# Relationships between temperament, feedlot performance and beef quality

Drewe M Ferguson[1], David Johnston[2], Heather M Burrow[3], Antonio Reverter[4]

Cooperative Research Centre for Cattle and Beef Quality
[1] CSIRO Livestock Industries, FD McMaster Laboratories, Armidale, NSW 2350
[2]Animal Genetics and Breeding Unit, University of New England, Armidale, NSW 2350
[3]CRC for Beef Genetic Technologies, University of New England, Armidale, NSW 2350
[4]CSIRO Livestock Industries, QLD Bioscience Precinct, St Lucia, QLD 4067.

## Introduction

Cattle express fear when exposed to human contact and novel environments or during major changes to their social structure (eg. isolation). This is manifest by changes in both their physiology (eg. increased heart rate, adrenal secretion of catecholamines and/or cortisol) and behaviour. With respect to the latter, cattle typically display escape and/or avoidance behaviour which is clearly designed to minimize or obviate the threat. The expression of this natural behaviour represents the trait commonly referred to as temperament.

Fearful behaviour or temperament can be measured using a range of different tests that objectively or subjectively assess the animal's behavioural response to a fear-eliciting situation. As stated these tests largely characterise escape and/or avoidance behaviour and range from simple subjective assessments of agitation in the crush to more complex tests (eg arena tests). Of these, the measurement of flight time, which involves measuring the time taken for an animal to break two infrared sensors 1.6 – 2 m apart on exit from a crush, is recognized as one of the more practical and objective tests for assessing temperament.

There is considerable variation between individuals in their behavioural responses to these tests and furthermore, the responses for some tests (eg flight time) are moderately heritable (Burrow 1997). Given this, the potential for genetic improvement in temperament is therefore, quite considerable. Notwithstanding this potential, it is still somewhat intriguing that despite thousands of years of domestication, considerable variation in cattle temperament, particularly fear of humans, still exists. There are probably several reasons for this but perhaps the lack of standardization in selection procedures (Boissy et al 2005) and their variable application in cattle industries are likely factors.

**Table 1. Summary of results examining the association between temperament and feedlot average daily gain (ADG)**

| Study | | Days on feed | Temperament test | Results |
|---|---|---|---|---|
| **Burrow & Dillon (1997)** | BI x BT cattle<br>(i) 96 heifers<br>(ii) 60 steers & 58 heifers | <br>129<br>87 – 96 | Flight time[1] | <br>Negative (P<0.05)<br>Negative trend (ns) |
| **Voisinet et al (1997a)** | BT & BT x BI cattle<br>292 steers & 144 heifers | 194 -213 | Crush score[2] | Negative (P<0.05) |
| **Fell et al (1999)** | BT steers<br>12 calm<br>12 nervous | 85 | Crush score[2]<br>Flight time x 2<br>Confidence test[3] | *ADG**<br>Calm 1.46 kg/day[a]<br>Nervous 1.04 kg/day[b]<br>Cohort[4] 1.20 kg/day[a] |
| **Petherick et al (2002)** | 120 BT x BI steers (2 yr)<br>3 temperament groups | 101 | Flight time[5] | *ADG**<br>Poor 1.37 kg/day[a]<br>Mixed 1.43 kg/day[a]<br>Good 1.54 kg/day[a] |
| **Colditz et al (2006)** | 210 BT steers | 71 | Flight time[6] | *Correlation*<br>Phenotypic = 0.35 |

[1] Mean of 5 measurements
[2] 1-5 where 1= calm, no movement and 5 = rearing, twisting or violently struggling
[3] Test measures the latency of the animal to walk past a human to enter a pen with access to food
[4] The mean ADG of the cohort of animals (n = 209) that received identical treatments and feedlot finishing as the two temperament groups
[5] Mean of 3 flight time measurements. Good and poor temperament was defined as a flight time (over 2.6 m) of 1.5 – 3.2 s and 0.6 – 1.4 s, respectively. The mixed group comprised equal numbers of good and poor temperament animals
[6] Single measurement taken approx. midway through feedlot finishing
* Treatment with different superscripts denote significant differences P<0.05

Selection for improved temperament or less fearful cattle can facilitate both human (ie. handler) and animal welfare benefits. Animals that display less fearful behaviour during routine handling and management are less likely to injure themselves and their handlers. However, there is emerging evidence that indicates that selection for temperament may be associated with additional production benefits. The purpose of this paper is to review these benefits and to attempt to explore the biological basis for them.

## Temperament and growth

The association between

temperament and growth, especially during feedlot finishing, has received the most attention. There has been a limited focus on this association at pasture although the work of Fordyce et al (1985, 1988) showed that Bos indicus crossbred cattle with a quiet or calm temperament (based on crush score) had higher liveweights on pasture. Notwithstanding these results, it is quite possible that the association may be less apparent under more extensive production systems due to several factors but notably, there is less human contact, the environment is more familiar to the animals and the fact that productivity is primarily influenced by pasture conditions.

The results from several studies that investigated the association between temperament and feedlot average daily gain are summarized in Table 1. Collectively, these results confirm that poor temperament cattle (ie. short flight times or high crush scores) grow at slower rates during feedlot finishing. In other words, some of the variability in feedlot productivity observed between individuals and cohorts is therefore associated with temperament. Moreover, it is undoubtedly a central factor in the incidence of shy feeders.

These results also indicate that production gains, particularly under intensive feeding systems, can be made through the identification and selection of cattle that are less fearful. Whilst intuitively, this makes sense, it raises the immediate question of what are the biological mechanisms that underpin the association between temperament and productivity?

There are several factors/mechanisms that might be implicit here but unfortunately, clear understanding of them is constrained by the paucity of published data. It is plausible that differences in feed conversion efficiency (FCE) might be involved as Petherick et al (2002) observed that the good temperament group had a significantly better FCE compared to the poor temperament group in their study. They hypothesized that more fearful cattle tend to be more vigilant to changes within their environment and that the energy costs of maintaining the additional vigilance came at the expense of growth. This was also proposed by Burrow and Dillon (1997).

Further evidence of the connection between feed utilization efficiency and stress responsiveness which is pivotal in the expression of fear emerges from the research into the trait known as residual feed intake (RFI) in cattle. Richardson and Herd (2004) suggested less efficient cattle (high RFI) may be more physiologically responsive to stress. This was predicated on the observed differences in blood indicators of stress between lines of cattle that were divergently selected for RFI. The least efficient line was characterized with a higher neutrophil:lymphocyte ratio and higher cortisol concentration. The association between RFI and stress susceptibility has also recently been observed in sheep. Knott et al (2005) demonstrated a positive association between cortisol response following an ACTH challenge and RFI ($r = 0.42$). Together these data lend support to the view that animals which are physiologically more responsive to stress are less efficient and this in turn could account for their reduced growth rates.

Whilst this seems reasonable, there is a problem in this biological construct. In the cattle RFI selection lines there do not appear to be differences in the behavioural responses to temperament tests such as flight time (Kilgour personal communication, Richardson et al 2000). This does not necessarily detract from the postulate that the association between temperament and growth is, in part, influenced by the efficiency of feed energy utilization and partitioning. Rather it simply reinforces the fact that further research is required to test and validate the hypothesis. Moreover, the assumption that temperament as determined by behavioral responses is consistently associated with stress susceptibility also needs to be tested.

The role of the immune system is another factor that may be important in the context of the association between temperament and growth. Stress-induced immunosuppression is a well documented phenomenon. Reduced immunocompetance in more fearful cattle may predispose them to disease and this would account for reduced productivity. However, in the only study where the associations between temperament, feedlot performance and immune function were investigated, Fell et al (1999) reported minimal differences in immune function between their extreme temperament groups.

## Temperament and beef quality

There has been a general view that temperament significantly influences beef quality traits. Yet surprisingly, this association has received very little attention.

Losses in both beef quality and quantity are inevitable during the critical pre-slaughter phase. The magnitude of these losses depends on the intensity and duration of the various stressors that apply between the farmgate and abattoir and also the susceptibility of the animal to stress (Ferguson et al 2001). Temperament and stress susceptibility are assumed to be associated. Therefore, it is reasonable to assert that temperament has the potential to directly and indirectly affect beef quality.

Three studies have been undertaken that investigated the association between temperament and carcass bruising (Fordyce et al 1985, 1988; Burrow and Dillon 1997). Intuitively, more excitable animals are more likely to incur more bruising during pre-slaughter handling, however, the results from the studies were equivocal. A positive correlation ($P<0.05$) was only found between the weight of bruise trim/carcass and temperament score in the one study by Fordyce et al (1988).

The condition known as dark cutting or dark, firm, dry (DFD) beef is a meat quality concern for all meat industries. As the name implies the meat is darker in colour but it also has a higher ultimate pH (typically pHu≥5.9) and higher water holding capacity and, depending on the ultimate pH, can have increased toughness (especially between pH 5.9 and pH 6.2). The problem occurs through physical and/or stress induced depletion of muscle glycogen reserves prior to slaughter. In two separate studies (Fordyce et al 1988 and Petherick et al 2002), temperament was not found to be associated with ultimate pH or the incidence of dark cutting. However, Voisinet et al (1997b) reported that temperament (based on crush score) was significantly correlated with the incidence of dark cutting as determined by subjective colour assessment in a study involving 306 cattle. Given that pH was not measured, the results need to be considered with some caution as colour assessment would not be considered the most definitive measure of dark cutting. Another concern with this study is that their sample comprised different groups of cattle that were mixed the night before slaughter.

**Table 2. Summary of results examining the association between temperament and beef tenderness or eating quality**

| Study | | Temperament test | Results |
|---|---|---|---|
| **Fordyce et al (1988)** | BT, BI x BT cattle<br>(i) 170 steers<br>(ii) 140 cows | Crush score[1]<br>Speed score[2] | Some indication of a trend between temperament scores and shear force – not conclusive. |
| **Voisinet et al (1997b)** | BT x BI cattle<br>162 steers & 144 heifers | Crush score[3] | *Temp.* *Shear force*<br>1 2.86 kg<br>2 2.88 kg<br>3 3.19 kg<br>4 3.63 kg<br>Significant effect observed |
| **Burrow et al (1999)** | 265 BI x BT cattle | Flight time[4] | Flight time not correlated with objective measures of tenderness |
| **Petherick et al (2002)** | 120 BT x BI steers (2 yr)<br>3 temperament groups | Flight time[5] | Flight time was not correlated with beef eating quality as assessed by MSA panel. |
| **Reverter et al (2003)** | 4137 BI and BI x BT cattle<br>2369 steers & 1768 heifers | Flight time[6] | Correlation with shear force<br>Phenotypic = -0.01<br>Genetic = -0.48<br>Correlation with panel tenderness score<br>Phenotypic = 0.06<br>Genetic = 0.37 |
| **Colditz et al (2006)** | 210 BT steers | Flight time[7] | Flight time was not correlated with objective or subjective assessments of tenderness |
| **Kadel et al (2006)** | 3594 BI and BI x BT cattle* | Flight time and crush score[8] | Correlation with shear force<br>Phenotypic = -0.02<br>Genetic = -0.42<br>Correlation with panel tenderness score<br>Phenotypic = 0.06<br>Genetic = 0.33 |
| **Petherick et al (unpubl.)** | 144 BT x BI steers | Flight time[9] | Phenotypic correlation with shear force<br>1 day ageing = -0.17 (ns)<br>14 days ageing = -0.06 (ns)<br><br>Phenotypic correlation with MSA CMQ4 score = 0.17 ($P<0.05$) |

[1] 1-7 where 1= no movement and 7 = struggling violently and attempting to jump out
[2] Assessed during isolation in a small yard in the presence of a human. 1-5 where 1 = stands and walls and 5 = trots and gallops.
[3] 1-4 where 1= calm, little movement and 4 = frenzied, rearing, twisting or violently struggling
[4] Mean of 4 flight time measurements (post-weaning – 12 mth)
[5] Mean of 3 flight time measurements. Good and poor temperament was defined as a flight time (over 2.6 m) of 1.5 – 3.2 s and 0.6 – 1.4 s, respectively. The mixed group comprised equal numbers of good and poor temperament animals
[6] Single measurement taken post-weaning
[7] Single measurement taken midaway through 70 day feedlot finishing
[8] 1-5 where 1 = docile and 5 = aggressive. Within each score there + and – subcategories.

With respect to beef eating quality, tenderness is paramount. The relationship between temperament and beef tenderness and eating quality has been examined in several studies and the results are summarized in Table 2.

These results (Table 2) suggest that the phenotypic association between temperament and tenderness or beef eating quality scores is either non-existent or very weak. The positive association reported by Voisinet et al (1997b) has to considered with some caution given that temperament was also associated with meat colour scores and by interpretation, dark cutting (and also because the different groups of cattle were mixed the night before slaughter). The increasing toughness observed with poorer temperament scores may simply be a function of ultimate pH. Nevertheless, in their study tenderness was associated with temperament. In CRC research, Petherick et al (2002) found no association between MSA CMQ4 scores of beef eating quality and flight time. They did however, report that post-mortem glycolytic rate may have been affected by temperament group where faster rates were more apparent in the poor temperament group. The post-mortem rates of muscle glycolysis and temperature declines are extremely important with regard to the expression of tenderness/toughness particularly in unaged meat (see review by Ferguson et al 2001). The lack of an association with MSA panel scores may have been because the meat was aged for 14 days. As can be seen in the subsequent study by Petherick et al (unpublished), the correlation between flight time and shear force deteriorated with ageing (Table 2). In this study, a significant association ($P<0.05$) was also found between the MSA CMQ4 score and flight time.

The post-slaughter management of the carcass is highly relevant in the context of tenderness/ toughness (see Ferguson et al 2001). The lack of any phenotypic association between temperament and tenderness in the above studies may in part, be due to the post-slaughter processing practices that were applied (Burrow et al 1999). It is plausible that any variation in tenderness due to temperament was minimized or negated through the application of best practice processing in abattoirs where the rate of muscle pH decline (via electrical stimulation) is controlled and/or the degree of muscle shortening is restricted (via tenderstretch). Electrical stimulation was applied in every experiment listed in Table 2 with the exception of the study by Fordyce et al (1988).

Whilst the phenotypic relationship between temperament and tenderness appears tenuous, the same cannot be said for the genetic correlation between these two traits (Reverter et al 2003, Kadel et al 2006). This highly salient CRC outcome indicates that selection for temperament based on flight time will indirectly result in genetic improvement in tenderness. Attempts to investigate the biological basis for this genetic association have not been successful largely because of the lack of a phenotypic association (Ferguson et al., unpublished data). In muscle, differences in fibre type, muscle membrane adrenergic receptor profiles and post-receptor responses and regulation in the rates of muscle protein degradation are all plausible factors that may be involved is this association. Another likely factor is the temperament associated differences in the response to pre-slaughter stress. In addition to the stress-mediated losses in muscle glycogen, there is emerging evidence that pre-slaughter stress can also negatively affect meat quality via mechanisms independent of ultimate muscle pH even when effective electrical stimulation is applied post-slaughter (eg. Daly et al 1995, Geesink et al 2001, Warner et al 2006).

Finally, it is worth noting that the association between temperament and tenderness is not just limited to cattle. Faure and Mills (1998) reported that in quail divergently selected for their duration of tonic immobility (behavioural response to fear) that tougher meat was more pronounced in the more fearful line (longer duration of tonic immobility).

## Conclusions

The behavioural responses in cattle to fear-elicting events or situations provide a practical and highly effective means for identifying and selecting cattle that are less fearful. From an animal welfare perspective, this strategy will facilitate the selection of animals that are better able to cope in their production environments. Moreover, it is clear that it will also yield productivity gains in traits such as feedlot growth and beef tenderness. Our understanding of the biological basis for such associations is still limited at this juncture and further investigation is warranted.

## References


Boissy A, Fisher AD, Bouix J, Hinch GN and Le neindre P (2005) genetics of fear in ruminant livestock. Livest. Prod. Sci. 93, 23-32.

Burrow HM and Dillon RD (1997). Relationships between temperament and growth in a feedlot and commercial carcass traits of Bos indicus crossbreds. Aust J. Exper. Agric. 37, 407-411.

Burrow, HM. (1997). Measurements of temperament and their relationships with performance traits of beef cattle: a review. Anim. Breed Abstr. 65, 7.

Burrow HM, Shorthose WR and Stark JL (1999) Relationships between temperament and carcass and meat quality attributes of tropical beef cattle. Proc. Association for the Advancement of Animal Breeding and Genetics, 13, 227-230.

Colditz IG, Ferguson DM, Greenwood PL, Doogan VJ, Petherick JC and Kilgour R (2006). The effect on meat quality of mixing unfamiliar Bos taurus feedlot cattle in the weeks prior to slaughter. Aust J. Exper. Agric. (in press).

Daly CC, Simmons NJ, Devine CE (1995). An interaction between pre-slaughter stress and electrical stimulation on tenderness of lamb. Internat. Congr. Meat Sci. and Technol., San Antonio, Texas 48, 226-227.

Faure JM and Mills AD (1998). Improving the adaptability of animals by selection. In Genetics and The Behaviour of Domestic Animals (Ed. T.Grandin) pp235-264. (academic Press, San Diego).

Fell, LR, Colditz, IG, Walker, KH and Watson DL (1999). Associations between temperament, performance and immune function in cattle entering a commercial feedlot. Aust J. Exper. Agric. 39, 795-802.

Ferguson DM, Bruce HL, Thompson JM, Egan AF, Perry D, Shorthose WR (2001) Factors affecting beef palatability - farmgate to chilled carcass. Aust. J. Exper. Agric. 41, 879-891.

Fordyce G, Goddard ME, Tyler R and Williams G (1985). Temperament and bruising of Bos indicus cross cattle. Aust J. Exper. Agric. 25:283-288.

Fordyce G, Wythes, JR, Shorthose WR, Underwood DW and Shepherd RK (1988). Cattle temperaments in extensive beef herds in northern Queensland. 2. Effect of temperament on carcass and meat quality. Aust. J. Exper. Agric. 28, 689-693.

Kadel, MJ, Johnston, DJ, Burrow HM, Graser H-U and Ferguson DM (2006) Genetics of flight time and other measures of temperament and their value as selection criteria for improving meat quality traits in tropically adapted breeds of cattle. Aust. J. Agric. Res. 57: (in press).

Geesink GH, Mareko MHD, Morton JD and Bickerstaffe R. (2001). Effects of stress and high voltage electrical stimulation on tenderness of lamb m. longissimus. Meat Sci. 57, 265-271.

Knott SA, Leury BJ, Cummins LJ and Dunshea,FR (2005). An adrenocorticotropin hormone (ACTH) induced stress challenge can be used to identify rams, which are different in net feed intake and feed conversion efficiency. Recent Adv. Anim. Nutr. 15: 12A.

Petherick JC, Holroyd RG, Doogan VJ, Venus BK (2002) Productivity, carcass and meat quality of lot-fed Bos indicus cross steers grouped according to temperament. Aust. J. Exper. Agric. 42, 389-398.

Reverter A, Johnston DJ, Ferguson DM, Perry D, Goddard ME, Burrow HM, Oddy VH, Thompson JM, Bindon BM (2003) Genetic and phenotypic characterisation of animal, carcass, and meat quality traits from temperate and tropically adapted beef breeds. 4. Correlations among animal, carcass, and meat quality traits. Aust. J. Agric. Res. 54, 149-158.

Voisinet BD, Grandin T, Tatum JD, OConnor SF and Struthers JJ (1997a). Feedlot cattle with calm temperaments have higher average daily gains than cattle with excitable temperaments. J. Anim. Sci. 75, 892-896.

Voisinet BD, Grandin T, OConnor SF, Tatum JD, Deesing MJ (1997b) Bos indicus cross feedlot cattle with excitable temperaments have tougher meat and a higher incidence of borderline dark cutters. Meat Sci. 46, 367-377.

Warner, RD, Ferguson, DM, Cottrell, JJ and Knee B (2006). Acute stress induced by the use of electric prodders pre-slaughter causes tougher beef meat. Aust. J. Exper. Agric. (in press).