Relationships between on-farm and pre-slaughter behaviour, and growth and meat quality for bulls and steers

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ABSTRACT

Angus and Hereford-Angus cross bulls (n = 58) and steers (n = 59) were assessed for temperament 3 times during post-weaning growth and for behaviour during pre-slaughter holding in order to investigate relationships between these traits and measures of growth and meat quality including meat tenderness and meat colour. Composite on-farm temperament scores encompassed measures during weighing of stepping and unease on the scale, and speed of movement and level of agitation when released from the scale. Pre-slaughter assessments included counts of butting, pushing, fighting and mounting. Plasma levels of cortisol, glucose, lactate and fatty acids at slaughter were measured. On-farm temperament scores were significantly correlated ($P < 0.0001$) between the 3 times and between measures within a time. On-farm measures, however, were not related to pre-slaughter scores or to plasma cortisol or metabolite levels. Plasma cortisol levels were significantly higher for steers than bulls (43.8 vs 22.4 ng/ml; $P < 0.001$) as reported previously, and bulls had significantly higher pre-slaughter behaviour scores, but there were no castration effects on levels of plasma metabolites or on-farm temperament scores. Relationships between behavioural traits and measures of growth rate and meat quality based on treatment-adjusted residuals were low and non-significant. It is concluded that despite on-farm temperament scores being moderately repeatable, these measures were not associated with differences in pre-slaughter behaviour, and neither of these traits was associated with growth rate or measures of meat quality.

Keywords: animal behaviour; meat quality; meat pH; cortisol; growth rate; tenderness.

INTRODUCTION

Relationships between the temperament of cattle and their productive characteristics such as growth rate and meat quality characteristics are of practical importance because, if they are sufficiently close, they may provide opportunities to improve productivity by selecting on temperament. Even in the absence of useful relationships with productivity, variation in cattle temperament has implications for operator safety and animal welfare when they are being handled. Information in the literature provides some support for the claim that cattle with quieter temperaments will tend to grow faster and produce meat that is of better quality, particularly in terms of tenderness (Fordyce *et al*., 1988; Voisinet *et al*., 1997a). The picture is not particularly clear, however, partly because different methods for measuring the temperament or behaviour of cattle have been used (Burrow, 1997). The objective for the present study was to evaluate the temperament and behaviour of bulls and steers at several times of weighing on the farm and during the pre-slaughter holding period, and to investigate relationships between these measurements and characteristics related to growth rate and meat quality.

MATERIAL AND METHODS

Details about the 117 Angus and Hereford-Angus cross bulls and steers and of the experimental design and sample collection procedures used were given in Purchas *et al*. (2002). Briefly, an approximately equal number of bulls and steers were grown on pasture along three different growth paths to similar final weights with half in each of two years. At the time of slaughter some measures of carcass composition were made and a sample of the longissimus muscle was taken from the 6 to 12 rib area for the evaluation of meat quality using laboratory methods and sensory-panel methods as described by Purchas *et al*. (2002). These included three measures of cooked meat toughness using a sensory panel, the use of a Warner-Bratzler shear device to give WB peak-force values, and a MIRINZ tenderometer to give MIRINZ force scores. Other measurements related to meat quality included a measure of water-holding capacity in terms of expressed juice, ultimate meat pH measured on an homogenate of muscle tissue, myofibrillar fragmentation index (MFI) as a measure of the fragility of muscle fibres, and measures of meat colour in terms of its lightness (L*) and the colour intensity (chroma) (Purchas *et al.,* 2002).

Assessment of temperament on the farm took place on three occasions when the cattle were being weighed, and was based on the following four measurements:

1. The number of steps of the front or back feet during a 20-second period while in the weighing crate.
2. An 8-point anxiety score during the same 20-second period using the scale of Hearnshaw and Morris (1984), where 1 = 'calm and still' and 8 = 'full of panic, attempts to climb out, may bellow'.

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3. The level of agitation when leaving the crate using the 6-point scale of Morris *et al.* (1994), where 1 = 'walks at a leisurely pace' and 6 = 'extremely disturbed'.
4. The speed of movement when leaving the crate on a 5-point scale where 1 = 'stands and walks', 2 = 'walks continuously', 3 = 'walks and trots', 4 = 'trots', and 5 = 'trots and gallops'.

These four measures were converted to a single composite measure of temperament between zero and 10 by first converting each to a scale from zero to 24, and then dividing the sum of these scores (which had a range from 0 to 96) by 9.6. The three scores, which are denoted Te1, Te2 and Te3, were measured at ages of approximately 8, 12 and 15 months, respectively.

Behaviour as a measure of temperament during the immediate pre-slaughter period was assessed by counting the number of interactions between individual animals (in groups of 6 bulls or steers) over two 30-minute observation periods. Interactions counted included head-butting, pushing, fighting and mounting. In addition, blood samples were collected at the time of slaughter and assayed for plasma levels of cortisol, glucose, lactate, and non-esterified fatty acids (NEFA).

Because many of the variables of interest were potentially influenced by castration status, year, nutritional treatment, and pre-slaughter holding time (4 or 28 hours), the data used for analysis here were in the form of residual values obtained after removing the effects of these factors using the general-least-squares procedure of SAS (1985). Relationships between residuals for the variables were assessed on the basis of simple linear correlation coefficients.

RESULTS AND DISCUSSION

Least-squares means for growth rate over a 10-month period from approximately 6 to 16 months of age and for the three on-farm measures of temperament are given in Table 1 for bulls and steers separately. The bulls grew significantly faster (+16.7%) as expected (Purchas *et al*., 2002), but the temperament scores did not differ significantly between the two groups.

Simple correlations between residuals of growth rate and the temperament scores (Table 1) were all very low for bulls and steers. When the bull and steer groups were combined correlations were similarly very low.

Pre-slaughter behaviour scores were significantly higher for bulls than steers (Table 2) mainly due to increased riding and fighting activity, but plasma cortisol levels were almost twice as high for the steer group. Higher plasma cortisol levels for steers than bulls have been reported previously (Tennessen *et al*., 1984; Gettys *et al*., 1988; Fritsche & Steinhart, 1998), but rather than being an indicator of higher levels of stress for steers, they appear to be a reflection of the absence of gonadal steroids such as testosterone, which inhibit the production of cortisol either at the pituitary or adrenal level (Gettys *et al.*, 1988).

TABLE 1: Least-squares means for growth rate over a period from approximately 6 to 16 months of age (ADG16) and temperament scores for bulls and steers, together with correlations between these characteristics.

	Gender			
	Bull	Steer	Effect[a]	R^2%, RSD[b]
Number of animals	58	59		
ADG16 (kg day^{-1})	0.784	0.672	<0.0001	88, 0.074
Temperament at time 1 (Te1)	2.96	3.05	0.77	9, 1.86
Temperament at time 2 (Te2)	3.55	3.34	0.54	9, 1.82
Temperament at time 3 (Te3)	2.71	2.86	0.65	8, 2.71
Correlations between residuals[c]:				
ADG16 vs Te1	-0.09	-0.12		
ADG16 vs Te2	-0.04	-0.13		
ADG16 vs Te3	-0.10	-0.16		

[a] Probability values
[b] Coefficient of determination and residual standard deviation
[c] Residuals after adjusting for nutritional treatments and year

TABLE 2: Least-squares means for a pre-slaughter behaviour score (BehavSc) of bulls and steers and for plasma levels of several items in blood collected at the time of exsanguination, together with correlations between BehavSc and growth rate and plasma parameters.

	Gender			
	Bull	Steer	Effect[a]	R^2%, RSD[b]
Behaviour score (BehavSc)	5.50	2.51	0.0002	27, 4.12
Plasma cortisol (ng mL^{-1})	22.4	43.8	<0.001	57, 11.6
Plasma glucose (mmol L^{-1})	6.94	6.78	0.80	20, 2.81
Plasma lactate (mmol L^{-1})	11.3	10.2	0.15	11, 3.79
Plasma NEFA[c] (mmol L^{-1})	0.173	0.169	0.81	8, 0.09
Correlations between residuals:				
BehavSc vs ADG16	0.06	0.31*		
BehavSc vs plasma cortisol	0.14	-0.04		
BehavSc vs plasma glucose	-0.17	0.00		
BehavSc vs plasma lactate	-0.13	-0.08		
BehavSc vs plasma NEFA[c]	0.11	0.03		

[a] Probability values.
[b] Coefficient of determination and residual standard deviation
[c] Non-esterified fatty acids
* $P < 0.05$

There was no indication of a relationship between pre-slaughter behaviour score and growth rate for the bulls (Table 2), but for the steers there was a tendency for higher scores to be associated with faster growth. It is possible that for the steers this was because the higher scores were indicative of animals that were more dominant, as dominance scores have been reported previously to be positively related to growth rate for cattle (Burrow, 1997). There were no significant correlations between pre-slaughter behaviour scores and plasma concentrations of cortisol, glucose, lactate or NEFA at the time of slaughter, suggesting that the number and/or the nature of the interactions were such that the animals were not significantly stressed.

TABLE 3: Simple linear correlations between residuals of the four measures of temperament/behaviour and residuals of other characteristics.

	Temperament or behaviour score			
	Te1 residual	Te2 residual	Te3 residual	BehavSc residual
Te1 residual		0.57**	0.57**	-0.01
Te2 residual			0.67**	0.00
Te 3 residual				-0.01
Correlations with residuals for plasma concentrations of:				
Cortisol	0.08	0.07	0.12	0.07
Glucose	0.05	0.13	0.25**	-0.14
Lactate	0.11	0.10	0.13	-0.11
NEFA	-0.15	-0.18	-0.25**	0.09
Correlations with residuals for meat-quality-related characteristics:				
Ultimate meat pH	0.15	0.08	0.12	0.22*
MFI[a]	0.14	0.30**	0.12	-0.00
Sensory-panel toughness	-0.13	-0.13	-0.11	-0.02
WB peak force	-0.06	-0.05	-0.05	-0.05
MIRINZ force score	-0.01	-0.03	-0.01	-0.07
Expressed juice	-0.18*	-0.03	-0.20*	-0.13
L*[b] (lightness)	-0.23*	-0.01	-0.10	-0.19*
Chroma[c] (colour intensity)	-0.14	-0.09	-0.20*	-0.28**

[a] Myofibrillar fragmentation index
** = $P < 0.01$; * = $P < 0.05$
[b] L* (lightness), a* (redness), and b* (yellowness) measured with a Minolta ChromaMeter
[c] Chroma = square root($(a^*)^2 + (b^*)^2$)

Correlations between the on-farm measures of temperament and the pre-slaughter behaviour scores (BehavSc; Table 3) indicated that the three measures of on-farm temperament were moderately closely correlated, but that none of these showed any relationship with subsequent pre-slaughter behaviour scores. Similar results were obtained when correlations were calculated for bulls and steers separately. It was noted by Burrow (1997) that measures of social interaction between animals, such as the BehavSc values reported here, need to be differentiated from human-animal interactions that are assessed in temperament tests, and that they are likely to be measuring different traits. The results in Table 3 are consistent with this suggestion. Moderate to high repeatabilities between sequential temperament scores for cattle have been reported previously (Hearnshaw & Morris, 1984; Grandin, 1993; Petherick *et al*., 2002).

The other productive advantage for beef cattle with more placid temperaments that has been reported in some studies is the production of more tender meat (Fordyce *et al*., 1988; Voisinet *et al*., 1997a). Results of other studies, however, have mirrored those of the current trial and shown no differences in the tenderness of meat from cattle varying in temperament scores (Petherick *et al*., 2002). As with growth rate, the relationships with tenderness have not been close in any of the reports. Burrow (1997) reviewed the evidence that pre-slaughter stress can sometimes lead to less tender beef because of the tendency for toughness to increase as ultimate meat pH increases from about 5.5 (the value for normal well-rested cattle) to an intermediate value of about 6.2 (Purchas *et al.*, 1999). Further increases in ultimate pH lead to more tender meat. She noted, however, that although the pH/toughness relationship is fairly clear, there is little information indicating whether temperament scores are an useful indicator of between-animal differences in susceptibility to the levels of stress that will be reflected in differences in ultimate meat pH. The fact that there was a very low incidence of elevated pH levels for the cattle of the current trial could explain the absence of any relationships between temperament scores and meat quality, if in fact such relationships are mediated through differences in ultimate pH levels.

It is concluded that for the 117 bulls and steers involved in the current study there was no indication that those with more placid or docile temperaments on the farm or with quieter behaviour during the pre-slaughter period grew any faster or produced more tender meat. Some other studies have suggested that such relationships exist, but the relationships have generally not been close and different types of cattle have been involved. It should be noted, however, that even in the absence of such relationships, the farming of quieter, more docile cattle will often have advantages with regard to operator safety and animal welfare.

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