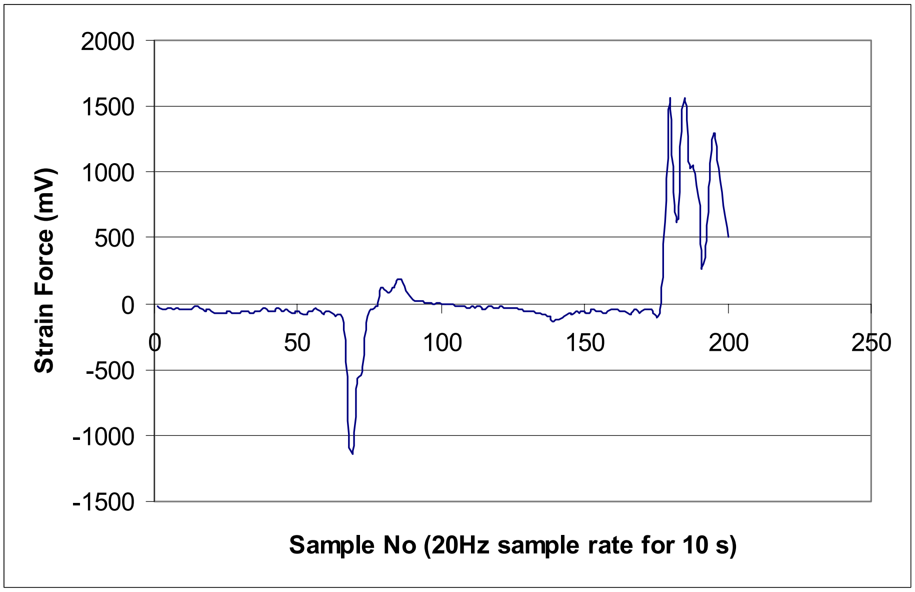

Fig. 3.2. Example of a strain gauge output from an animal that was struggling against the headgate during a 10 s period. Positive deflections indicate the animal pulling on the headgate and negative deflections indicate the animal pushing on the headgate. 200 data points are obtained in the strain gauge output for 10 s.

3.2.4 Subjective scoring

Subjective scoring was done on a continuous 1-5 scale by a single person, through visual assessment of the animal's reactivity during handling. This was performed while each animal was restrained in the headgate. The guidelines used for scoring are given in Table 3.1 (Grandin, 1993). The same person did the observations for all three sets of evaluations.

3.2.5 Sequence of handling and measurements

On the day of testing, animals were moved out of their pen and led through the chute system and into the testing barn (Fig. 3.3). Within the barn while one animal was restrained in the headgate, two additional animals remained waiting behind. The headgate had a pair of strain gauges attached above the level of animal's neck. During headgate restraint the force from struggling was measured for 10 s using the strain gauges. During the second half of the 10 s period, the person who operated the headgate also handled each animal's ear to simulate a processing procedure. During the same 10 s period the subjective scores were assigned. Following the 10 s period, when the animal was released from the headgate they moved into the weigh scale, the sides of which were solid thereby preventing visual contact with animals or humans. MMD values were recorded for 1 minute while the animal was reacting within the weigh scale. When released from the weigh scale, the steer was allowed to traverse the 2.9 m race unaided. Two laser beams positioned at the beginning and end of the race allowed for accurate measurement of time taken to travel the race (exit time).

3.3 Statistical analyses

Data were analyzed using the Statistix software (2000) and the tests employed were mostly nonparametric, as the strain gauge, MMD data and exit time were not distributed normally and the variances were not constant. The objective measures were summarized using the median and IQR (interquartile range - the 25^{th} to 75^{th} percentiles). The number of shifts of the strain forces about a mean was examined using the Runs test. Correlations between strain gauge, MMD and exit time values within the evaluation series and between repetitions were examined by Spearman's rank correlation. Spearman's correlation (ρ) was interpreted as follows: $\rho<0.1$, trivial correlation; $0.1< \rho <0.3$, slight correlation; $0.3< \rho < 0.5$, moderate correlation; $0.5< \rho <0.7$, substantial or large correlation; and $\rho >0.7$, very large correlation (Hopkins, 2000).

Table 3.1. Subjective score guidelines

Score	Description
1	Very little or no movement
2	Low amplitude movements, or ≤ 2 vigorous kicks or shakes
3	more than 2 violent/vigorous kicks, shakes, jumps, etc.
4	nearly continuous violent movements (some brief pauses)
5	continuous violent movements (no pauses)

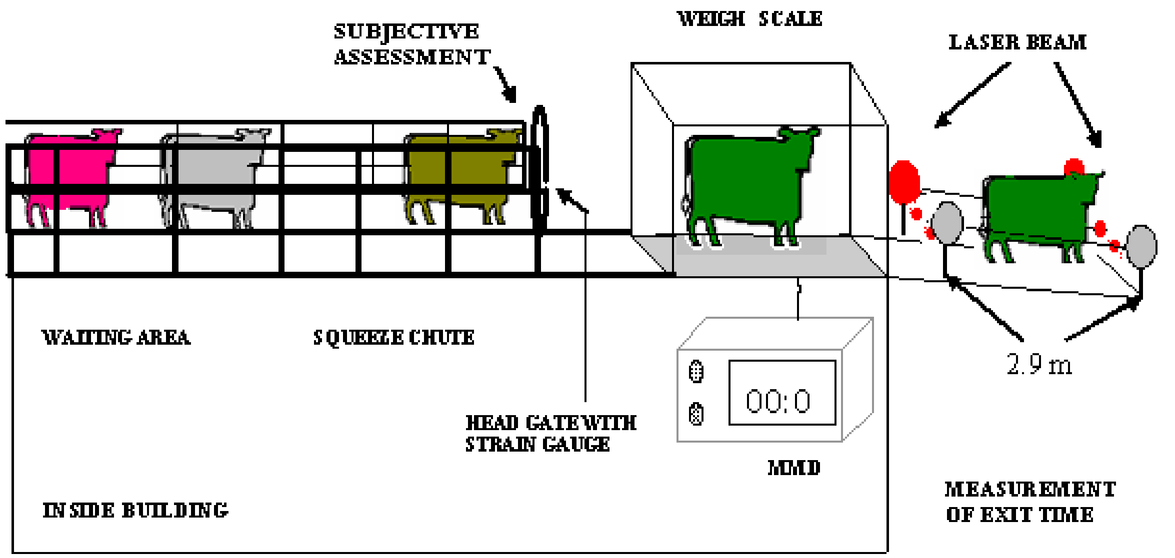

Fig. 3.3. Experimental set-up for measuring temperament

The animals were grouped into 'calm' and 'wild' based on their subjective score (scores 1 and 2 = calm, scores>2 = wild). Rank sum tests were used to determine whether there was any significant difference in the strain gauge, MMD values, and exit time of 'calm' and 'wild' groups. Differences between the strain gauge values of the first and second half of the 10 s strain force measurement period were compared using the Wilcoxon signed Rank Sum Test. The differences between the repetitions of all the objective and subjective measurements were also examined with the Wilcoxon signed rank test. A PROC MIXED model in SAS (1999) was also used to analyze the repeated objective measures. To further interpret the relation among 15 objective temperament measures, Principal Component Analysis was used.

The effect of subjective temperament measures on backgrounding ADG was examined using mixed models to account for pen effects (PROC MIXED, SAS). Initial body weight was used as a covariate. For the purpose of this analysis, animals that were 'calm' for at least two sets of evaluations out of the three were designated as 'calm' and those that were 'wild' for at least two sets of evaluations were designated as 'wild'. The same subjective data were used for analyzing the relationship with the number of Runs obtained from the strain gauge data (Rank sum test). The relationships between the objective temperament measures and ADG were also examined using the model specifications outlined above. Objective measures were summarized for each animal using the mean for the three sets of evaluations. The following model was used: Y (ADG) = $\alpha + \beta_1$ * objective measure + β_2 * initial body weight + μ (pen), where Y = dependant variable, α = intercept, β_1 = regression coefficient of objective measure, β_2 = regression coefficient of initial body weight, μ = random pen effect. As all the animals were housed in two large pens in the finishing feedlot, the effect of objective and subjective measures on finishing ADG and hot carcass weight was analyzed using the above model after removing the effect of pen from the model.

3.4 Results

3.4.1 Objective measures: Consistency within the evaluation series

The correlation coefficients for the relationship between animals' MMD mean scores and absolute strain forces were not significant for all the sets of evaluations whereas correlation of MMD mean and SG SD were not significant for two sets of evaluations and weak for another set (ρ = 0.12, *P*<0.05) (Table 3.2). Since the MMD mean is proportional to animal weight, there is little evidence that strain forces were greatly affected by the size of the animal. The SD of force exerted by the steer during the first half of the 10 s period was significantly different from the second half for the initial set of evaluations, but the difference became insignificant subsequently. However, the absolute strain force exerted by the steer was significantly different only for the second set of evaluations (Table 3.3). Since there was little indication that steers responded differently between the first 5 seconds and next 5 seconds of restraint, the entire 10 s of strain force measurement was further analyzed as a single unit.

While exit time was moderately negatively correlated with MMD SD and MMD peaks (*P*<0.001), the correlation of exit time with absolute strain force was slight negative and was only significant (*P*<0.001) for two sets of evaluations. A slight positive but significant (*P*<0.01) correlation of MMD peaks with absolute strain forces only occurred at the first evaluation of behaviour. The correlation of SG SD with exit time was slight negative but significant (*P*<0.001, *P*<0.05 and *P*<0.05 respectively for 3 sets of evaluations). A slight positive but significant correlation of SG SD with MMD SD occurred at the first and third evaluation (*P*<0.01 and *P*<0.05 respectively) (Table 3.4).

3.4.2 Objective and subjective measures: Consistency across repetitions (Repeatability)

There was no evidence of habituation to handling treatment (see Table 3.5, Fig. 3.4, 3.5, 3.6, 3.7, and 3.8). Instead, SG SD and MMD SD values progressively increased (by at least *P*<0.05) between the first, second and third sets of evaluations. However the exit time, MMD peaks and absolute strain forces do not show such a trend between serial evaluations. While the exit time decreased significantly from first to second (*P*<0.001) and increased from second to third set of tests (*P*<0.001), the MMD peaks and absolute strain forces increased from first to second (*P*<0.001), MMD peaks increased (although non-significant) and absolute strain forces decreased from second to third repetitions (*P*>0.5 and *P*<0.001 respectively). The third set of observations of MMD SD, Peaks and SG SD also increased (*P*<0.001) from the first. The differences of exit time values and absolute strain force observations between first and third repetitions were not significant (Table 3.5). Mixed procedure in SAS also showed very similar results for SG SD, absolute strain force, MMD SD, MMD peaks and exit time where the effect of

Table 3.2. Spearman's correlations between MMD mean values and both SG SD and absolute strain force for all three sets of evaluations

Evaluation	SG SD	Absolute Strain Force
1	0.07	-0.01
2	0.12 *	-0.02
3	0.03	-0.06

* *P*<0.05

Table 3.3. Median (IQR) of strain gauge values during the initial and later half of 10 s measurement period

Evaluation	Observation	SG SD median (IQR)	Absolute Strain Force median (IQR)
1	**First half**	183.15** (93.365-297.28)	39285 (20790-62524)
	Second half	218.37 (128.65-326.44)	42564 (24872-63321)
2	**First half**	272.37 (150.51-396.57)	63602* (42822-90120)
	Second half	300.10 (173.93-415.52)	71192 (50874-89862)
3	**First half**	331.09 (204.28-493.94)	38788 (19287-60850)
	Second half	339.48 (225.25-501.84)	38451 (22114-62833)

IQR-interquartile range
** There was a significant difference between the SG SD of first half of observation and second half (P<0.01).
* There was a significant difference between absolute strain force of first half of observation and second half (P<0.05).
The values are expressed in mV units.

Table 3.4. Correlation between objective measures (inter-test correlations)

	Evaluation	MMD SD	MMD Peaks	SG SD	Absolute Strain Force
Exit Time	**1**	-0.40***	-0.40***	-0.18***	-0.21***
	2	-0.40***	-0.39***	-0.12*	0.02 NS
	3	-0.34***	-0.27***	-0.15*	-0.19***
MMD SD	**1**	N/A	N/A	0.15**	N/A
	2			0.03 NS	
	3			0.13*	
MMD Peaks	**1**	N/A	N/A	N/A	0.13**
	2				-0.07 NS
	3				0.05 NS

* *P*<0.05
** *P*<0.01
*** *P*<0.001
N/A: not applicable
NS: non-significant

Table 3.5. Median (IQR) of strain gauge, MMD and exit time values recorded during first, second and third evaluations

	First Evaluation	Second Evaluation	Third Evaluation
Variable	**Median (IQR)**	**Median (IQR)**	**Median (IQR)**
SG SD (mV)	252.10[a] (170.81-337.36)	328.31[b] (217.68-431.94)	380.21[c] (274.76-513.25)
Absolute Strain Force(mV)	83319[a] (49449-123068)	135240[b] (98847-179224)	77753[a] (48888-122050)
MMD SD (mV)	1.05[a] (0.82-1.45)	2.12[b] (1.62-2.78)	2.24[c] (1.76-2.89)
No. of MMD Peaks	14.00[a] (6.00-30.00)	51.00[b] (31.00-90.00)	52.50[b] (25.00-82.25)
Exit Time (s)	3.25[a] (2.75-3.97)	2.58[b] (2.07-3.14)	3.1[a] (2.29-4.20)

Numbers with different superscripts on the same line differ from one another (P<0.001-P<0.05).

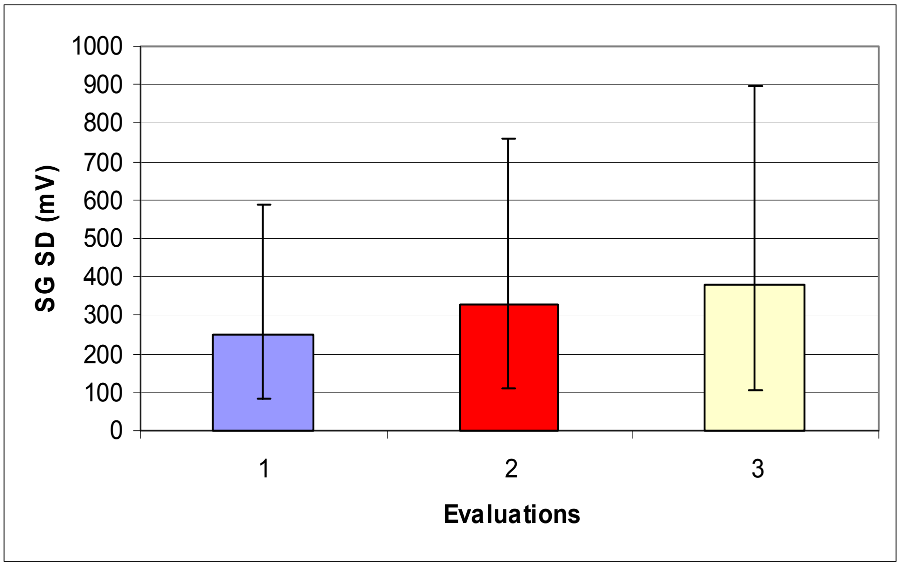

Fig. 3.4. Bar graphs showing median SG SD (strain gauge standard deviation) of steers recorded during restraint at the headgate for 10 s over three time points. The error bars represent interquartile ranges.

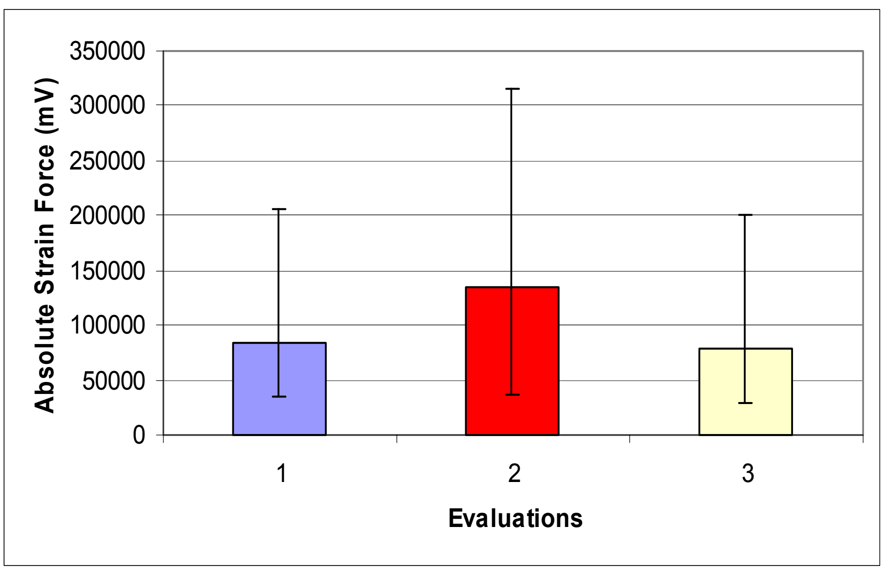

Fig. 3.5. Bar graphs showing median absolute strain force of steers recorded during restraint at the headgate for 10 s over three time points. The error bars represent interquartile ranges.

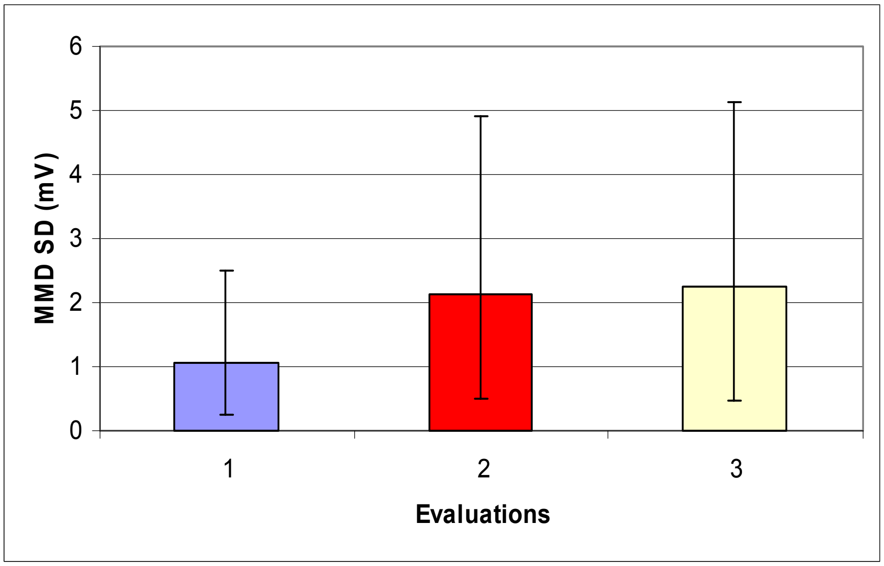

Fig. 3.6. Bar graphs showing median MMD SD of steers recorded over three time points when the animals move on scale platform for 1 min. The error bars represent interquartile ranges. MMD SD-standard deviation of voltage recorded by the movement-measuring-device.

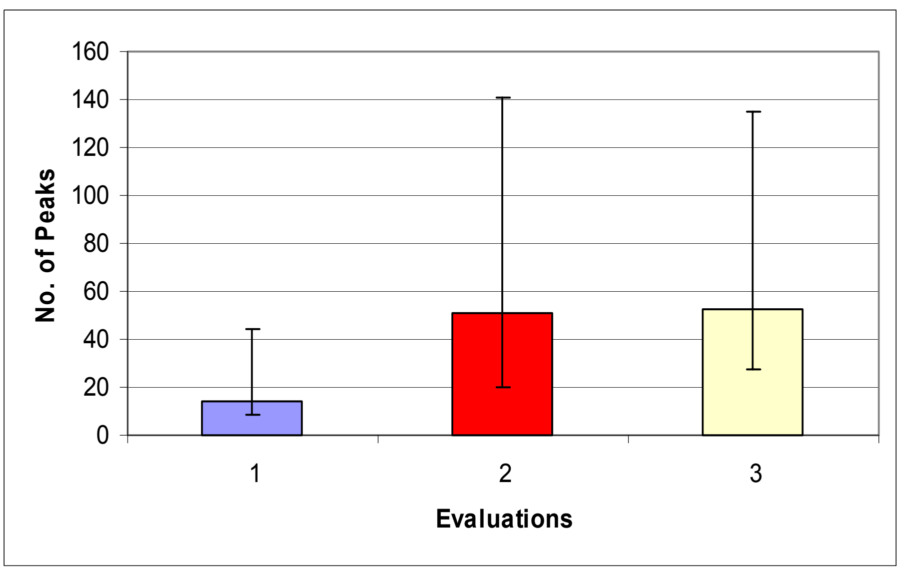

Fig. 3.7. Bar graphs showing median MMD peaks of steers recorded over three time points when the animals move on scale platform for 1 min. The error bars represent interquartile ranges. MMD peak- frequency of body movements recorded by the movement-measuring-device.

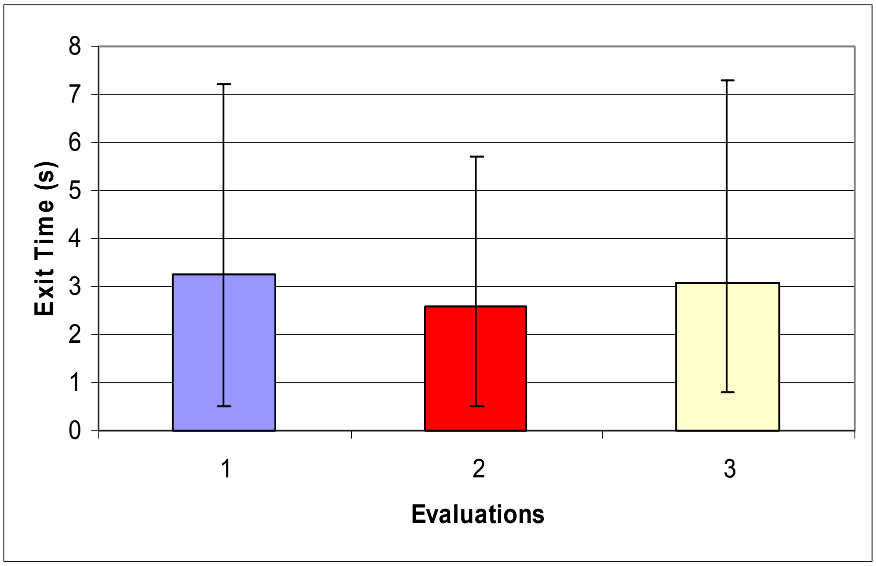

Fig. 3.8. Bar graphs showing median exit time of steers recorded over three time points when released from the weight scale. The error bars represent interquartile ranges.

pen was also accounted. There was a significant difference across repetitions for all objective measures ($P<0.001$). The distribution of SG SD, absolute strain forces, MMD SD, MMD peaks, exit time and subjective scores are shown in Figures 3.9, 3.10, 3.11, 3.12, 3.13 and 3.14 respectively. While the subjective score increased ($P<0.001$) significantly from first to second set, the difference was not significant between second and third set. There was also a significant increase ($P<0.001$) in subjective score from first to third set. The proportion of animals that were consistently calm or wild for all the sets of evaluations and the proportion of animals that showed variability in their response over time are shown in Table 3.6.

While the strength of correlation between individual measures on the same animals from one time period to the next varied from slight to moderate ($0.12< \rho <0.49$), the relationship was statistically highly significant ($P<0.001$) with the exception of SG SD-correlation between first and third set and subjective score relationship between the second and third set which were again significant at $P<0.01$ level and $P<0.05$ level respectively (Table 3.7).

3.4.3 Principal component analysis

PCA was used to further summarize the data and the relationships of Strain gauge, MMD and exit time variables with 5 principal components detected are given in Table 3.8. Eigenvalues for the first 5 principal components were 3.66, 2.11, 1.68, 1.41, and 1.16 respectively. All the 5 principal components together could explain only 67% of the individual variability in response with the first two components accounting for 38% of the variability (24% and 14% for the first and second PC respectively). SG SD and absolute strain force showed higher loadings on component 2 and MMD SD and peaks showed higher loadings on Component 1.

3.4.4 Objective and subjective measurements: Relationships

When the temperament was assessed on a continuous 5-point scale, most of the animals had their scores ranging from 1-3 (Table 3.9, Fig. 3.14). The relationships between subjective scores and strain gauge, MMD and exit time measurements are shown in Figures 3.15, 3.16, 3.17, 3.18 and 3.19. In general, increasing subjective scores were associated with higher MMD and strain gauge numbers and shorter exit times. For the ease of analysis the animals with scores 1 and 2 were arbitrarily designated as 'calm' and scores 3, 4 and 5 as 'wild'. The two groups

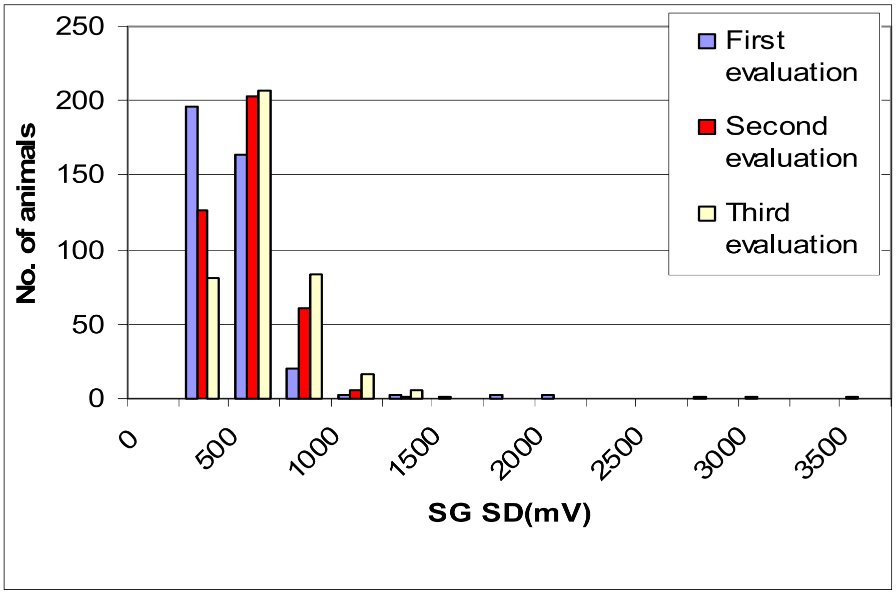

Fig. 3.9. Frequency distribution of SG SD (strain gauge standard deviation) of steers recorded during restraint at the headgate for 10 s over three time points.

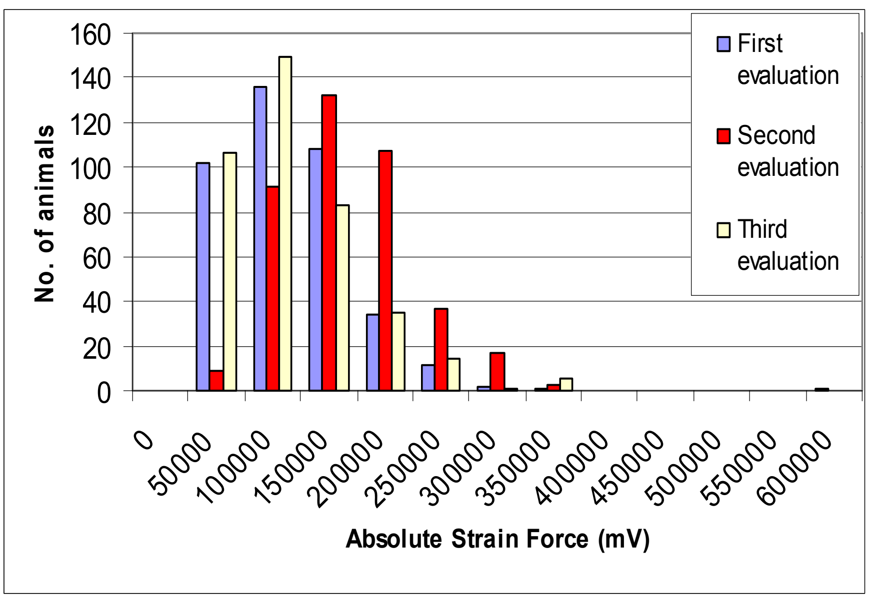

Fig. 3.10. Frequency distribution of absolute strain force of steers recorded during restraint at the headgate for 10 s over three time points.

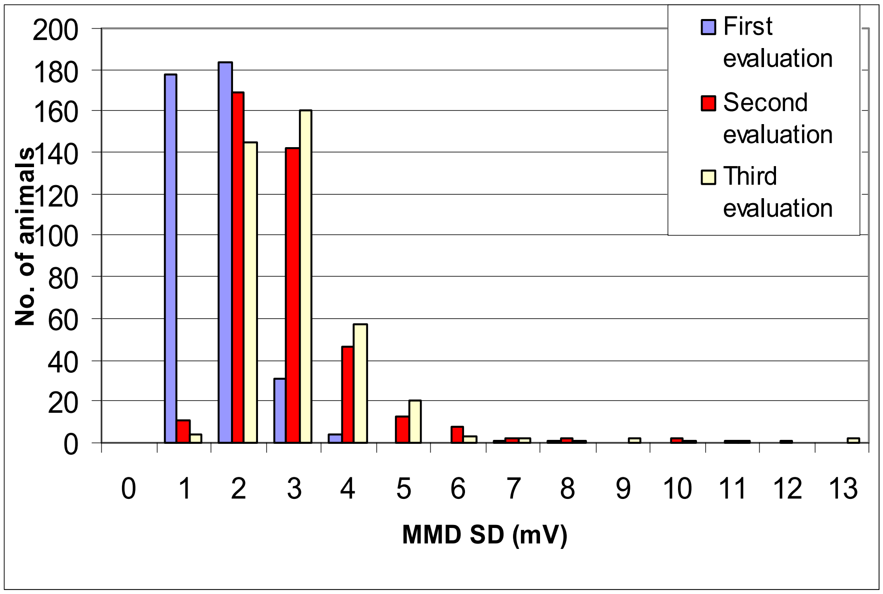

Fig. 3.11. Frequency distribution of MMD SD of steers recorded over three time points when the animals move on scale platform for 1 min. MMD SD-standard deviation of voltage recorded by the movement-measuring-device.

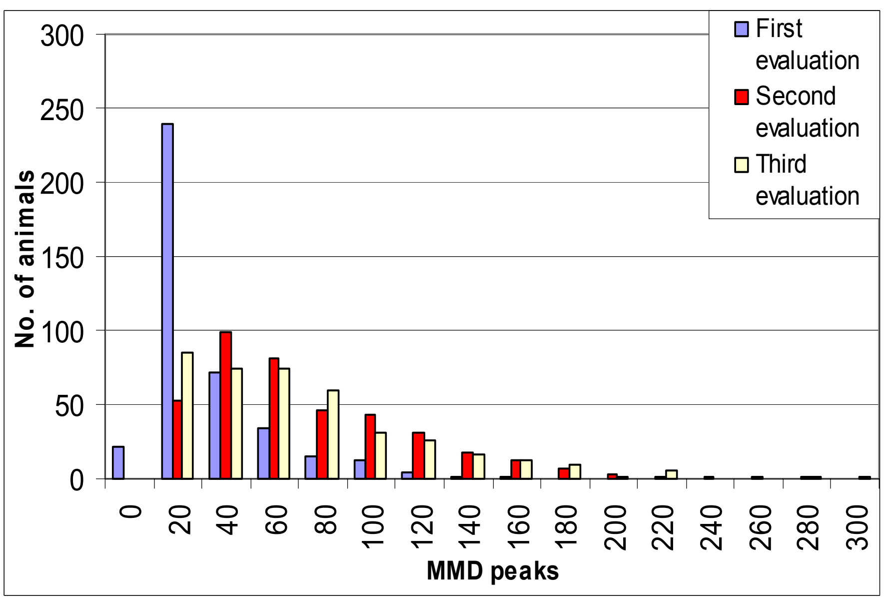

Fig. 3.12. Frequency distribution of MMD peaks of steers recorded over three time points when the animals move on scale platform for 1 min. MMD peak-frequency of body movements recorded by the movement-measuring-device.

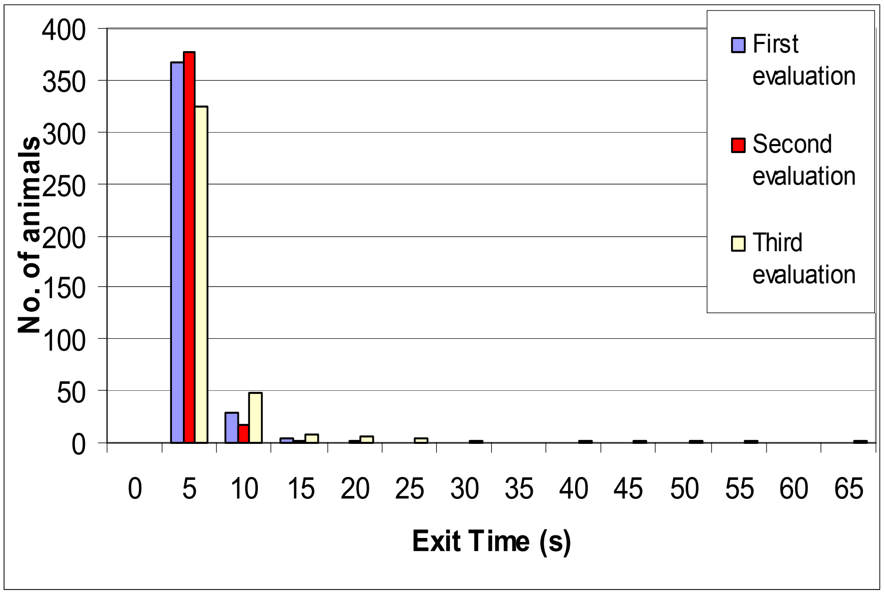

Fig. 3.13. Frequency distribution of exit time of steers recorded over three time points when released from the weight scale

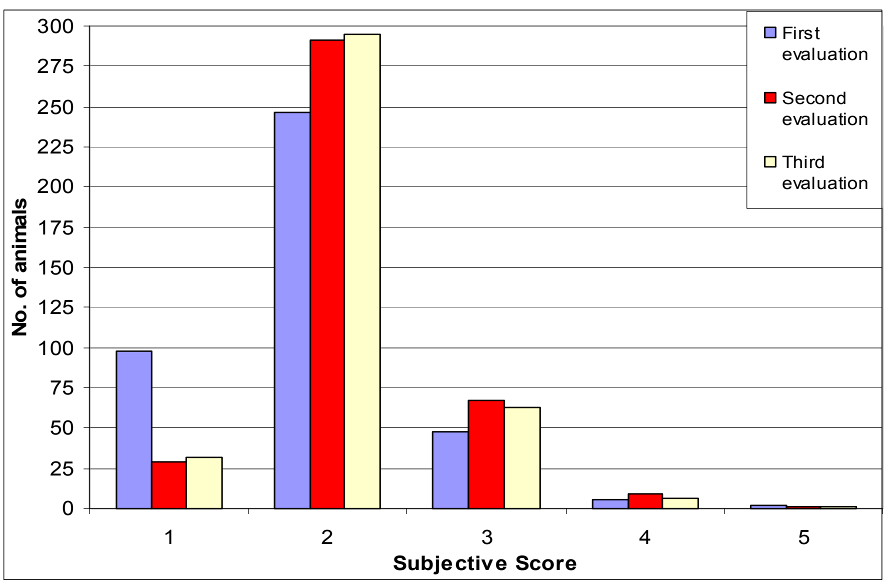

Fig. 3.14. Frequency distribution of subjective scores of steers recorded over three time points during headgate restraint. Subjective score-numerical scores assigned to animals based on their reactivity during headgate restraint.

Table 3.6. Behavioural consistency and variability of animals based on subjective temperament data

Calm		Wild		Among the total number of animals the proportion that showed consistency for all sets of evaluations n = 251
% of animals that were calm for all 3 sets of evaluations n = 241	% of animals that were calm for only 2 sets of evaluations n = 120	% of animals that were wild for all 3 sets of evaluations n = 10	% of animals that were wild for only 2 sets of evaluations n = 23	
66.76 (61.17)	33.24 (30.46)	30.3 (2.54)	69.7 (5.83)	63.71

Proportion of calm and wild expressed as a percentage of total number (394) of animals is given in parenthesis.

Table 3.7. Correlations within objective and subjective measures between evaluations (intra-test correlations)

Evaluation	**Exit Time**	**MMD SD**	**MMD Peaks**	**SG SD**	**Absolute Strain Force (mV)**	**Subjective Score**
1-2	0.22***	0.21***	0.21***	0.23***	0.41***	0.20***
2-3	0.25***	0.19***	0.20***	0.35***	0.40***	0.12*
1-3	0.48***	0.49***	0.42***	0.15**	0.31***	0.32***

* $P<0.05$
** $P<0.01$
*** $P<0.001$

Table 3.8. Eigenvectors of the correlation Matrix (Relationship between principal components and objective measures)

Variables	Evaluation	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5
SG SD	1	0.08	-0.02	-0.22	**0.59**	0.10
	2	0.23	0.29	0.02	-0.12	-0.10
	3	0.21	**0.40**	0.01	-0.27	0.23
Absolute	1	0.20	0.25	-0.14	0.55	0.09
Strain Force	2	0.18	**0.44**	0.002	0.06	0.01
	3	0.21	**0.48**	-0.01	-0.12	0.20
MMD SD	1	**0.37**	-0.23	0.28	0.20	0.14
	2	0.20	-0.20	-0.51	-0.21	0.34
	3	**0.37**	-0.15	0.17	-0.22	-0.16
MMD Peaks	1	**0.38**	-0.25	0.28	0.14	0.14
	2	0.24	-0.24	**-0.49**	-0.18	0.26
	3	**0.39**	-0.15	0.20	-0.17	-0.16
Exit time	1	-0.25	0.05	0.004	-0.19	0.12
	2	-0.14	0.04	**0.41**	-0.03	**0.53**
	3	-0.19	-0.11	0.18	0.02	**0.56**

Higher loadings of variables on principal components are shown in bold
Comp: component

Table 3.9. Distribution of subjective scores for the three consecutive evaluations

Subjective score	First evaluation	Second evaluation	Third evaluation
	% of animals	% of animals	% of animals
1	24.56	7.30	8.06
2	61.65	73.3	74.31
3	12.03	16.88	15.87
4	1.25	2.27	1.51
5	0.50	0.25	0.25

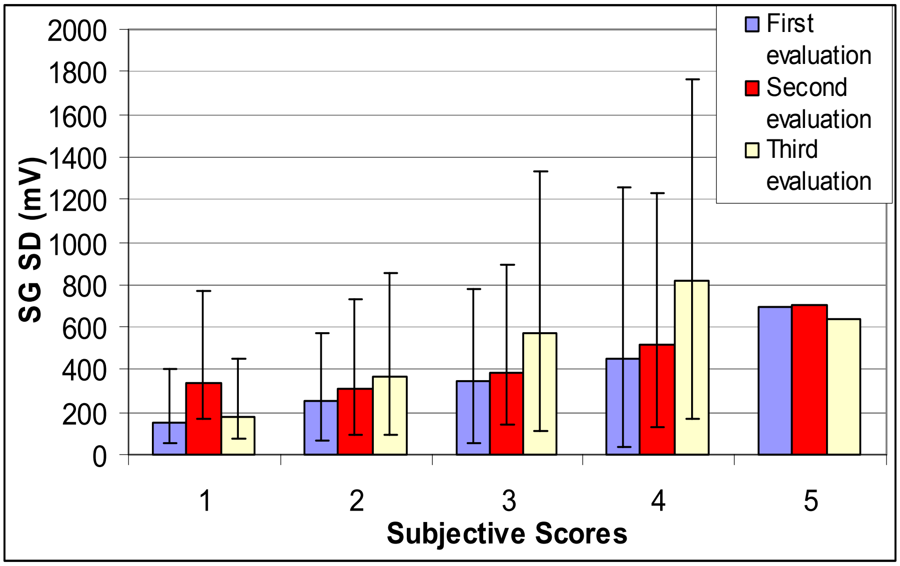

Fig. 3.15. The relationship between the headgate median SG SD (strain gauge standard deviation) and subjective scores of animals for three sets of evaluations. The error bars represent interquartile ranges. Subjective score-numerical scores assigned to animals based on their reactivity during headgate restraint.

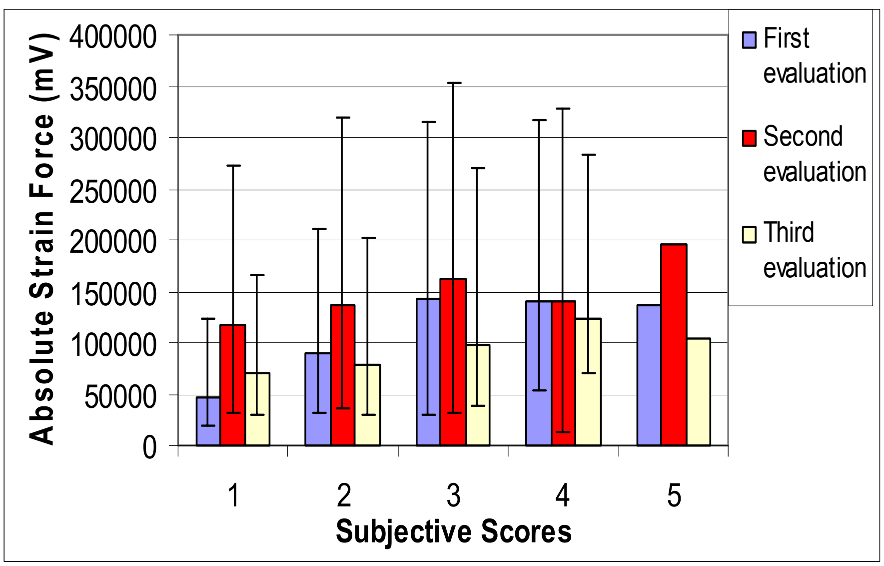

Fig. 3.16. The relationship between median absolute strain force exerted during restraint in headgate and subjective scores. The error bars represent interquartile ranges. Subjective score-numerical scores assigned to animals based on their reactivity during headgate restraint.

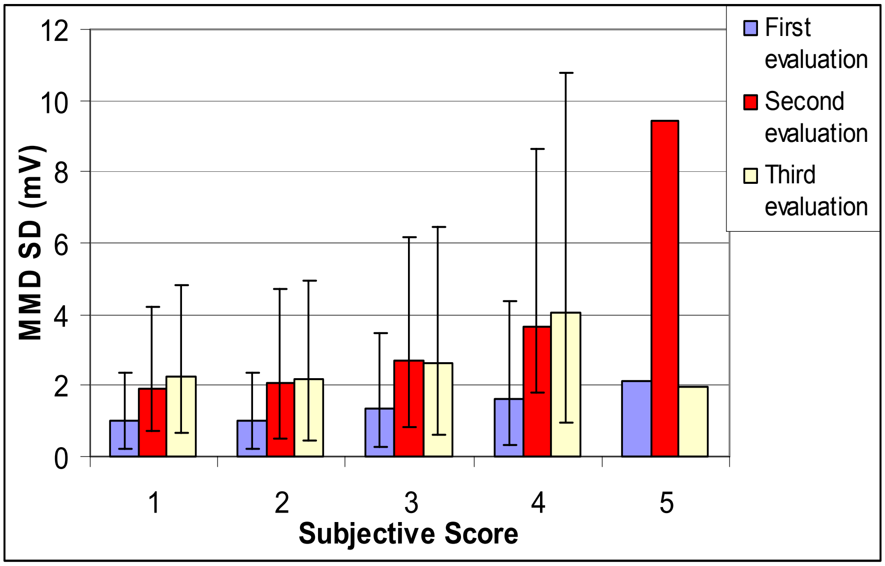

Fig. 3.17. Bar graphs showing median (IQR) MMD SD compared across five subjective scores. Values recorded while steers were isolated 1minute on a weigh scale. MMD SD-standard deviation of voltage recorded by the movement-measuring-device. IQR-interquartile range. Subjective score-numerical scores assigned to animals based on their reactivity during headgate restraint.

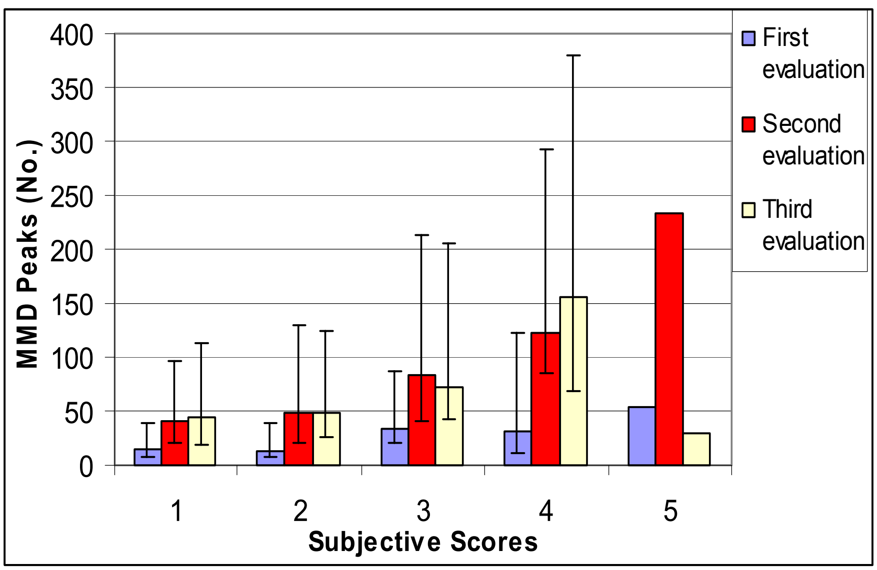

Fig. 3.18. Bar graphs showing median MMD peak values recorded while steers were isolated 1minute on a weigh scale compared across five subjective scores. The error bars represent interquartile ranges. MMD peak-frequency of body movements recorded by the movement-measuring-device. Subjective score-numerical scores assigned to animals based on their reactivity during headgate restraint.

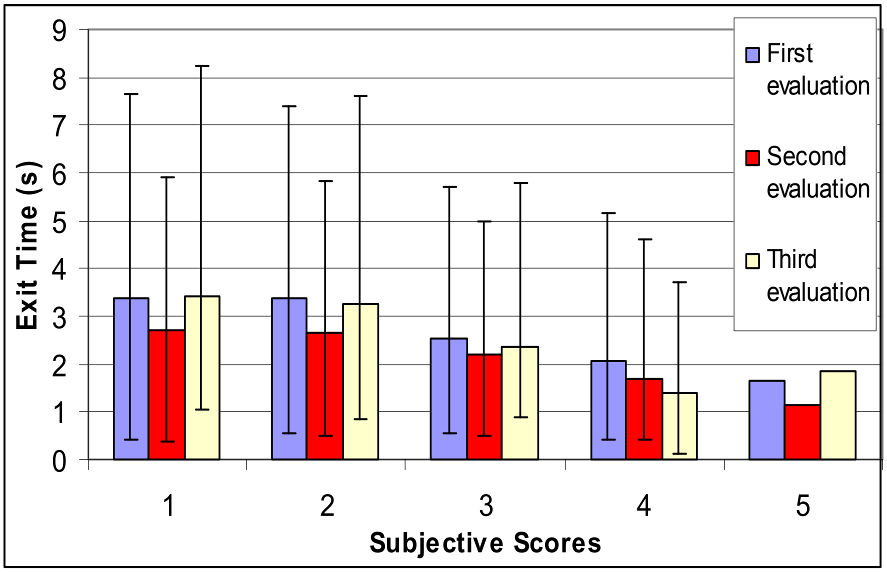

Fig. 3.19. Charts showing the relationship between median exit time of steers when released from the weigh scale and subjective scores. The error bars represent interquartile ranges. Subjective score-numerical scores assigned to animals based on their reactivity during headgate restraint.

('calm' and 'wild') differed significantly (by $P<0.001$) in SG SD, absolute strain force, MMD SD, MMD peaks and exit time (Wilcoxon rank sum test), except for one set (second set) of absolute strain force measurements where the *P*-values only tended towards significance ($P = 0.069$) (Fig. 3.20, 3.21, 3.22, 3.23 and 3.24). Animals designated as 'calm' also differed significantly ($P<0.001$) from 'wild' ones in their average number of Runs (Fig. 3.25).

3.4.5 Temperament measures and performance

There was a difference ($P<0.01$) in the backgrounding ADG between wild and calm animals (Fig. 3.26). The initial weight of the steers was included as a covariate in the model as two sample t-test showed that there is significant difference ($P<0.01$) in the initial weight of calm and wild steers. Calm animals gained an extra 76 ± 29 g per day after adjusting for effects of initial weight and pen; therefore the difference in gain between calm and wild animals over the backgrounding period was 9.93 ± 3.5 kg ($P = 0.02$) after accounting for the effect of pen ($P<0.05$) and initial body weight ($P<0.001$). The association between MMD values (MMD SD and MMD peaks) and ADG were also significant ($P<0.05$, $P<0.001$ respectively) after accounting for the effects of pen and initial body weight (Fig.3.27 and 3.28). But the SG SD, absolute strain forces and exit time showed no significant relationships with backgrounding ADG. Subjective temperament measures (calm vs. wild), SG SD values, MMD measures (SD and peaks) and exit time measures obtained during the backgrounding period were not significantly related to the animals' ADG in the finishing feedlot. However, absolute strain forces was associated ($P = 0.02$) with finishing feedlot ADG. Hot carcass weight of steers was not associated with any of the temperament measures.

3.5 Discussion

Significant relationships between almost all the objective measures within the evaluation series and across repetitions were slight to moderate in strength which may support the idea that we are measuring a consistent attribute of the animal. Also, since repeatability of a trait is related to its heritability, behavioural consistency is essential for the evolution of the trait (Svartberg et al., 2005). Studies with dairy cattle (Kerr and Wood-Gush, 1987) show that temperament as a trait takes shape early in life and remains consistent towards adulthood. “Evolutionary stability” of personality trait has been demonstrated in dogs (Svartberg and Forkman, 2002). Consistency

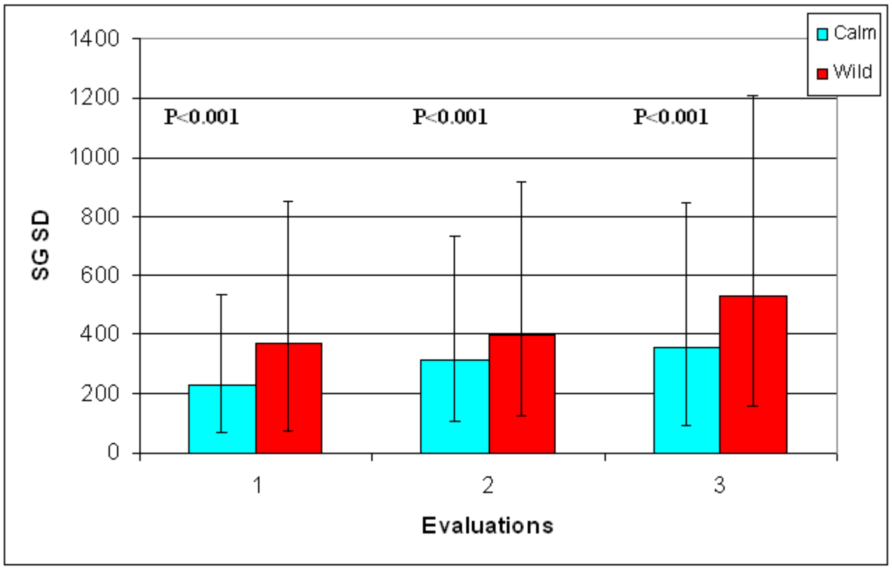

Fig. 3.20. Median SG SD (strain gauge standard deviation) of ‘calm’ and 'wild' steers. There was a significant difference in the SG SD of calm and wild steers for all the three sets of evaluations (Wilcoxon test). The error bars represent interquartile ranges.

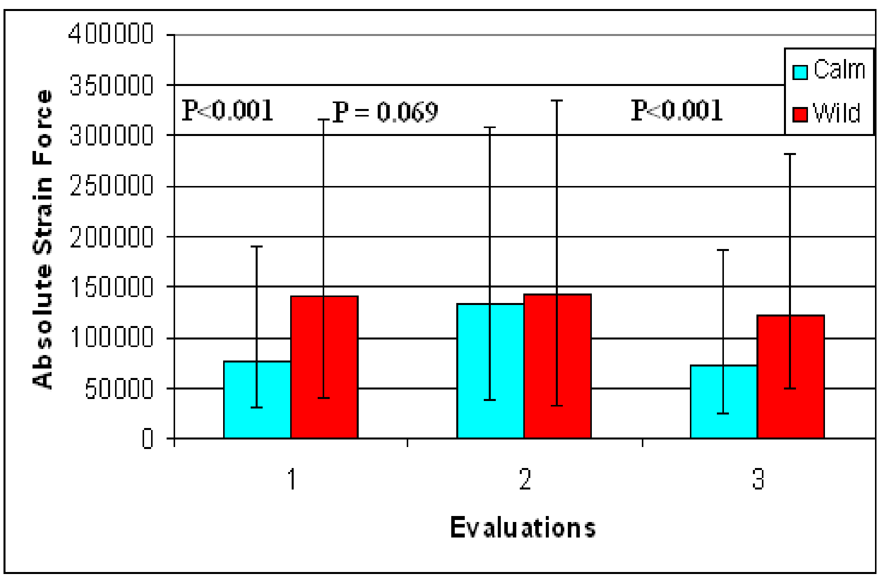

Fig. 3.21. Median absolute strain force of 'calm' and 'wild' steers. There was a significant difference in the absolute strain force of calm and wild steers for two sets of evaluations (Wilcoxon test). The error bars represent interquartile ranges.

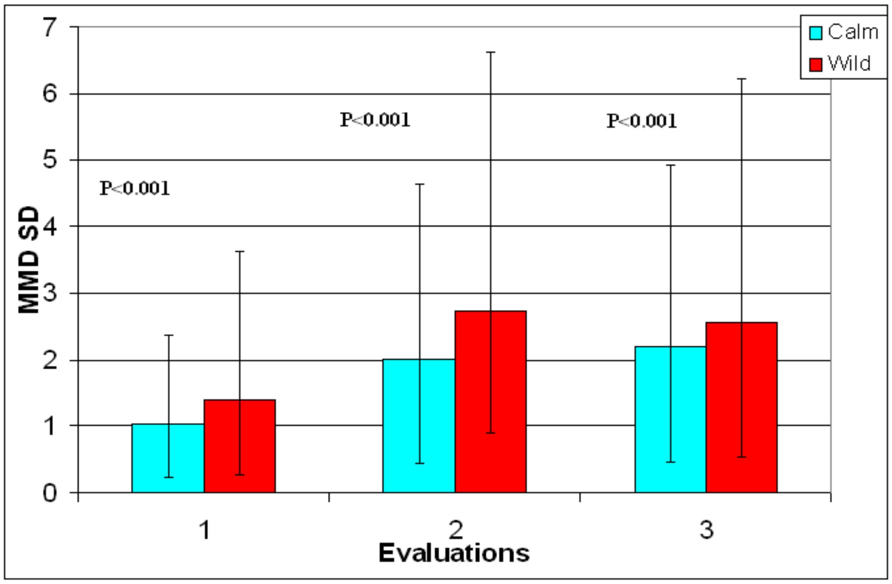

Fig. 3.22. Median MMD SD of 'calm' and 'wild' steers. There was a significant difference in the MMD SD of calm and wild steers for all the three sets of evaluations (Wilcoxon test). The error bars represent interquartile ranges. MMD SD-standard deviation of voltage recorded by the movement-measuring-device

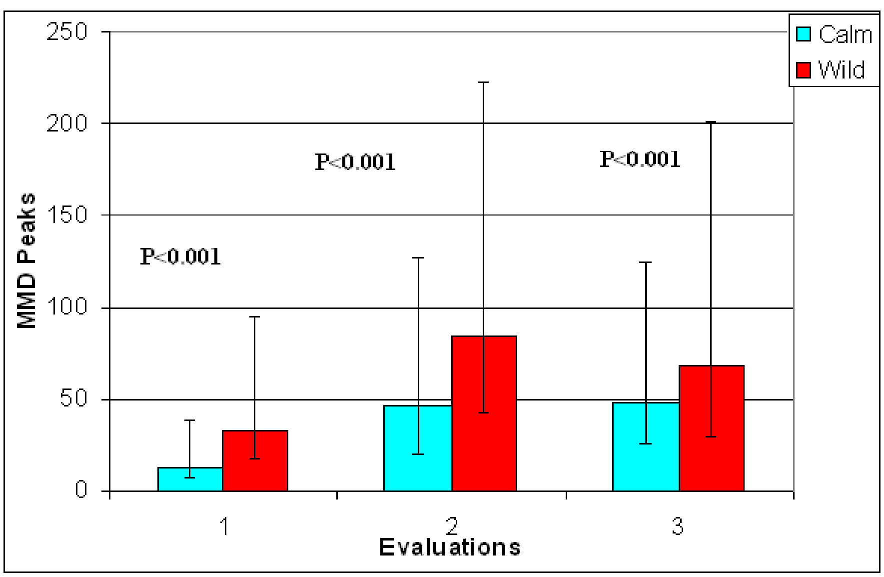

Fig. 3.23. Median MMD peaks of 'calm' and 'wild' steers. There was a significant difference in the MMD peaks of calm and wild steers for all the three sets of evaluations (Wilcoxon test). The error bars represent interquartile ranges. MMD peak-frequency of body movements recorded by the movement-measuring-device.

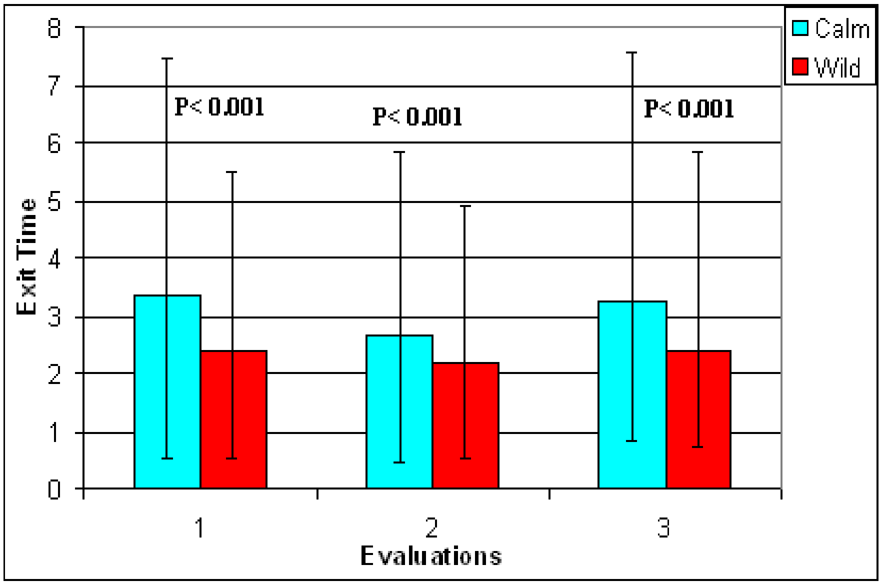

Fig. 3.24. Median exit times of 'calm' and 'wild' steers. There was a significant difference in the exit time of calm and wild steers for all the three sets of evaluations (Wilcoxon test). The error bars represent interquartile ranges.

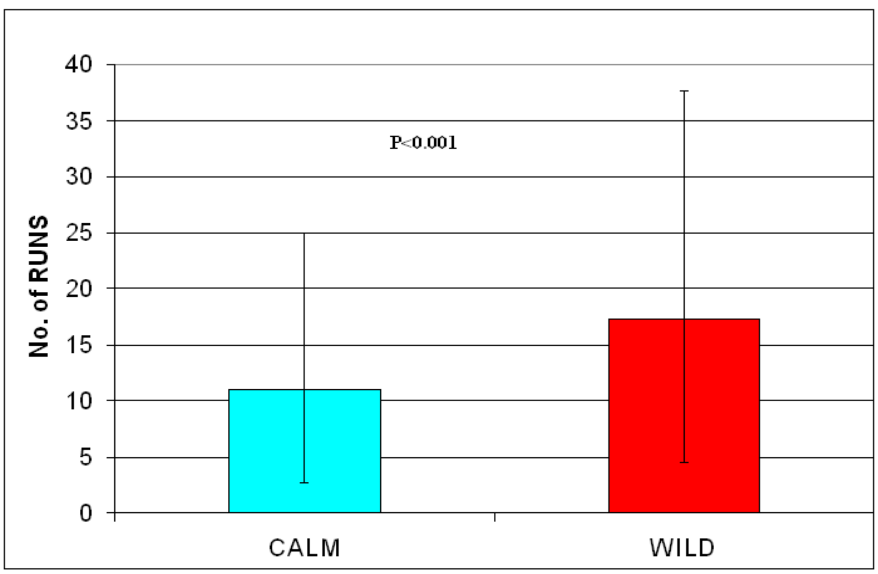

Fig.3.25. Median number of Runs of 'calm' and 'wild' steers. There was a significant difference in the number of Runs of calm and wild steers (Wilcoxon test).Runs- the number of shifts of the strain gauge force about a mean. The error bars represent interquartile ranges.

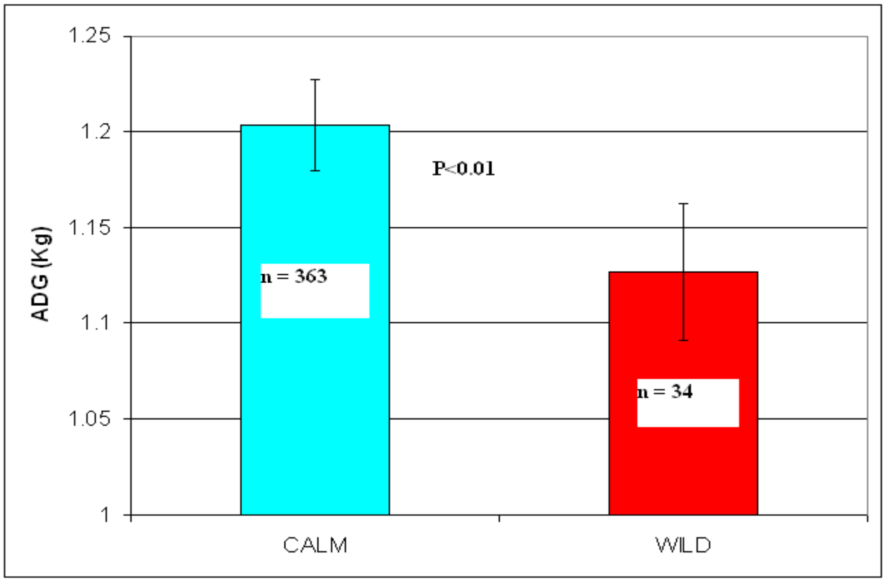

Fig. 3.26. Relationship between mean (± S.E) subjective score based temperament rating and backgrounding ADG

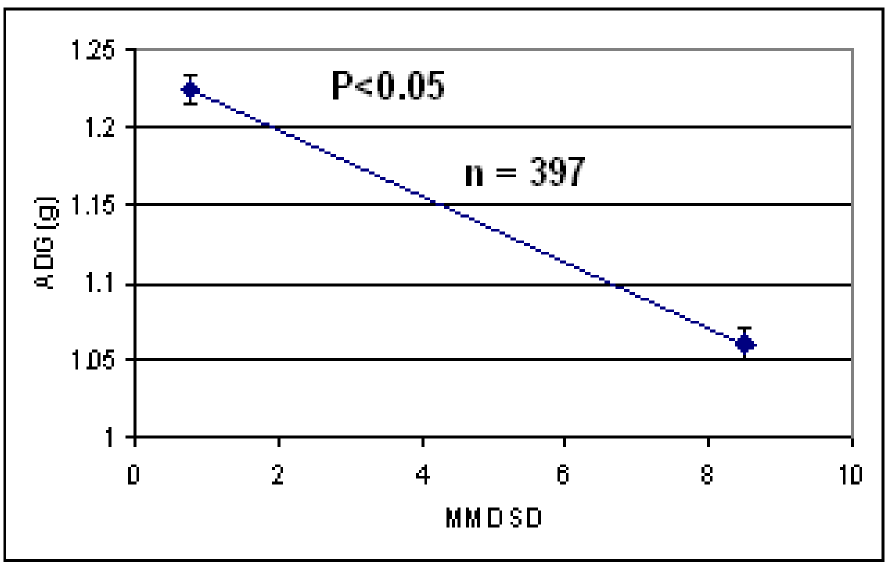

Fig. 3.27. Relationship between MMD SD and ADG during backgrounding period

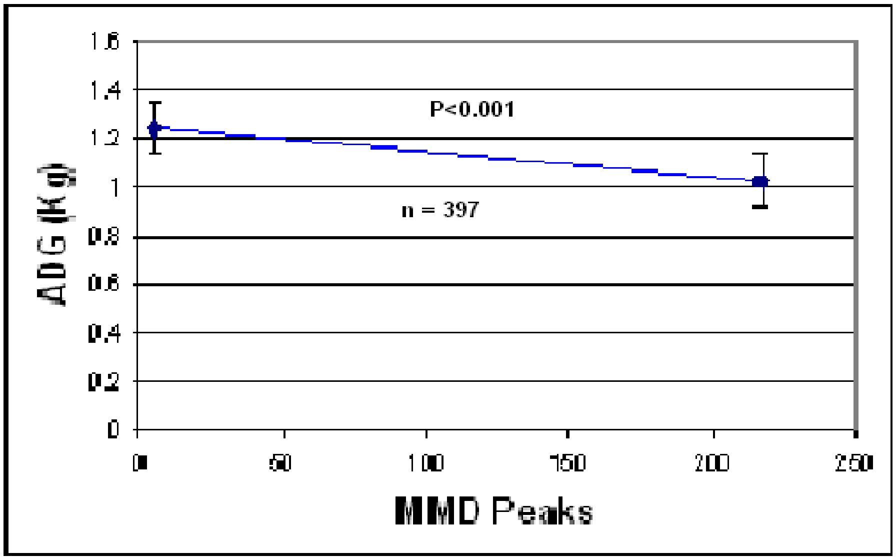

Fig.3.28. Graph illustrating the relationship between MMD peak and ADG during backgrounding period

in behavioural activities have also been reported in pigs across repeated administrations of the same test (18, 22 and 27 weeks) (Von Borell and Ladewig, 1992; van Erp-van der Kooij et al., 2002) and across situations (van Erp-van der Kooij et al., 2002). Temperament assessment in horses using different tests has also been shown to be correlated across situations (Scolan et al., 1997; Visser et al., 2001). Among the objective measures used here, exit time (flight speed) as a temperament measure, has previously been shown to be repeatable in *Bos indicus* (Burrow and Dillon, 1997; Petherick et al., 2002; Petherick et al., 2003; Curley et al., 2006) and *Bos taurus* (Muller and Keyserlingk, 2006) beef cattle. The lack of significant correlation between MMD means (which is proportional to the animal's weight) and strain forces indicate that the force exerted by the steer is not influenced by minor body weight (± 19 Kg) fluctuations. Fordyce et al. (1988) also could not find a consistent relationship between live weight and temperament. Schwartzkopf-Genswein et al. (1997) showed that animals habituate to the handling chute on repeated exposure. In another study, Piller et al. (1999) observed that animal movement recorded on a weigh scale using MMD decreased over a period of five/ten consecutive days. In my study handling treatments, which were spaced two months apart, did not appear frequent enough to cause habituation. But in a similarly spaced experiment Curley et al. (2006) demonstrated a decrease in subjective and objective measures over the three time points. Interestingly the study animals showed increases in response over time, which could possibly be due to the fact that the animals were oblivious of the previous experience because of the time lag. Another plausible reason for this type of response is due to the maturational changes (including major body weight changes) occurring in the study animals during this period. Or it could also be the result of combined effects of elements from the above two explanations. A possible explanation for the significantly lower subjective and objective measure responses in the first set of evaluations is due to the energy expenditure and other physiological changes taking place in the animals due to travel from auction markets and 'processing' at the feedlot. Though the animals might have forgotten the previous handling experience, the impact of bleeding one month before the second data collection may have lingered. This is corroborated by the fact that they showed increased response during the second evaluation series as evidenced by more MMD peaks, higher absolute strain forces and lower exit times when compared to first sets of tests. It is clear from the SG SD distribution chart that more animals migrated subsequently from 'lower force region' to 'higher force region' (Fig. 3.9). Subsequent evaluations of absolute strain force also see more animals migrating higher on the 'strain force scale' (Fig. 3.10). We can see only fewer animals in the lower scales of MMD SD during subsequent evaluations (Fig. 3.11). While there were 22 animals showing '0' peaks during the first set of evaluations there were none with '0' peaks during the subsequent evaluations (Fig. 3.12). Though more animals were expected to show higher exit times (slow pace) during subsequent evaluations, the trend is ambiguous (Fig. 3.13). Of the subjective observations from 394 animals, 63.71% of the animals showed consistency in reactivity for all 3 sets of evaluations. The proportion of animals that were consistently calm was more than twice as that of the animals that were consistently wild (Table 3.6). But more studies are required to substantiate the finding of this experiment that calmness, as a temperament trait, is more consistent than wildness. The results of PCA analysis (Table 3.8) when complemented with other results (Table 3.4 and Table 3.7) indicate that these objective measures may be measuring slightly different aspects of beef cattle temperament even though there is certain degree of commonality between what is measured by these objective tools.

Temperament measures of beef cattle based on subjective means have already been reported to be consistent over time (Grandin, 1993). The relationships between strain gauge values, MMD measures, exit times and the subjective scores of all the three sets of evaluations, show that these objective measures are consistent across time as well during the periods of an animal's development and are as reliable as subjective scores. However, it is believed that the objectivity of these measures makes them better candidates for assessing temperament for genetic selection and ethological studies. Boivin et al. (1992b) suggested that objectivity of the temperament test may be compromised by 'observer bias'. But Lyons (1989) suggested that subjectivity element or observer prejudice is unavoidable in behaviour studies and that mechanical instruments used in behaviour research could not give holistic information on animal temperament. The test clearly showed that there is inter-individual behavioural variability and within individual consistency/repeatability in their manifestation of 'temperament' irrespective of the tests used. Put in other words, the unevenness of animals' response was moderately consistent across time for three sets of temperament evaluations. Though behavioural and maturational changes are taking place in an animal over time, there is a certain degree of stability in this change and this 'enduring property in an animal's constitution' is called temperament (Lyons et al. 1988a). Though Burrow and Corbet (2000) could not find any correlation between subjective and objective measures this study could clearly demonstrate shorter exit times for wild as compared with calmer animals. Findings of this study are consistent with Curley et al. (2006) who obtained positive correlations between exit velocity and chute score (subjective) in Brahman animals. Kilgour et al. (2006) suggested that exit time corresponds to an animal's response to previous treatment i.e., restraint .The significant differences between 'calm' and 'wild' animals in their objective measures support our belief that we are measuring the same intrinsic attribute of these animals whether we use objective or subjective means. This stable individual trait (Grandin, 1997) constitutes an animal's "excitatory or inhibitory reactions, level of motor activity, persistent habits, emotionality, alertness, etc." (Hurnik et al., 1995). Individual differences in behaviours such as escape, fearfulness, freezing, aggression, docility (Burrow, 1997), and avoidance, alertness, boldness, hesitation and environmental surveillance (Lyons, 1989) have been termed either as temperament (Kilgour, 1975) or personality (Gosling and John, 1999). Nervousness, quietness, excitability, individuality, libido, constitution and emotionality are the specific terms used by Stricklin and Kautzscanavy (1984) to describe temperament. However, although many authors agree, qualitatively, on the behavioural expressions of temperament, the term itself still escapes a concise definition. Though there has been considerable research on the concept of animal temperament, it is still obscure, as there is ambiguity as to whether what we are measuring is what we are describing. Although temperament, disposition or mood of the animal can be the way it reacts or 'behaves' in a particular environment, the behaviour of an individual probably reflects underlying personality traits of that particular animal. Erhard and Schouten (2001) suggested that a behaviour should be consistent in order to describe it as a measure of personality. Though an animal's individual characteristic is stable it may not be the result of a single controlling factor but it could be modulated by many interacting components (Reenen et al., 2004). Similarly, lack of significant correlation between measures of behaviour obtained in social and non-social situations indicate that these behaviours are not modulated by a single mechanism (Lawrence et al., 1991). All these suggest that the term temperament or personality should be used to denote differences in a combination of many behaviours instead of a single character trait. So an encompassing or comprehensive definition of temperament appears to be more suitable than an exclusive one which focuses only on a single behavioural trait. The traditional terms of definition of temperament as reaction to being handled should in future be extrapolated or generalized to develop a working empirical definition of temperament that incorporates most of the responses of animals in their behavioural repertoire.

Significant increase in the body weight gain of calm animals were consistent with the findings of Burrow and Dillon (1997), Voisinet et al. (1997b) and Petherick et al. (2002) suggesting again that selection for calmer temperament may also have a beneficial effect on production in addition to its effects on welfare and ease of handling. Other studies also have found correlation between temperament and productivity. For example, goats which showed exaggerated responsiveness (temperament) also had trouble in milk let-down (Lyons, 1989). Evidence from the study in pigs (Hemsworth et al., 1990) also suggest that temperament measured as fearfulness towards humans may negatively impact reproductive function. Similarly Van Erp-van der Kooij et al. (2000) found positive correlation between lean meat yield and temperament scores in pigs. As opposed to this Mendl et al. (1992) reported higher initial body weight gain and reproductive performance of pigs with aggressive temperaments when compared to less aggressive ones. The lack of significant relationship between exit time and ADG was surprising as Burrow and Dillon (1997) and Petherick et al. (2002) have shown that exit speed based temperament measures can be used as a performance predictor. Whether this discrepancy reflects a species difference between *Bos indicus* and *B. taurus* cattle, or to other parameters of the experiment is to be further examined. It is also possible that the exit time measurements might be confounded by the difference in the footing conditions on the race due to the variable weather conditions over three time points. Muller and Keyserlingk (2006) also could not find a clear relationship between exit speed and ADG. In another study Petherick et al. (2003) found a negative correlation between flight speed and ADG. Furthermore, the significant relationships between MMD values and backgrounding performance indicate that this tool can replace subjective measures in assessing temperament and predicting performance. The data also show that the strain gauges can be consistently used as a temperament measure though we need more study to determine whether, or how, they can be used to predict performance. Lack of consistency of some of the measures in this study could be due to the subtle interactions that is taking place between the animal and the environment over time (Boissy, 1995). Absence of significant relationship between temperament measures obtained during backgrounding and finishing feedlot performance may indicate that temperaments of animals assessed in one social and environmental situation can not be replicated in an entirely different setting.

4 ASSESSMENT OF REACTION OF BEEF CATTLE TO A NOVEL STIMULUS

4.1 Introduction

Novelty tests are often designed to measure the reactions of animals individually in a separate testing arena with or without the presence of a discrete stimulus. Animals response to such novel stimuli is considered as a measure of their temperament (Lanier et al., 2000). Sometimes referred to as ‘open-field tests’, such experiments may in fact be measuring the animal’s search for conspecifics (Le Neindre, 1989) fear, exploration (Munksgaard and Jensen, 1996) or any one of these behaviours. Boissy and Bouissou (1995) used a variety of tests to measure an animal’s response to novelty (Table 2.2). However, their animals and the animals used in other researchers’ tests might have shown a response which could be a result of the novel environment, novelty of the testing apparatus (Schrader, 2002), the effect of separation from conspecifics (Munksgaard and Simonsen, 1996; Veissier and Le Neindre, 1992), handling (Munksgaard and Jensen, 1996) or any one or combination of these novel exposures. Because of these problems Herskin et al. (2004) suggested that reactivity in novel environment does not correspond well to how they respond in their natural environment. But temperament testing in home pen is also not without problems. Since environmental familiarity may tone down an animal’s response to the test, it may be difficult to pick up treatment differences.

I am not aware of novelty tests, using beef cattle, that were conducted in the home environment without the confounding effects of handling. However, Herskin et al. (2004) and Schrader (2002) conducted novelty test with dairy cattle with “minimal situational novelty” in the home environment. Also, Veissier and Le Neindre (1992) eliminated the confounding effect of separation from conspecifics by testing them in groups. Veissier and Le Neindre (1992) demonstrated that Aubrac heifers tested singly and in groups differed significantly in their reactivity to novelty and isolated heifers readily responded to novelty more than cattle tested in groups. Herskin and Munksgaard (2000) tested the reactivity of dairy heifers to novel food in their home environment without handling and without altering the social situation. They thought that such a test will yield a better measure of reaction to a specific novel stimulus compared to traditional open field tests which often evoke reactions due to the disruption of social environment and the novelty of the surroundings.

A test was designed to measure beef cattle's reaction to a novel stimulus in their home pen, in the presences of pen mates, without altering the social set-up and without any human presence or handling during the testing time. The test had no situational novelty, and no confounding effects due to an alteration of the social environment and handling. Since the animals were handled by the experimenters in the first study (Chapter 3) a need was felt to develop an alternative method to assess temperament of the same animals when not in the presence of people. The test was voluntary, in that the animals were free to interact or not with the testing apparatus. The objectives were to measure the reaction of beef cattle to a novel situation and to look for correlations between measures of novelty and measures of temperament from the previous handling study conducted on the same animals (Chapter 3). I was also interested in whether the animals that participated in the voluntary novelty test were different from those that failed to interact with the novelty apparatus. In general it was hypothesized that an animal's reactivity to novelty in its home pen when not in the presence of people is related to other measures of temperament obtained during handling and restraint.

4.2 Animals, materials and methods

Two hundred and sixty two steers that were a subset of 400 steers housed at the University feedlot, as part of a larger temperament-genetic study, were exposed to a novelty test. Approximately 33 animals were housed in each of 8 pens. The novelty test was conducted between 0900 and 0600 hrs in all 8 pens on consecutive days from April 24 to May 1 in 2006.

In the corner of the pen was placed a salt feeder, constructed from two plastic upright barrels attached one above the other with a side opening in the top barrel at the same level as the animal's head into which a steer could easily insert and withdraw its head. A tennis ball suspended from the ceiling of the barrel could be raised or lowered with the help of a string which was remotely controlled by an experimenter hidden within a nearby farm shed. A salt block was placed inside the novelty apparatus to attract animals to investigate it (Fig. 4.1). The animals were observed by the experimenter via a monitor (using a split screen). Continuous

Fig. 4.1. Experimental set-up showing the salt feeder and a steer tentatively approaching the salt feeder for the first time

observation was employed. The remote controlled tennis ball was released (dropped from the ceiling) in front of animal's face one minute after the animal started licking the salt. A steer was considered to be licking the salt when its muzzle was in contact with the salt. Steers were free to visit the apparatus multiple times and the "ball drop" treatment was applied for each visit. The steer's behaviour was videotaped using two cameras (Panasonic Model WV-BL 200); one positioned 5m above the pen to record the distance an animal retreated from the salt feeder after the ball drop and the other camera mounted near the side of the salt feeder to determine the individual identification number on the animal's ear tag and whether the animal was licking the salt. The cameras were connected to a monitor through a VCR and a video quad unit (Panasonic Model WJ-MS 424) which displayed images from both the cameras on a single monitor. Digitization and analyses of the video footage were carried out using Northern Eclipse image analysis software package (Version 6.0) where the distances measured in pixels were converted into metric units. This was done by equating the distance in pixels with the measured distance (m) of a measuring rod that had been videotaped in the pen near the salt feeder at the start of test on each day. The major dependent variables of interest were whether or not each animal in the pen participated in the test, the distance backed up in its startle reactions, the latency to react to the stimulus a second time and the number of times a steer was "tested" at the salt feeder. The average distance moved by the animals was also calculated. Rushen (1986) observed that the more the degree of aversion to stimuli the higher the 'cost' the animal will be ready to incur for the purpose of avoiding the stimuli. In this study, the cost involved could be the energy expended for moving to a safer place from the source of danger (novel stimuli). Hence it is hypothesized that the distance moved by the animals from the novelty apparatus is a measure of animal's reaction to novelty. It is also proposed that the latency to interact with the apparatus the second time and the number of such interactions are indicative of a calmer disposition, lack of fear and favorable temperament.

In this experiment salt kept inside the salt feeder is proposed to act as positive reinforcement whereas dropping ball is hypothesized to be aversive. This would result in a conflictual situation between their motivation to eat and the fear of novelty (Romeyer and Bouissou, 1992; Boissy and Bouissou, 1995; Herskin et al., 2003). It was proposed that those animals whose motivation to lick the salt and attractivity to novelty, overcome their aversion to fear stimuli (swinging ball), will continue to visit the salt and hence their reactions could be measured repeatedly. The data obtained from this study were compared with the results of other types of temperament measures already gathered from this group. It was also examined if there is any difference in objective, subjective and novelty measures of animals that visited the apparatus once and those that visited at least 10 times. The animals' performance data were also compared with the novelty measures to check for any significant relationship between these two variables.

4.3 Statistical analyses

One hundred and twenty observations from a total of 774 were dropped because of uncertainty in establishing the animals' identities. As the data were not distributed normally and variances were not constant, non-parametric statistics were used in SAS. In the previous study of these same animals (Chapter 3) temperament was subjectively assessed on a 1-5 scale during headgate restraint. The animals were grouped into 'calm' and 'wild' based on their subjective scoring (scores 1 and 2 = calm, scores>2 = wild). Chi-square analysis on the 3 dimensional contingency tables were used to test whether investigation/lack of investigation of the salt apparatus occurred independently of animal's calm/wild subjective temperament score and pen number. Differences of subjective scores/objective measures of animals that participated in the novelty test and not participated were examined on ranked data using the Friedman's Two-way non-parametric ANOVA. Whether calm and wild animals differ in their novelty measures was also tested using the same test. For assessing the relationships between previous objective temperament measures and present novelty measures Spearman's correlations were calculated between them. Spearman's correlations were also calculated between novelty measures. In order to compare the first response of animals to the subsequent responses a PROC MIXED model was used to analyze repeated measures using AR (1) (first order auto regressive) as the best fit covariance structure. Any difference in objective, subjective and novelty measures of animals that visited the apparatus once and at least 10 times were examined using Friedman's Two-way ANOVA. The relationships between novelty measures and backgrounding ADG, finishing ADG and hot carcass weight were also examined in SAS (PROC MIXED) using the same model that was used to test the relationship between these variables and handling measures (see the statistics section of the first study).

4.4 Results

4.4.1 Response of 'calm' and 'wild' animals to novelty

Ninety-six animals from a total of 262 in the 8 pens participated in the novelty test. It was tested whether investigation/lack of investigation of the salt apparatus occurred independently of animal's calm/wild temperament measure and pen number (Table 4.1).

The Chi-square test was not significant. The null hypothesis is accepted and concluded that investigation of the novelty apparatus occurred independently of animal's subjective temperament measure and pen number. But it is to be noted that, when the animals' salt investigation characteristics are compared to the third set of subjective scores, the model 'tended towards significance' as indicated by nearly equal values of calculated Chi-square statistic and critical value.

4.4.2 Subjective scores of participating and non-participating animals

It was also tested whether participation in the novelty test occurred independently of an animal's raw subjective temperament measure and pen number (Friedman's Two-way ANOVA). There was significant difference between the median subjective scores of animals that participated from the non-participants ($P<0.001$) for the third set of handling measurement. There was a significant pen effect ($P = 0.02$) on subjective score of participants and non-participants of novelty for the second set of handling study.

4.4.3 Objective measures of participating and non-participating animals

When the objective measures of participating and non-participating animals were compared, among the 15 objective measures only 3 sets (i.e., the third set of SG SD measures ($P<0.05$), absolute strain force measures ($P<0.05$) and second set of median exit time measures ($P<0.01$)) differed between the participating and non-participating groups (Table 4.2). The effect of pen was found to be significant for third set of absolute strain force evaluation ($P<0.01$), first set of MMD SD ($P<0.05$), first and third set of MMD peaks ($P<0.05$, $P<0.001$ respectively) and first set of exit time evaluations ($P<0.05$).

Table 4.1. Three dimensional (2 X 8 X 2) contingency table used for Chi-square analysis showing the relationship between presence or absence of salt investigation, ‘calm/wild’ subjective temperament score and pen number. Observed frequencies of participating and non-participating animals are shown in each cell with expected frequency in parentheses.

Pen		**First Evaluation**		**Second Evaluation**		**Third Evaluation**	
		calm	**wild**	**calm**	**wild**	**calm**	**Wild**
1	**Participants**	12 (10.60)	0 (1.53)	11 (9.95)	1 (2.19)	12 (10.12)	0 (1.89)
	Non-participants	20 (18.22)	1 (2.64)	15 (17.11)	6 (3.76)	18 (17.69)	3 (3.30)
3	**Participants**	15 (10.92)	1 (1.58)	10 (10.25)	6 (2.25)	15 (10.43)	1 (1.94)
	Non-participants	15 (18.78)	3 (2.72)	11 (17.62)	7 (3.87)	14 (18.23)	4 (3.40)
4	**Participants**	8 (10.28)	1 (1.49)	8 (9.95)	1 (2.19)	6 (10.12)	3 (1.89)
	Non-participants	20 (17.67)	3 (2.56)	20 (17.11)	4 (3.76)	17 (17.69)	7 (3.30)
5	**Participants**	9 (10.60)	0 (1.53)	9 (9.95)	0 (2.19)	9 (10.12)	0 (1.89)
	Non-participants	22 (18.22)	2 (2.64)	22 (17.11)	2 (3.76)	18 (17.69)	6 (3.30)
6	**Participants**	8 (10.28)	2 (1.49)	8 (9.65)	2 (2.12)	10 (9.82)	0 (1.83)
	Non-participants	20 (17.67)	2 (2.56)	19 (16.59)	3 (3.64)	18 (17.12)	4 (3.20)
7	**Participants**	11 (9.64)	1 (1.40)	10 (9.05)	2 (1.99)	12 (9.20)	0 (1.72)
	Non-participants	14 (16.57)	4 (2.40)	14 (15.55)	4 (3.42)	15 (16.08)	3 (3.00)
8	**Participants**	9 (10.60)	3 (1.53)	11 (9.95)	1 (2.19)	11 (10.12)	1 (1.89)
	Non-participants	19 (18.22)	2 (2.64)	17 (17.11)	4 (3.76)	20 (17.69)	1 (3.30)
9	**Participants**	13 (10.92)	3 (1.58)	15 (9.95)	1 (2.19)	14 (10.12)	1 (1.89)
	Non-participants	13 (18.78)	5 (2.72)	14 (17.11)	3 (3.76)	11 (17.69)	7 (3.30)
Calculated χ^2 statistic		**19.27**		**25.44**		**32.27**	
Critical value of $\chi^2_{0.05, 22}$				**33.924**			

Table 4.2. Relationships of objective measures of steers that investigated the apparatus from those not investigated (Friedman's Two-way ANOVA)

	Evalu-ation	Participants	Non-participants	*P*-value
SG SD (mV)	1	252.53 (172.39-331.31)	230.60 (148.34-315.40)	0.21
	2	285.54 (207.59-398.09)	318.41 (210.75-414.14)	0.26
	3	354.40 (248.77-491.34)	399.51 (299.55-547.66)	0.03*
Absolu-te Strain Force (mV)	1	77609 (37910-105918)	76083 (46101-119817)	0.25
	2	127031 (92475-157218)	124222 (93035-166757)	0.50
	3	74544** (41536-113015)	85076 (51319-124655)	0.02*
MMD SD (mV)	1	1.05** (0.82-1.45)	1.05 (0.79-1.46)	0.89
	2	2.14 (1.61-2.52)	2.23 (1.65-2.81)	0.16
	3	2.27 (1.68-2.67)	2.32 (1.85-3.12)	0.06
MMD Peaks	1	14** (6-29)	13.5 (5.75-30)	0.99
	2	50 (31-83)	55.5 (31.75-92.25)	0.32
	3	56** (27-76)	59.5 (28.75-105.5)	0.06
Exit Time (s)	1	3.27** (2.80-4.09)	3.3 (2.82-3.99)	0.71
	2	2.7 (2.33-3.27)	2.48 (1.97-3.05)	0.008*
	3	3.31 (2.68-4.14)	3.03 (2.14-5.02)	0.23

The values are expressed as medians and corresponding interquartile ranges.
** 3rd set of absolute strain force, 1st set of MMD SD, 1st and 3rd set of MMD peaks and 1st set of exit time measurements showed significant (P<0.01, P<0.05, P<0.05, P<0.001 and P<0.05 respectively) variation due to pen between participating and non-participating group.
* There was a significant difference (P<0.05) in the median values of objective measures of animals that investigated the apparatus from those not investigated.

4.4.4 Novelty measures of 'calm' and 'wild' animals

Comparisons were also made between the novelty measures of calm and wild animals (Table 4.3). There was no significant difference in the distance backed up by the calm and wild animals when their first reaction was taken into account. But the pen effect was found to be significant ($P<0.001$). This was true for all the three sets of subjective score measurements. Likewise, there was no significant difference in the median number of responses of calm and wild animals. This was also true for all the subjective score ratings. Similarly there was no significant difference of calm and wild animals in the latency to return to the novelty apparatus the second time after the first sudden exposure to novelty. Calm and wild animals also did not differ in their average distance moved when all their reactions were considered. But there were significant variations due to pen ($P<0.001$).

4.4.5 Correlations between temperament measures and novelty measures

Table 4.4 shows the correlations between temperament measures and novelty measures. Of 60 correlations only 3 were significant.

4.4.6 Correlations among novelty measures

Coefficients of correlations were also calculated between novelty measures namely the distance backed up during the first response, latency to return to the novelty apparatus the second time, number of responses and the average response (Table 4.5).

4.4.7 Habituation

The PROC MIXED model compared the first response of animals to the subsequent responses and the overall reduction in distance backed up as the response number increased, was significant at 0.05 level. The data were blocked for pen and the pen effect was also found to be significant ($P<0.05$). The number of animals that visited the novelty apparatus repeatedly also declined steadily (Table 4.6). The above table also shows the *P*-values representing the significance of the difference between individual measurements and the distance backed up during the first response. The shaded region of the graph representing the reduction in response (Fig. 4.2) shows irregular peaks which may be an artifact of the experiment as the number of

Table 4.3. Relationship between different measures of reactivity of animals to the novelty apparatus and subjective temperament rating undertaken at an earlier occasion (Friedman's Two-way ANOVA)

Evaluation		**Distance backed up on 1st response (cm) n = 96**	**No. of responses n = 96**	**Latency to return (s) n = 62**	**Average distance[a] (cm) n = 96**
1	**calm**	43.33* (26.32-69.22)	5 (2-10)	120 (60-165)	44.84* (26.81-65.80)
	wild	42.04 (28.77-61.20)	6 (5-9)	60 (60-210)	51.28 (37.70-56.27)
2	**calm**	48.81* (27.13-69.12)	5 (2-11)	120 (60-180)	46.52* (29.90-64.19)
	wild	34.42 (23.48-52.64)	4.5 (1.75-7)	60 (60-120)	40.81 (26.71-58.10)
3	**calm**	43.56* (26.36- 69.22)	5 (2-10)	120 (60-120)	45.08* (28.13-64.54)
	wild	37.33 (25.76-61.84)	7.5 (4.75-18)	60 (60-180)	42.61 (35.19-54.62)

All the measures are expressed as median and IQR.
*Significant variation in response of calm and wild animals due to the effect of pen (*P*<0.001).
Treatment effect was not significant for any of the variables described above.
[a] Takes into account all the responses of animals.

Table 4.4. Correlation between objective measures and the distance backed up during the first response, number of responses and latency to react to the salt the second time and the average distance backed up

	Evalu -ation	Distance backed up on 1st response n = 96	No. of responses n = 96	Latency to return n = 62	Average distance[a] n = 96
SG SD	1	-0.04	-0.001	-0.14	0.12
	2	-0.04	-0.06	-0.23	0.04
	3	-0.04	0.30*	0.12	-0.04
Absolute Strain Force	1	-0.01	0.14	-0.06	0.07
	2	0.02	-0.14	0.02	0.11
	3	-0.10	0.18	0.03	-0.10
MMD SD	1	-0.23*	-0.01	-0.19	-0.01
	2	-0.02	0.08	-0.20	0.04
	3	-0.14	-0.001	-0.20	-0.04
MMD Peaks	1	-0.20	-0.01	-0.15	0.02
	2	-0.14	0.10	-0.27*	-0.10
	3	-0.17	0.003	-0.14	-0.05
Exit Time	1	-0.02	-0.06	0.12	-0.10
	2	0.07	-0.09	0.23	0.02
	3	0.13	0.03	0.15	0.01

* $P<0.05$

[a] Takes into account all the responses of animals.

Table 4.5. Correlation coefficients of different measures of novelty

	Distance backed up on 1st response n = 96	**No. of responses n = 96**	**Average distance[a] n = 96**
Distance backed up on 1st response n = 96	N/A	-0.04	0.79***
No. of responses n = 96	N/A	N/A	-0.24*
Latency to return n = 62	0.33**	-0.13	0.26*

* P<0.05, ** P<0.01, *** P<0.001
N/A- not applicable
[a] Takes into account all the responses of animals.

Table 4.6. Mean (± S.E) responses of steers to the novelty apparatus (PROC MIXED was used to analyze repeated measures)

Response No.	Mean ± S.E (cm) distance backed up	No. of animals participated	Significance level of reduction in subsequent responses compared to the first response
1	51.30 ± 5.88	96	-
2	51.13 ± 5.85	78	0.96
3	47.67 ± 5.96	65	0.34
4	45.88 ± 6.04	58	0.17
5	46.42 ± 6.10	53	0.23
6	44.89 ± 6.22	46	0.13
7	40.60 ± 6.44	37	0.02
8	42.80 ± 6.53	34	0.07
9	36.34 ± 6.64	31	0.002
10	37.12 ± 6.77	28	0.005
11	37.30 ± 7.14	22	0.01
12	35.58 ± 7.39	19	0.007
13	36.03 ± 7.73	16	0.01
14	37.15 ± 8.20	13	0.04
15	39.46 ± 8.62	11	0.10
16	39.80 ± 9.58	8	0.17
17	42.32 ± 9.58	8	0.29
18	29.44 ± 11.42	5	0.04
19	31.41 ± 12.48	4	0.09
20	35.76 ± 12.48	4	0.18
21	23.42 ± 14.09	3	0.04
22	31.75 ± 14.09	3	0.14
23	38.39 ± 14.09	3	0.33
24	38.86 ± 14.09	3	0.35
25	28.53 ± 16.87	2	0.16
26	32.23 ± 16.87	2	0.24
27	27.16 ± 16.87	2	0.13

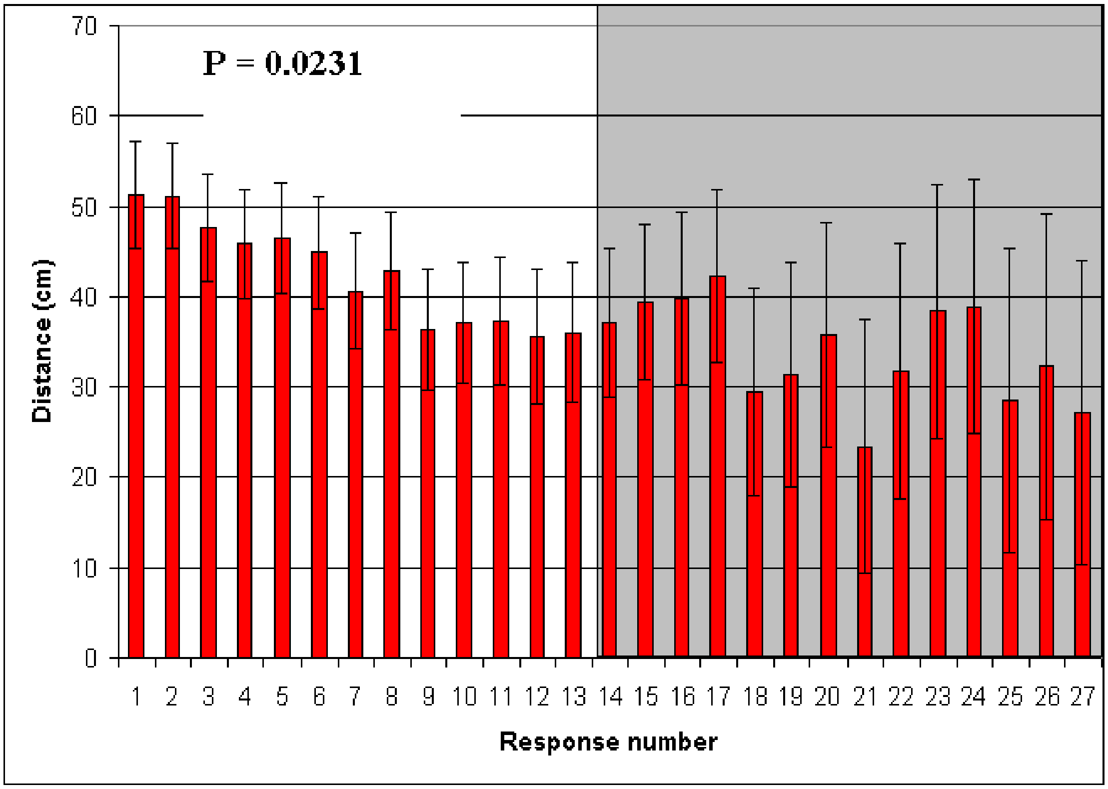

Fig. 4.2. Chart depicting progressive reduction in response of steers housed in home pen to novelty over time. There was a significant reduction (*P* = 0.0231) in subsequent responses of steers. Sample size representing the shaded region of the chart is much less (Table 4.7) and hence less robust than that of the unshaded region.

animals representing this region of the graph (i.e., those responded repeatedly) is much less. But the unshaded region of the chart is more robust as the sample size representing this region is relatively higher.

4.4.8 One time participants vs. multiple time participants

When differences were tested between one time participants and multiple time participants, except for the average response (distance moved) to novelty ($P = 0.04$), there weren't any differences in objective, subjective and novelty measures of animals that visited the apparatus once and those that visited at least 10 times (Table 4.7).

4.4.9 Novelty and production

The study also tested the relationship between measures of novelty and ADG during the backgrounding and finishing periods, and hot carcass weight of the animals. Participation or non-participation in novelty test was not significantly related to their backgrounding ADG or hot carcass weight. During the finishing feedlot period animals which did not participate in the novelty test gained an extra 72 ± 0.03 g per day compared to participants ($P = 0.02$). Distance backed up during the first response to novelty was not significantly related to their ADG during any period in the feedlot or to their hot carcass weight where initial body weight was also included as a covariate in the model. The number of responses to novelty was not significantly related to backgrounding, finishing ADG or hot carcass weight when the initial body weight effects were also accounted. Latency to react to novelty the second time, was also not related to backgrounding ADG. There was a significant reduction ($P = 0.02$) in finishing feedlot ADG with increase in latency to react to novelty the second time after accounting for the effects of initial body weight. Significant reduction ($P = 0.04$) in hot carcass weight with increase in latency to react to the novelty the second time, was also observed. The average distance backed up was not significantly related to backgrounding, finishing ADG or hot carcass weight.

4.5 Discussion

Reaction to a novel stimulus has been used to assess temperament. I wanted to test the steers' reaction to a novel stimulus (dropping ball) without changing their social situation and

Table 4.7. Differences in the subjective, objective and novelty measures of animals that reacted to the apparatus once and more than 10 times (Friedman's Two-way ANOVA)

Variables	**Evalu-ation**	**Reacted only once n = 18**	**Reacted ≥ 10 n = 28**
SG SD (mV)	1	214.11 (119.31-386.13)	228.32 (139.81-329.68)
	2	316.57 (224.45-416.33)	285.54 (161.81-350.66)
	3	327.86 (249.24-409.44)	408.07 (278.73-582.19)
Absolute Strain Force (mV)	1	54168 (22346-129496)	78458 (38380-104310)
	2	145986 (97368-177595)	102587 (76799-167687)
	3	51276 (39852-101504)	82013 (49115-114707)
MMD SD (mV)	1	0.9885 (0.78-1.33)	1.04 (0.86-1.45)
	2	2.15 (1.46-2.63)	2.21 (1.84-2.46)
	3	2.22 (1.56-2.76)	2.36 (1.77-2.89)
MMD Peaks	1	13.5 (5.25-20.5)	13.5 (7.5-29)
	2	51.5 (27.25-84.75)	58 (40.5-80.25)
	3	50 (29.5-74.5)	51 (24.75-80.5)
Exit Time (s)	1	3.38 (2.65-4.42)	3.05 (2.91-4.09)
	2	2.91 (2.42-3.36)	2.69 (2.36-3.27)
	3	2.94*** (2.47-3.95)	3.35 (2.88-3.97)
Subjective Score	1	2 (1-2)	2 (2-2)
	2	2* (2-2)	2 (2-2)
	3	2 (2-2)	2 (2-2)
Distance backed up on 1st response (cm)	-	51.80** (34.31-69.57)	50.43 (25.16-73.6)
Ave. distance[a] (cm)	-	51.8*** (34.31-69.57)	39.69 (25.92-50.91)

Values are expressed as median and corresponding IQR.
Treatment effect was not significant for any of the variables described above except for the average distance backed up ($P<0.05$). The effect of pen was significant at * $P<0.05$, ** $P<0.01$ and *** $P<0.001$ level. [a] Takes into account all the responses of animals.

environmental setting. I also wanted to compare the results of this study which involved no handling to the previous handling study conducted on the same animals. It is proposed that correlated results between these two studies would indicate that 'temperament' measured by these two different tests would probably represent a similar character trait. As there are ample opportunities for animals to get themselves exposed to fearful novel stimuli from the environment, I also wanted to test its relationship with their productivity. Studies of steers' reaction to novelty not only add to our existing knowledge of beef cattle temperament but also help in devising methods to improve their temperament.

4.5.1 Participating vs. non-participating animals

It should be noted that the greatest number of visits to the salt feeder (hence participation in the novelty test) was mainly concentrated in the morning and evening hours with many of the steers resting during the mid day. Though there was no significant difference between the proportion of calm and wild animals that visited the novelty apparatus from those not novelty tested for the first two subjective (calm/wild) evaluations, a 'tendency towards significance' was observed when the last 'calm/wild' measures was used (Table 4.1). Similarly subjective scores of animals that participated in the novelty test and those not participating were significantly different when I compared them to the third set of subjective evaluation. However, there was no difference in the subjective score of animals that visited the apparatus from those not visited for the first two subjective evaluations. Moreover, the relationship between objective measures such as SG SD, absolute strain force , MMD SD, MMD peaks and exit time of animals that investigated the apparatus from those not investigated (Table 4.2) suggests that participating animals do not differ much in their objective measures from the non-participating group. Only 3 out of 15 measures were significant, which could be a chance occurrence. But the median of 8 out of 15 objective measures and the mean of all the subjective measures were higher for non-participants to novelty although most of the measures could not reach statistical significance. However, overall relationship of subjective and objective measures of the participating group from non-participating group (Table 4.1, and 4.2) shows that there is no evidence to support the hypothesis that the animals that did not visit the salt were more afraid of novelty than those visited. Another likely reason for the lack of significant difference could be that all the animals in the pen were not aware of the presence of the novelty instrument as they are not individually exposed to it.

4.5.2 Novelty measures vs. objective/subjective measures of participating animals

Lack of significant difference in the distance moved in the first response, number of responses, latency to return to the apparatus the second time and average response between calm and wild animals (Table 4.3) indicates that subjective measures of temperament taken from these animals in a different context at an earlier occasion were not related to measures of novelty in general. When correlation of objective measures such as SG SD, absolute strain force, MMD SD, MMD peaks, exit time of animals and novelty measures were calculated, all the correlations were weak and only 3 out of 60 correlations were significant (P<0.05) (Table 4.4) which could be dismissed as a chance occurrence. This means that the objective handling responses measured on these animals at the chute were not related to their measures of novelty in their home pen.

Lack of significant correlations between novelty measures and temperament ratings based on other objective and subjective measures could be that in the novelty test we might be measuring only the 'fearfulness' (Boissy and Bouissou, 1995) component of the temperament and in other objective and subjective tests we could be measuring a combination of behaviours in an animals' repertoire. How the animal perceives a novel stimuli depends on the species (Vandenheede et al., 1998) and rearing conditions (Moberg and Wood, 1982) of the animal, abruptness, familiarity, expectations (predictability) (Scherer, 2001), strength, length, nearness of the stimuli and physical conditions of the testing situation (Boissy,1995). So the 'dropping ball' stimuli can be deemed novel in terms of suddenness and lack of familiarity and predictability during the first exposure.

4.5.3 Novelty measures: Relationships

The negative relationship between number of responses and average distance backed up (ρ = -0.24) may be explained as a result of the cattle habituating to the dropping of the ball. Over time they become less startled, conserve energy and retreat a shorter distance from the dropped ball as the frequency of visits to the salt apparatus increases. A similar but non-significant relationship was also visible between the number of responses and distance backed up during the first response. A negative relationship (although weak and non-significant) between the distance backed during the first response and the number of responses may indicate that those animals backing up a greater distance during their first response were apparently more startled and less likely to have a high number of visits. Similarly more latency on the part of animals to return to the novelty apparatus proportionate to the distance backed up during the first response and average distance also follows the same principle that those animals showing the greatest startle response (i.e., moved back the greater distance on the first and subsequent exposures) had a higher latency before returning to the salt. The high correlation ($\rho = 0.79$, $P<0.001$) between the distance backed up during the first response and the average distance backed up (which take into account all the responses) shows that animals have some consistency in their behavioural response to the apparatus.

The habituation to the stimuli (Table 4.6, Fig. 4.2) during subsequent exposure can be explained in terms of an increase in familiarity and predictability of the stimulus even though the 'suddenness' component of the stimulus remained the same. Habituation of beef cattle to fearful stimuli such as noises has previously been reported (Waynert et al., 1999). Wood-Gush and Vestergaard (1991) demonstrated in pigs that response to novelty waned over time due to reduction in the novelty value of stimulus to the animal. In contrast with the finding of this study, Archer (1973) suggested that, due to the effect of variables that can not be strictly regulated in the test situation, the reduction in response to novelty may not always be steady. Inability to pick up significant difference of objective, subjective and novelty measures between one time participants and multiple time participants (Table 4.7) shows no evidence that 'one time reactors' are more 'temperamentally difficult' than 'multiple time reactors'. Though the average response of one time responders significantly differed from multiple time responders, other objective measures and novelty measures are not supportive of this finding so as to draw a definitive conclusion.

4.5.4 General interpretation

There were only 3 measures (participation or non-participation and latency) out of a total of 15 possible comparisons that were significantly correlated to production parameters. Hence the overall relationship of reaction to novelty to productivity in this study is ambiguous or weak. This is in contrast with the finding in pigs where Rasmussen (1991) observed depressed rate of growth of animals that were showing more exploratory behaviour. Negative relationship between fear and production parameters has also been observed in poultry (Hemsworth and Barnett, 1989; Barnett et al., 1992). The absence of relationship between measures of the handling study and the novelty study could be that the handling study was undertaken in a non-social context where as the novelty study was carried out in a social context in their own home pen. Consistent with this Lawrence et al. (1991) also could not find any correlation between tests undertaken to assess temperament in social context (feeding competition test) and in non-social context (response to human handling) in pigs. The study also supports the finding of Hemsworth et al. (1996) that animals' response to a challenging situation is 'stimulus specific'. The study found that the response to novelty in pigs is different from response to humans. Behavioural tests employed by Spoolder et al. (1996) in pigs failed to show correlations between different situations. Likewise, Herskin et al. (2004) also could not obtain any consistency in the behavioural reactivity of dairy cows exposed to novel food, novel object and unfamiliar person. Boissy (1995) suggested that generalization of measures of animal's reactivity from one situation to another is unfeasible and that the results obtained from one experimental context is applicable only to that context. But Romeyer and Bouissou (1992) could obtain correlated measurements of 'fear' in sheep between tests within the same testing situation. These authors have pointed out that when food is offered as part of testing procedure to assess reaction to novelty (fear), there will be a motivational conflict between food and fear. In my experiment, the provision of salt amidst a frightful stimulus might also have created a conflict testing situation. It is possible that some animals in my experiment had their appetite for salt overtaken by their fear of the stimuli or vice versa, influencing the number of times they visited the apparatus, the distance they retreated and the latency they took to return.

Though the objective of the test was not comparing the reaction of steers in presence of conspecifics and individually, the fact that the relationship between handling measures and novelty measures of animals could not reach statistical significance, could be due to the so called 'social buffering' effect of companion animals. Research with dairy heifers (Boissy and Le Neindre, 1990) and poultry (Jones, 1983) also show that frightening (novel) stimuli produced less behavioural agitation when they are with their group-mates than tested alone. This means that in my study, the novelty value of the testing apparatus as well as the social environment may have dampened the steers' response.

The results of the study do not support the hypothesis that temperament measured as reaction to handling and reaction to novelty are correlated. The results contrast with the findings of Lawrence et al. (1991) in pigs, who obtained good correlations of temperament measured as reaction to handling and reaction to novelty. This discrepancy may be due to the difference in the social context of their study and ours. Lawrence et al. (1991) carried out the novelty test in a separate pen after isolating the test animal. Likewise, the lack of apparent correlation between novelty test measures conducted in the home environment and other objective measures undertaken at the handling area may be attributed in part to the difference in the social situation in my study. The findings of the study support the observation made by Herskin et al. (2004) in that the response to novelty will be toned down if the animals are tested in the home environment. Part of reason for the lack of correlation could be due to the difference in handling treatment received. In my first study (Chapter 3) all the animals were handled and the animals could see the experimenters during 2 types of measurements. But in the novelty experiment, animals were neither handled nor could they see or hear the experimenters. Bovin and co-workers (1992) also found no correlation between measures that involved handling cattle (in a corner) and no handling (open-field test). Kilgour (1975) could not find any correlation between subjective dairy temperament ratings obtained during handling and open-field test scores (novel arena, no handling). Boissy and Bouissou (1988) also could not demonstrate a clear relationship between tests that involved human contact and open-field tests which involved no handling (novel arena). Another reason that may be attributed to the lack of correlation is the difference in the nature of stimuli to which the animals are exposed. While the 'squeeze chute experiment' provided constant physical stimuli for the cattle, the 'novelty experiment' provided only a sudden stimulus. Lanier et al. (2000) observed that an abrupt, periodical stimulus is more likely to produce a heightened reaction in cattle compared to steady unvarying stimuli. Erhard and Schouten (2001) have suggested that, with respect to an animal's reactivity, consistency within the test situation is more important than consistency across test situations. Taken together, the results suggest that there is no evidence that 'temperament' measured as reaction to handling in the handling experiment and 'temperament' measured as reaction to novelty in the 'novelty experiment' are one and the same trait. Another surprising finding of the study is that, for most of the novelty observations, pen effect was significant. It seems possible that the difference in the physical conditions of the pen may have contributed to this finding. The study was conducted in the pens during the 'mud season' (after the spring thaw) and it is cautioned that the results might be confounded by the difference in the amount of mud in the pen. Also the day of the test and the pen are confounded, since only one pen of cattle was tested per day. It is possible that the environmental factors of the day (i.e., temperature, cloudiness, etc.) combined with the conditions of the pen may have resulted in the "pen effect" which may have little bearing on the overall influence of the temperament of the animal and its reaction to novelty. Also, the fact that only 37% animals from 8 pens participated in the novelty test is perhaps because of the 9h time limit set for testing each pen. It is also possible that the difference in the steer's appetite for salt might have confounded the results.

5 GENERAL SUMMARY AND CONCLUSIONS

The two studies in this thesis afforded the opportunity to characterize different under-explored areas of beef cattle temperament. The review and study discussion points towards developing an integrated approach to the idea of cattle temperament as opposed to viewing temperament solely as the responsiveness of cattle during handling. The first study presented in Chapter 3 collected 15 dependant variables from the same animals using 3 objective instruments. This study stands in contrast to other studies in that mechanical measures were used to assess behavioural activity. The objective measures yielded slight to moderately correlated results within the evaluation series and across repetitions, and therefore may quantify related aspects of a personality trait (i.e., temperament). The objective scores are related to the traditional subjective score, but they provided the advantage of eliminating observer bias and may offer better tools for temperament selection. Also, objective techniques are generally preferred as far as possible in scientific research due to their unbiased nature, repeatability and reliability. Mechanical devices accurately record behavioural data while long periods of behavioural observation can be taxing for experimenters. Subjective and objective methods used in the study measure animals' reactions in the presence of people. But any one specific measure can not be described as the most pertinent to characterize temperament. All these tests measure realms of animal behaviour, which would be collectively termed as 'temperament' although we can not precisely state what aspect of animal temperament is measured by the different tools. The concept of 'temperament' needs to be refined as an attribute of individual cattle that can be evaluated and may be useful in managing their performance, handling and welfare. The scope of temperament research should be widened to include different dimensions of beef cattle behaviour including their handling reactions. Like human personality, which are "systematic and subject to theoretical formulation" (Eysenck, 1967) further research in personality and individual differences in cattle will help define the same purported dimensions of cattle temperament. Furthermore, positive relationship of subjective and objective temperament measures and production parameters present a promising area for future researchers to further cement the validity of this finding with more subjects, varied settings (social vs. non-social, handled vs. non-handled) and ages.

The first study (Chapter 3) did not find any significant relationship between temperament measures and the finishing feedlot performance. But animals which showed less behavioural agitation (as assessed by subjective and objective measures) gained faster during the backgrounding period. Does it mean that maturational and other environmental and social changes taking place over long periods during an animals' development can overshadow their temperamental traits assessed during an earlier occasion even though there is certain degree of consistency in their reactivity over time? Though the first study found consistency in steers' reactivity over a 4 month period, the question about individual consistency and variability over long periods needs further study involving temperament measurements during the backgrounding and follow up measurements during the finishing periods.

Though Chapter 4 in the thesis describes the study on a subset of animals used in the previous study, it gave ample opportunity to correlate the animal's measures of reactivity in the chute with their responsiveness in the home pen. The animals could not be exposed individually to the novel stimulus; nevertheless the novelty test measured the exploratory/search behaviour and startle response of a significant number of animals within the pen. The study did not find any significant variability in animals' response to novel stimuli when comparisons were made to their respective responses during handling. It was concluded that the reactivity of animals measured in the handling complex is not the same as their response to fear inducing novel stimuli in the home environment. However, it was evident from the study that the novel stimulus I provided was aversive to them as they were seen 'working hard' to escape from it though they habituated subsequently. Another interesting area for future study would be to further explore the relationship between reaction to novelty and performance using a great number of animals and giving all the animals a chance to expose themselves to the novelty test.

The results show that a calmer temperament in beef cattle is conducive to productivity. From an industry standpoint, this research might help producers see the value of selecting cattle for calmer temperaments, thereby improving both productivity and welfare. Overall the results of the study parallel with the observations of Boissy and Bouissou (1995) in that research focusing on inter-individual variability in animals' response will open up new vistas of improving productivity and welfare.

6 REFERENCES

Agyemang, K., Clapp, E., Van Vleck, L.D., 1982. Components of variance of dairymen's workability traits among Holstein cows. J. Dairy Sci. 65, 1334-1338.

Aitchison, T.E., Freeman, A.E., Thomson, G.M., 1972. Evaluation of a type appraisal program in Holsteins. J. Dairy Sci. 55, 840-844.

Arave, C.W., Kilgour, R., 1982. Differences in grazing and milking behaviour in high and low breeding index cows. Proc. New Zeal. Soc. An. 42, 65-67.

Archer, J., 1973. Tests for emotionality in rats and mice: A review. Anim. Behav. 21, 205-235.

Ashmore, C., Carroll, F., Doerr, L., Tompkins, G., Stokes, H., Parker, W., 1973. Experimental prevention of dark cutting meat. J. Anim. Sci. 36, 33.

Barnett, J.L., Hemsworth, P.H., Newman, E.A., 1992. Fear of humans and its relationships with productivity in laying hens at commercial farms. Br. Poult. Sci. 33, 699-710.

Beilharz, R.G., Cox, D.F., 1967. Genetic analysis of open field behaviour in swine. J. Anim. Sci. 26, 988-990.

Beilharz, R.G., Butcher, D.F., Freeman, A.E., 1966. Social dominance and milk production in Holsteins. J. Dairy Sci. 49, 887-892.

Bekoff, M., 1977. Mammalian dispersal and the ontogeny of individual behavioral phenotypes. Am. Nat. 111, 715-732.

Benus, R.F., Bohus, B., Koolhaas, J.M., van Oortmerssen, G.A., 1991. Heritable variation for aggression as a reflection of individual coping strategies. Experientia. 47, 1008-1019.

Berlyne, D.E., 1960. Conflict, Arousal and Curiosity. Mc Graw Hill, New York, pp. 78-79.

Blackshaw, J.K., Blackshaw, A.W., Kusano, T., 1987. Cattle behaviour in a saleyard and its potential to cause bruising. Aust. J. Exp. Agr. 27, 753-757.

Blockey, M.A..de B., Lade, A.D., 1974. Social dominance relationships among young bulls in a test of rate of gain after weaning. Aust. Vet. J. 50, 435-437.

Boissy, A., 1995. Fear and fearfulness in animals. Q. Rev. Biol. 70, 165-191.

Boissy, A., 1998. Fear and fearfulness in determining behavior. In: Grandin, T. (Ed.), Genetics and Behavior of Domestic Animals. Academic press, San Diego, pp. 67-111.

Boissy, A., Bouissou, M.F., 1988. Effects of early handling on heifers' subsequent reactivity to humans and to unfamiliar situations. Appl. Anim. Behav. Sci. 20, 259-273.

Boissy, A., Bouissou, M.F., 1995. Assessment of individual differences in behavioural reactions of heifers exposed to various fear-eliciting situations. Appl. Anim. Behav. Sci. 46, 17-31.

Boissy, A., Le Neindre, P., 1990. Social influences on the reactivity of heifers: Implications for learning abilities in operant conditioning. Appl. Anim. Behav. Sci. 25, 149-165.

Boivin, X., Le Neindre, P., Chupin, J.M., 1992a. Establishment of cattle-human relationships. Appl. Anim. Behav. Sci. 32, 325-335.

Boivin, X., Le Neindre, P., Chupin, J.M., Garel, J.P., Trillat, G., 1992b. Influence of breed and early management on ease of handling and open-field behavior of cattle. Appl. Anim. Behav. Sci. 32, 313-323.

Breuer, K., Hemsworth, P.H., Barnett, J.L., Mathews, L.R., Coleman, G.J., 2000. Behavioural response to humans and the productivity of commercial dairy cows. Appl. Anim. Behav. Sci. 66, 273-288.

Broom, D.M., 1988. The scientific assessment of animal welfare. Appl. Anim. Behav. Sci. 20, 5-19.

Brown, W.G. Jr., 1974. Some aspects of beef cattle behaviour as related to productivity. Dissertation Abstracts International, B. 34, 1805.

Burrow, H.M., 1997. Measurements of temperament and their relationships with performance traits of beef cattle. Anim. Breed. Abstr. 65, 477-495.

Burrow, H.M., 2001.Variances and covariances between productive and adaptive traits and temperament in a composite breed of tropical beef cattle. Livest. Prod. Sci. 70, 213-233.

Burrow, H.M., Corbet, N.J., 2000. Genetic and environmental factors affecting temperament of zebu and zebu derived beef cattle grazed at pasture in the tropics. Aust. J. Agri. Res. 51, 155-162.

Burrow, H.M., Dillon, R.D., 1997. Relationships between temperament and growth in a feedlot and commercial carcass traits of *Bos indicus* crossbreds. Aust. J. Exp. Agr. 37, 407-411.

Burrow, H.M., Seifert, G.W., Corbet, N.J., 1988. A new technique for measuring temperament in cattle. Anim. Prod. Aust. 17, 154-157.

Christensen, J.W., Keeling, L.J., Nielsen, L.B., 2005. Responses of horses to novel visual, olfactory and auditory stimuli. Appl. Anim. Behav. Sci. 93, 53- 65.

Craig, J.V., Adams, A.W., 1984. Behavior and well-being of hens (*Gallus domesticus*) in alternative housing environments. World's Poultry. Sci. J. 40, 221-240.

Curley, K.O., Paschal, J.C., Welsh, J.H., Randel, R.D., 2006. Technical note: Exit velocity as a measure of cattle temperament is repeatable and associated with serum concentration of cortisol in Brahman bulls. J. Anim. Sci. 84, 3100-3103.

Curley, K.O., Neuendorff, D.A., Lewis, A.W., Cleere, J.J., Randel, R.D., 2003. Interrelationship between various measurements of temperament in Brahman cows and their Brahman calves. J. Anim. Sci. 81 (Suppl. 1), 120-121.

Dickson, D.P., Barr, G.R., Johnson, L.P., Wieckert, D.A., 1970. Social dominance and temperament of Holstein cows. J. Dairy Sci. 53, 904-907.

Erhard, H.W., Schouten, W.G.P., 2001. Individual differences and personality. In: Keeling, L.J., Gonyou, H.W. (Ed.), Social Behaviour in Farm Animals. CABI publishing, Oxon, U.K, pp. 343.

Ewbank, R., 1961. The behavior of cattle in crushes. Vet. Rec. 73, 853-856.

Eysenck, H.J., 1967. The Biological Basis of Personality. 2nd ed. Thomas, Springfield, IL, pp. 5-6.

Fell, L.R., Shutt, D.A., 1989. Behavioural and hormonal responses to acute surgical stress in sheep. Appl. Anim. Behav. Sci. 22, 283-294.

Fimland, E., 1984. Progeny testing procedures in Norway. International Dairy Federation Bulletin. 183, 117-132.

Fordyce, G., Dodt, R.M., Wythes, J.R., 1988. Cattle temperament in extensive beef herds in northern Queens land. 1. Factors affecting temperament. Aust. J .Exp. Agr. 28, 683-687.

Fordyce, G., Goddard, M.E., Seifert, G.W., 1982. The measurement of temperament in cattle and the effect of experience and genotype. Proc. Aust. Soc. Animal. Pro. 14, 329-332.

Gonyou, H.W., Hemsworth, P.H., Barnett, J.L., 1986. Effects of frequent interactions with humans on growing pigs. Appl. Anim. Behav. Sci. 16, 269-278.

Gosling, S.D., John, O.J., 1999. Personality dimensions in non-human animals: A cross-species review. Current directions in psychological science. 8, 69-75.

Grandin, T., 1993. Behavioral agitation during handling of cattle is persistent over time. Appl. Anim. Behav. Sci. 36, 1-9.

Grandin, T., 1997. Assessment of stress during handling and transport. J. Anim. Sci. 75, 249-257.

Grandin, T., Deesing, M.J., 1998. Genetics and behavior during handling, restraint, and herding. In: Grandin, T. (Ed.), Genetics and the Behavior of Domestic Animals. Academic Press, San Diego, CA, pp. 113-144.

Grignard, L., Boivin, X., Boissy, A., Le Neindre, P., 2001. Do beef cattle react consistently to different handling situations? Appl. Anim. Behav. Sci. 71, 263-276.

Grignard, L., Boissy, A., Boivin, X., Garel, J.P., Le Neindre, P., 2000. The social environment influences the behavioural responses of beef cattle to handling. Appl. Anim. Behav. Sci. 68, 1-11.

Gupta, S.C., Mishra, R.R., 1978. Temperament and its effect on milking ability of Karan Swiss cows. Proceedings of the XX International Dairy Congress. p. 130.

Gupta, S.C., Mishra, R.R. 1979. Effect of dairy temperament on milking ability of Karan Swiss cows. Indian J. Dairy Sci. 32, 32-36.

Hall, C.S., 1941. Temperament: A survey of animal studies. Psycol. Bull. 38, 909-943.

Hargreaves, A.L., Hutson, G.D., 1990a. Some effects of repeated handling on stress responses in sheep. Appl. Anim. Behav. Sci. 26, 253-265.

Hargreaves, A.L., Hutson, G.D., 1990b. The effect of gentling on heart rate, flight distance and aversion of sheep to a handling procedure. Appl. Anim. Behav. Sci. 26, 243-252.

Hearnshaw, H., Morris, C.A., 1984. Genetic and environmental effects on a temperament score in beef cattle. Aust. J. Agric. Res. 35, 723-733.

Hearnshaw, H., Barlow, R., Want, G., 1979. Development of a "temperament" or "handling difficulty" score for cattle. Proceedings of the Australian Association of Animal Breeding and Genetics. 1, 164-166.

Heird, J.C., Deesing, M.J., 1998. Genetic effects on horse behavior. In: Grandin, T. (Ed.), Genetics and the Behavior of Domestic Animals. Academic Press, San Diego, CA, pp. 203-234.

Heird, J.C., Whitaker, D.D., Bell, R.W., Ramsey, C.B., Lokey, C.E., 1986. The effects of handling at different ages on subsequent learning ability of 2 year old horses. Appl. Anim. Behav. Sci. 15, 15-25.

Hemsworth, P.H., Barnett, J.L., 1989. Relationships between fear of humans, productivity and cage position of laying hens. Br. Poult. Sci. 30, 505-518.

Hemsworth, P.H., Barnett, J.L., Hansen, H., 1986a. The influence of handling by humans on the behavior, reproduction and corticosteroids of male and female pigs. Appl. Anim. Behav. Sci. 15, 303-314.

Hemsworth, P.H., Brand, A., Willems, P., 1981. The behavioral response of sows to the presence of human beings and its relation to productivity. Livest. Prod. Sci. 8, 67-74.

Hemsworth, P.H., Price, E.O., Borgwardt, R., 1996. Behavioural responses of domestic pigs and cattle to humans and novel stimuli. Appl. Anim. Behav. Sci. 50, 43-56.

Hemsworth, P.H., Barnett, J.L., Hansen, C., Gonyou, H.W., 1986b. The influence of early contact with humans on subsequent behavioral response of pigs to humans. Appl. Anim. Behav. Sci. 15, 55-63.

Hemsworth, P.H., Barnett, J.L., Treacy, D., Madgwick, P., 1990. The heritability of the trait fear of humans and the association between this trait and subsequent reproductive performance of gilts. Appl. Anim. Behav. Sci. 25, 85-95.

Herskin, M.S., Munksgaard, L., 2000. Behavioral reactivity of cattle towards novel food: effects of testing time and food type of neighbours. J. Anim. Sci. 78, 2323-2328.

Herskin, M.S., Kristensen, A.M., Munksgaard, L., 2004. Behavioural responses of dairy cows toward novel stimuli presented in the home environment. Appl. Anim. Behav. Sci. 89, 27-40.

Herskin, M.S., Munksgaard, L., Kristensen, A.M., 2003. Behavioural and adrenocortical responses of dairy cows toward novel food: effects of food deprivation, milking frequency and energy density in the daily ration. Appl. Anim. Behav. Sci. 82, 251-265.

Hillmann, E., Hollen, F.V., Bünger, B., Todt, D., Schrader, L., 2003. Farrowing conditions affect the reactions of piglets towards novel environment and social confrontation at weaning. Appl. Anim. Behav. Sci. 81, 99-109.

Hinch, G.N., Lynch, J.J., 1987. A note on the effect of castration on the ease of movement and handling of young cattle in yards. Anim. Prod. 45, 317-320.

Hohenboken, W.D., 1986. Inheritance of behavioural characteristics in livestock. A review. Anim. Breed. Abstr. 54, 623-639.

Holmes, J.H.G., Robinson, D.W., Ashmore, C.R., 1972. Blood lactic acid and behaviour in cattle with hereditary muscular hypertrophy. J. Anim. Sci. 35, 1011-1013.

Hopkins, W.G., 2000.Retrieved July 28, 2007. A new view of statistics. Internet Society for Sport Science web site: http://www.sportsci.org/resource/stats/.

Hurnik, J.F., Webster, A.B., Siegel, P.B., 1995. Dictionary of Farm Animal Behavior. 2nd ed, Ames: Iowa State University Press, pp. 183-184.

Hutson, G.D., 1982. 'Flight distance' in Merino sheep. Anim. Prod. 35, 231-235.

Jones, A C., Gosling, S.D., 2005. Temperament and personality in dogs (*Canis familiaris*): A review and evaluation of past research. Appl. Anim. Behav. Sci. 95, 1-53.

Jones, R.B., 1983. Fear responses in domestic chicks as a function of the social environment. Behav. Processes. 8, 309-325.

Jones, R.B., 1994. Regular handling and the domestic chick's fear of human beings: generalization of response. Appl. Anim. Behav. Sci. 42, 129-143.

Jones, R.B., Mills, A.D., 1983. Estimation of fear in two lines of the domestic chick: Correlations between various methods. Behav. Processes. 8, 243-253.

Jones, R.B., Waddington, D., 1993. Attenuation of the domestic chick's fear of human beings via regular handling: in search of a sensitive period. Appl. Anim. Behav. Sci. 36, 185-195.

Jones, R.B., Duncan, I.J.H., Hughes, B.O., 1981. The assessment of fear in domestic hens exposed to a looming human stimulus. Behav. Processes. 6, 121-133.

Kabuga, J.D., Appiah, P., 1992. A note on the ease of handling and flight distance of *Bos indicus* and *Bos taurus* and their crossbreds. Anim. Prod. 54, 309-311.

Kabuga, J.D., Gari-kwaku, J., Annor, S.Y., 1991. Social status and its relationships to maintenance behaviour in a herd of N'Dama and West African Shorthorn cattle. Appl. Anim. Behav. Sci. 31, 169.

Kerr, S.G.C., Wood-Gush, D.G.M., 1987. The development of behavior patterns and temperament in dairy heifers. Behav. Process. 15, 1-16.

Kersten, A.M.P., Meijsser, F.M., Metz, J.H.M., 1989. Effects of early handling on later open-field behavior in rabbits. Appl. Anim. Behav. Sci. 24, 157-167.

Khanna, A.S., Sharma, J.S., 1988. Association of dairy temperament score with performance in some Indian breeds and crossbred cattle. Indian J. Anim. Sci. 58, 237-242.

Kilgour, R., 1975. Open-field test as an assessment of temperament in dairy cows. Anim. Behav. 23, 615-624.

Kilgour, R., Melville, G.J., Greenwood, P.L., 2006. Individual differences in the reaction of beef cattle to situations involving social isolation, close proximity of humans, restraint and novelty. Appl. Anim. Behav. Sci. 99, 21-40.

King, T., Hemsworth, P.H., Coleman, G.J., 2003. Fear of novel and startling stimuli in domestic dogs. Appl. Anim. Behav. Sci. 82, 45-64.

Lanier, J.L., Grandin, T., Green, R., Avery, D., McGee, K., 2000. The relationship between reaction to sudden, intermittent movements and sounds and temperament. J. Anim. Sci. 78, 1467-1474.

Lanier, J.L., Grandin, T., Green, R., Avery, D., McGee, K., 2001. A note on hair whorl position and cattle temperament in the auction ring. Appl. Anim. Behav. Sci. 73, 93-101.

Lawrence, A.B., Terlouw, E.M.C., Illius, A.W., 1991. Individual-differences in behavioral-responses of pigs exposed to non social and social challenges. Appl. Anim. Behav. Sci. 30, 73-86.

Lawstuen, D.A., Hansen, L.B., Steuernagel, G.R., 1988. Management traits scored linearly by dairy producers. J. Dairy Sci. 71, 788-799.

Le Neindre, P., 1989. Influence of rearing conditions and breed on social-behavior and activity of cattle in novel environments. Appl. Anim. Behav. Sci. 23, 129-140.

Le Neindre, P., Boivin, X., Boissy, A., 1996. Handling of extensively kept animals. Appl. Anim. Behav. Sci. 49, 73-81.

Le Neindre, P., Trillat, G., Sapa. J., Menissier, F., Bonnet, J.N., Chupin, J.M., 1995. Individual differences in docility in Limousin cattle. J. Anim. Sci. 73, 2249-2253.

Lowe, S.E., Bradshaw, J.W.S., 2001. Ontogeny of individuality in the domestic cat in the home environment. Anim. Behav. 61, 231-237.

Lyons, D.M., 1989. Individual differences in temperament of dairy goats and the inhibition of milk ejection. Appl. Anim. Behav. Sci. 22, 269-282.

Lyons, D.M., Price, E.O., 1987. Relationship between heart-rates and behavior of goats in encounters with people. Appl. Anim. Behav. Sci. 18, 363-369.

Lyons, D.M., Price, E.O., Moberg, G.P., 1988a. Individual-differences in temperament of domestic dairy goats: constancy and change. Anim. Behav. 36, 1323-1333.

Lyons, D.M., Price, E.O., Moberg, G.P., 1988b. Social modulation of pituitary-adrenal responsiveness and individual differences in behavior of young domestic goats. Physiol. Behav. 43, 451-458.

Mal, M.E., McCall, C.A., 1996. The influence of handling during different ages on a halter training test in foals. Appl. Anim. Behav. Sci. 50, 115-120.

Manteca, X., Deag, J.M., 1993. Individual differences in temperament of domestic animals: A review of methodology. Anim. Welfare. 2, 247-268.

Mateo, J.M., Estep, D.Q., McCann, J.S., 1991. Effects of differential handling on the behavior of domestic ewes (*Ovis aries*). Appl. Anim. Behav. Sci. 32, 45-54.

McDevitt, S.C., 1986. Continuity and discontinuity of temperament in infancy and early childhood: A psychometric perspective. In Plomin, R., Dunn, J. (Eds), The Study of Temperament: Changes, Continuities and Challenges. Erlbaum, NJ, pp. 27-38.

Mendl, M., Zanella, J.A., Broom, D.M., 1992. Physiological and reproductive correlates of behavioral strategies in female domestic pigs. Anim. Behav. 44, 1107-1121.

Mishra, R.R., Chauhan, R.S., Gupta, S.C., 1975. Studies of dairy temperament of Karan Swiss cows. Indian J. Dairy Sci. 28, 85-88.

Moberg, G.P., Wood, V.A., 1982. Effect of differential rearing on behavioral and adreno-cortical response of lambs to a novel environment. Appl. Anim. Ethol. 8, 269-279.

Morisse, J.P., Boilletot, A., Martrenchar, A., 1999. Preference testing in intensively kept meat production rabbits for straw on wire grid floor. Appl. Anim. Behav. Sci. 64, 71-80.

Morris, C.A., Cullen, N.G., Kilgour, R., Bremner, K.J., 1994. Some genetic factors affecting temperament in *Bos taurus* cattle. New Zeal. J. Agr. Res. 37, 167-175.

Muller, R., Von Keyserlingk, M.A., 2006. Consistency of flight speed and its correlation to productivity and to personality in *Bos taurus* beef cattle. Appl. Anim. Behav. Sci. 99, 193-204.

Munksgaard, L., Jensen, M.B., 1996. The use of “open-field” tests in the assessment of welfare of cattle. Acta. Agric. Scand. Sect. A. Animal. Sci. 27 (Suppl.), 82-85.

Munksgaard, L., Simonsen, H.B., 1996. Behavioral and pituitary adrenal-axis responses of dairy cows to social isolation and deprivation of lying down. J. Anim. Sci. 74, 769-778.

Murphey, R.M., Duarte, F.A.M., Penedo, M.C.T., 1980. Approachability of bovine cattle in pastures: Breed comparisons and a breed X treatment analysis. Behav. Genet. 10, 171-181.

Murphey, R.M., Duarte, F.A.M., Penedo, M.C.T., 1981. Responses of cattle to humans in open spaces: breed comparisons and approach-avoidance relationships. Behav. Genet. 11, 37-48.

Nielsen, M.A., Luescher, U.A., 1988. A study of the investigatory behavior of the dairy- cow. Appl. Anim. Behav. Sci. 21, 191-200.

Northern Eclipse image analysis software package (Version 6.0), Empix Imaging Inc., Mississauga, Ontario, Canada.

O’Bleness, G.V., Van Vleck, L.D., Henderson, C.R., 1960. Heritabilities of some type appraisal traits and their genetic and phenotypic correlations with production. J. Dairy Sci. 43, 1490-1498.

Petherick, J.C., Holroyd, R.G., Swain, A.J., 2003. Performance of lot-fed *Bos indicus* steers exposed to aspects of a feedlot environment before lot-feeding. Aust. J .Exp. Agr. 43, 1181-1191.

Petherick, J.C., Holroyd, R.G., Doogan, V.J., Venus, B.K., 2002. Productivity, carcass and meat quality of lot-fed *Bos indicus* cross steers grouped according to temperament. Aust. J. Exp. Agr. 42, 389-398.

Piller, C.A.K., Stookey, J.M., Watts, J.M., 1999. Effects of mirror-image exposure on heart rate and movement of isolated heifers. Appl. Anim. Behav. Sci. 63, 93-102.

Plomin, R., 1981.Heredity and temperament: A comparison of twin data for self-report questionnaires, parental ratings, and objectively assessed behavior. In: Gedda, L., Parisi, P., Nance, W.E. (Ed.), Progress in Clinical and Biological Research: Twin Research III, Part B. Intelligence, Personality, and Development. Alan R. Liss, New York, pp. 269-278.

Pollard, J.C., Littlejohn, R.P., Webster, J.R., 1994. Quantification of temperament in weaned deer calves of two genotypes (*Cervus elaphus* and *Cervus elaphus* × *Elaphurus davidianus* hybrids). Appl. Anim. Behav. Sci. 41, 229-241.

Prayaga, K.C., 2003. Evaluation of beef cattle genotypes and estimation of direct and maternal genetic effects in a tropical environment. 2. Adaptive and temperament traits. Aust. J. Agri. Res. 54, 1027-1038.

Ramos, A., Mormède, P., 1998. Stress and emotionality: a multidimensional and genetic approach. Neurosci. Biobehav. Rev. 22, 33-57.

Rasmussen, A.A., 1991. Behavioural reaction of individual pigs raised in different environments to a novel object and to handling at slaughter in relation to measurements of the adrenal cortex. Appl. Anim. Behav. Sci. 30, 176. (Abstract).

Rauw, W.M., 2006. A note on behavioural response to a novel arena in lactating mice highly selected for litter size. Appl. Anim. Behav. Sci. 99, 357-365.

Reenen, V.C.G., Engel, B., Ruis-Heutinck, L.F.M., Van der Wert, J.T.N., Buist, W.G., Jones, R.B., Blokhuis, H.J., 2004. Behavioural reactivity of heifer calves in potential alarming test situations: A multivariate and correlational analysis. Appl. Anim. Behav. Sci. 85, 11-30.

Romeyer, A., Bouissou, M.F., 1992. Assessment of fear reactions in domestic sheep and influence of breed and rearing conditions. Appl. Anim. Behav. Sci. 34, 93-l 19.

Ruis, M.A.W., te Brake, J.H.A., Engel, B., Buist, W.G., Blokhuis, H.J., Koolhaas, J.M., 2002. Implications of coping characteristics and social status for welfare and production of paired growing gilts. Appl. Anim. Behav. Sci., 75, 207-231.

Rushen, J., 1986. The validity of behavioral measures of aversion-a review. Appl. Anim. Behav. Sci. 16, 309-323.

Rushen, J., de Passille´, A.M.B., Munksgaard, L., 1999. Fear of people by cows and effects on milk yield, behavior and heart rate at milking. J. Dairy Sci. 82, 720-727.

Russel, P.A., 1983. Psychological studies of exploration in animals: a reappraisal. In: Archer, J., Birke, L.I.A. (Ed.), Exploration in Animals and Humans. Van Nostrand Reinhold (UK) Co. Ltd. pp. 22-54.

Sato, S., 1981. Factors associated with temperament of beef cattle. Japanese Journal of Zootechnical Science. 52, 595-605.

Scherer, K.R., 2001. Appraisal considered as a process of multilevel sequential checking. In: Scherer, K.R., Schorr, A., Johnstone, T. (Ed.), Appraisal Processes in Emotion: Theory, Methods, Research. Oxford University press, New York, pp. 95.

Schmutz, S.M., Stookey, J.M., Winkelman- Sim, D.C., Waltz, C.S., Plante, Y., Buchanan, F.C., 2001. A QTL study of cattle behavioral traits in embryo transfer families. J. Hered. 92, 290-292.

Schrader, L., 2002. Consistency of individual behavioural characteristics of dairy cows in their home pen. Appl. Anim. Behav. Sci. 77, 255-266.

Schwartzkopf-Genswein, K.S., Stookey, J.M., Welford, R., 1997. Behavior of cattle during hot-iron and freeze branding and the effects on subsequent handling ease. J. Anim. Sci. 75, 2064-2072.

Schwartzkopf-Genswein, K.S., Stookey, J.M., Crowe, T.G., Genswein, B.M.A., 1998. Comparison of image analysis, exertion force, and behavior measurements for use in the assessment of beef cattle responses to hot-ion and freeze branding. J. Anim. Sci. 76, 972-979.

Scolan, N.L., Hausberger, M., Wolff, A., 1997. Stability over situations in temperamental traits of horses as revealed by experimental and scoring approaches. Behav. Process. 41, 257-266.

Sharma, J.S., Khanna, A.S., 1980. Note on genetic group and parity differences in dairy temperament score of crossbred cattle. Indian Journal Animal Research. 14, 127-128.

Shrode, R.R., Hammack, S.P., 1971. Chute behavior of yearling beef cattle. J. Anim. Sci. 33, 193. (Abstract).

Spoolder, H.A.M., Burbidge, J.A., Lawrence, A.B., Simmins, P.H., Edwards, S.A., 1996. Individual behavioural differences in pigs: intra- and inter-test consistency. Appl. Anim. Behav. Sci. 49, 185-198.

Statistical Analysis System Software, 1999, Release 8.02, Cary, NC, U.S.A.

Statistix Analytical Software, 2000, Version V.7, Tallahassee, Florida, USA.

Stephens, D.B., Toner, J.N., 1975. Husbandry influences on some physiological parameters of emotional responses in calves. Appl. Anim. Ethol. 1, 233-243.

Stookey, J.M., Nickel, T., Hanson, J., Vandenbosch, S., 1994. A movement-measuring device for objectively measuring temperament in beef cattle and for use in determining factors that influence handling. J. Anim. Sci. 72 (Suppl. 1), 207.

Stricklin, W.R., Kautzscanavy, C.C., 1984. The role of behavior in cattle production: A review of research. Appl. Anim. Ethol. 11, 359-390.

Stricklin, W.R., Heisler, C.E., Wilson, L.L., 1980. Heritability of temperament in beef cattle. J. Anim. Sci. 51 (Suppl.1), 109. (Abstract).

Svartberg, K., Forkman, B., 2002. Personality traits in the domestic dog (*Canis familiaris*). Appl. Anim. Behav. Sci. 79, 133-155.

Svartberg, K., Tapper, I., Temrin, H., Radesäter, T., Thorman, S., 2005. Consistency of personality traits in dogs. Anim. Behav. 69, 283-291.

Syme, L.A., 1981. Social disruption and forced movement orders in sheep. Anim.Behav. 29, 283-288.

Talling, J.C., Waran, N.K., Wathes, C.M., Lines, J.A., 1996. Behavioural and physiological responses of pigs to sound. Appl. Anim. Behav. Sci. 48, 187-202.

Taylor, G.T., 1974. Stimulus change and complexity in exploratory behavior. Anim. Learn. Behav. 2, 115-118.

Thompson, J.R., Freeman, A.E., Wilson, D.J., Chapin, C.A., Berger, P.J., 1981. Evaluation of a linear type program in Holsteins. J. Dairy Sci. 64, 1610-1617.

Tilbrook, A.J., Hemsworth, P.H., Barnett, J.L., Skinner, A., 1989. An investigation of the social behaviour and response to humans of young cattle. Appl. Anim. Behav. Sci. 23, 107-116.

Torres- Hernandez, G., Hohenboken, W., 1979. An attempt to assess traits of emotionality in crossbred ewes. Appl. Anim. Behav. Sci. 5, 71-83.

Tulloh, N.M., 1961a. Behaviour of cattle in yards. II. A study of temperament. Anim. Behav. 9, 25-30.

Tulloh, N.M., 1961b. Behaviour of cattle in yards. I. Weighing order and behaviour before entering scales. Anim. Behav. 9, 20-24.

Vandenheede, M., Bouissou, M.F., Picard, M., 1998. Interpretation of behavioural reactions of sheep towards fear-eliciting situations. Appl. Anim. Behav. Sci. 58, 293-310.

Vanderwert, W., Berger, L.L., McKeith, F.K., Baker, A.M., Gonyou, H.W., Bechtel. P.J., 1985. Influence of Zeranol implants on growth, behavior and carcass traits in Angus and Limousin bulls and steers. J. Anim. Sci. 61, 310-319.

Van Erp-van der Kooij, E., Kuijpers, A.H., Schrama, J.W., Ekkel, E.D., Tielen, M.J.M., 2000. Individual behavioural characteristics in pigs and their impact on production. Appl. Anim. Behav. Sci. 66, 171-185.

Van Erp-van der Kooij, E., Kuijpers, A.H., Schrama, J.W., van Eerdenburg, W.G.P., Schouten, F.J.C.M., Tielen, M.J.M., 2002. Can we predict behaviour in pigs? Searching for consistency in behaviour over time and across situations. Appl. Anim. Behav. Sci. 75, 293-305.

Van Vleck, L.D., 1964. Variation in type appraisal scores due to sire and herd effects. J. Dairy Sci. 47, 1249-1256.

Veissier, I., Le Neindre, P., 1992. Reactivity of Aubrac heifers exposed to a novel environment alone or in groups of four. Appl. Anim. Behav. Sci. 33, 11-15.

Visser, E.K., Reenen, V. C.G., Hopster, H., Schilder, M.B.H., Knaap, J.H., Barneveld, A., Blokhuis, H.J., 2001. Quantifying aspects of young horses' temperament: consistency of behavioural variables. Appl. Anim. Behav. Sci. 74, 241-258.

Voisinet, B.D., Grandin, T., O'Connor, S.F., Tatum, J.D., Deesing, M.J., 1997a. Bos indicus-cross feedlot cattle with excitable temperaments have tougher meat and higher incidence of border line dark cutters. Meat. Sci. 46, 367-377.

Voisinet, B.D., Grandin, T., Tatum, J.D., O'Connor, S.F., Struthers, J.J., 1997b. Feedlot cattle with calm temperaments have higher average daily gains than cattle with excitable temperaments. J. Anim. Sci. 75, 892-896.

Von Borell, E., Ladewig, J., 1992. Relationship between behavior and adrenocortical response pattern in domestic pigs. Appl. Anim. Behav. Sci. 34, 195-206.

Wagnon, K.A., Loy, R.G., Rollins, W.C., Carroll, F.D., 1966. Social dominance in a herd of Angus, Hereford and Shorthorn cows. Anim. Behav. 14, 474-479.

Walsh, R.N., Cummins, R.A., 1976. The open-field test: A critical review. Psycol. Bull. 83, 482-504.

Watts, J.M., Stookey, J.M., Schmutz, S.M., Waltz, C.S., 2001.Variability in vocal and behavioural responses to visual isolation between full-sibling families of beef calves. Appl. Anim. Behav. Sci. 70, 255-273.

Waynert, D.F., Stookey, J.M., Schwartzkopf-Genswein, K.S., Watts, J.M., Waltz, C.S., 1999. The response of beef cattle to noise during handling. Appl. Anim. Behav. Sci. 62, 27-42.

Welp, T., Rushen, J., Kramer, D.L., Festa-Bianchet, M., de Passillé, A.M.B., 2004. Vigilance as a measure of fear in dairy cattle. Appl. Anim. Behav. Sci. 87, 1-13.

Whittaker, D., Knight, R.L., 1998. Understanding wildlife responses to humans. Wildlife Soc. B. 26, 312–317.

Wickham, B.W., 1979. Genetic parameters and economic values of traits other than production for dairy cattle. Proc. New Zeal. Soc. An. 39, 180-193.

Wilson, D.S., 1998. Adaptive individual differences within single populations. Philos. T. Roy. Soc. B. 353, 199-205.

Wood-Gush, D.G.M., Vestergaard, K., 1989. Exploratory behavior and the welfare of intensively kept animals. J. Agr. Environ. Ethic. 2, 161-169.

Wood-Gush, D.G.M., Vestergaard, K., 1991. The seeking of novelty and its relation to play. Anim. Behav. 42, 599-606.

APPENDICES

A Chapter 3: Measurement of temperament: Abstract

Temperament is an individual trait influencing an animal's behavioural response to handling. This characteristic likely modulates the response of the animal to its environment and social situation, and is perhaps best viewed as a component of its personality. Temperament was assessed using three objective measurements, to determine if correlations existed between these and the traditional subjective evaluation. Objective measures were made using strain gauges, a Movement-measuring-device (MMD) and a chute exit timer. The strain gauges measured the force exerted on the headgate in which an animal was restrained. The MMD measured voltage fluctuations in the load cells of an electronic weigh scale as each animal moved on the scale platform. The exit timer electronically recorded the time taken for the animal to traverse a 2.9 m exit chute upon release from the weigh scale. Subjective assessment of reactivity during handling and restraint was recorded on a 1-5 scale. Four hundred steers (243 ± 19 kg) were used. Each animal's responses were measured on three occasions, separated by a two-month interval. Each animal was restrained in a headgate, while strain forces were measured over a 10 s period. It was then moved to a weigh scale where it was visually isolated for one minute and MMD scores were recorded. After release it moved along the race, at which point the exit time was measured. Exit time was correlated (Spearman's correlations) with MMD peaks ($P<0.001$) consistently and with two sets of absolute strain forces ($P<0.001$). MMD peaks were related to absolute strain forces ($P<0.01$) for one set only. When the animals were classified as 'calm' or 'wild' based on their subjective scoring (scores 1 and 2 = calm, scores >2 = wild), these two groups differed ($P<0.001$) in their median absolute strain forces, MMD peaks and exit times except for the second set of absolute strain force evaluation (Wilcoxon test). The three objective measures yielded correlated results between tests and across repetitions, and therefore may quantify related aspects of a personality trait (i.e., temperament). The objective scores were related to the traditional subjective score, but they provided the advantage of eliminating observer bias and may offer better tools for temperament selection. Significant relationships existed between the animals' backgrounding daily gain and subjective score, and MMD values (SD and peaks) ($P<0.01$, $P<0.05$ and $P<0.001$ respectively). This indicates that traditional subjective scoring techniques can be replaced with more repeatable objective measures when temperaments are assessed for performance studies.

B Chapter 4: Assessment of reaction of beef cattle to a novel stimulus: Abstract

Reaction to a novel object or environment can be used as a measure of temperament in beef cattle. Animal's investigatory and fearful/avoidance behaviour can be assessed by such tests. A 'novelty test' was designed to assess both. The instruments consisted of two barrels placed one above the other with an opening in the upper one for the animal to insert or withdraw

its head. It was proposed that the salt block kept inside the apparatus would attract animals to investigate it. A remotely operated tennis ball was dropped in front of animals' face from above when the animals investigated the apparatus and variables such as whether or not they investigated the apparatus, distance moved in its startle reactions, the latency to react to the stimulus the second time and the number of such reactions were measured from the videotape. The data were compared with the previous objective and subjective measures of the same animals to check how reaction to handling and reaction to novelty co-vary with one another. There was no significant difference ($P<0.05$) between the proportion of calm and wild animals that explored the testing device from those not explored. The subjective scores of animals that participated in the novelty test differed ($P<0.001$) only for the last set among the 3 sets of measurements from the score of animals that did not participate in the novelty test. Among the 15 objective measures only 3 sets differed between investigated and non-investigated group. Reactions of animals to novelty apparatus such as distance moved during the first response, number of responses, latency to return to the apparatus and the average response did not differ between calm and wild animals for all sets of measurements. Fifty-seven out of sixty correlations between novelty measures and objective temperament measures were non-significant. Habituation effects were evident ($P<0.05$) when the first response of animals were compared with the subsequent responses. Except for the average response to novelty ($P = 0.04$), there weren't any difference in objective, subjective and novelty measures of animals that visited the apparatus once and those that visited at least 10 times. Results show that the reactivity of animals measured in the handling chute is not the same as their response to novelty in the home environment. This discrepancy could be that the novelty test measured the 'fearfulness' component of temperament whereas other objective and subjective tests measured a combination of behaviours (including fearfulness) in the animals' repertoire.

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