Temperament of hand-reared beef-cross-dairy cattle does not influence production traits

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Abstract

Evaluation of temperament of calves early in life is associated with growth and meat quality in extensively farmed beef cattle. However, the relationship between temperament and performance is unclear for hand-reared beef-cross-dairy calves. This experiment analysed temperament of 1077 Angus- and Hereford-sired cattle born to dairy-breed cows and hand-reared, and evaluated the value of these measurements as predictors of growth and meat quality traits. Cattle in this study were calm, with mean exit velocity (EV) between 0.76 and 1.15 m/s from 200 d to 800 d, crush score (CS) between 1.38 and 1.79 from 200 d to slaughter (1-5 scale), and measurements were highly correlated at all ages ($P<0.05$). Temperament at 200 d and 400 d was not related to growth, but CS was related to growth from 600-800 d (-0.011 kg/d for a 1-point increase in CS at 600 d, $P<0.05$). Temperament at 800 d or before slaughter was not related to meat ultimate pH or colour score. The small variation in temperament among animals was probably the consequence of cattle being acclimatised to the presence of humans due to hand-rearing and frequent handling. Therefore, temperament is unlikely to be an issue in hand-reared beef-cross-dairy cattle and should not influence growth and meat quality traits.

Keywords: Artificial rearing; beef-on-dairy; beef production; crush score; exit speed; exit velocity; flight time

Introduction

Cattle temperament is related to stress responsiveness and can be associated with animal performance and meat quality (Behrends et al. 2009; Cafe et al. 2011; del Campo et al. 2021; Ponnampalam et al. 2017). This is particularly true for *Bos indicus* cattle, entire bulls, animals that have been handled infrequently or that had negative experiences (Behrends et al. 2009; Bonin et al. 2014; Grandin et al. 2015; Haskell et al. 2014). Studies reporting on *Bos taurus* breeds, on the other hand, show variable results in the associations between temperament and performance traits (Boles et al. 2015; Burnham et al. 2005; Cafe et al. 2011; Coombes et al. 2014; Della Rosa et al. 2019; Haskell et al. 2014). The temperament of beef-cross-dairy cattle has never been explored to determine whether this is an issue affecting meat quality, and the incidence of aggressive and nervous animals within these crosses has never been quantified.

The temperament of cattle can be assessed by exit velocity (EV) and crush score (CS), traits that are persistent over time (Cafe et al. 2011). Temperamental cattle (faster EV or greater CS) can have lower growth rates, produce smaller carcasses with less fat cover, and have darker meat that is tougher to eat, all economically detrimental parameters (Behrends et al. 2009; Burrow et al. 1997; Cafe et al. 2011; Cooke et al. 2018; Olson et al. 2019). The slower growth may be a result of lower feed intake and/or more use of energy in avoidance behaviour. The inferior meat quality is partially a result of metabolic mechanisms. Temperamental cattle have a greater stress response to handling and transport, resulting in depletion of muscle glycogen before slaughter, more transport of lactate from the muscle into the bloodstream (Boles et al. 2015; Cafe et al. 2011), and hence, greater carcass pH and the associated negative characteristics. Consequently, evaluation of temperament early in life may be a helpful tool, because animals could be allocated to different management groups for yarding, feeding, production systems or end markets (Behrends et al. 2009; Burdick et al. 2011). Specific management practices for temperamental cattle could include being handled only by experienced staff, and go to slaughter without reaching their ideal fattening conditions, given that they would unlikely have good meat quality, nonetheless.

In most beef systems, one of the first calf-human interactions happens at weaning, when the calf is separated from its dam. This is one of the most stressful times in a beef animal's life, and it is argued that the variation in temperament measured at weaning may re-emerge at the time of harvest, when cattle are exposed to a novel experience and a new environment (Behrends et al. 2009; Cafe et al. 2011). However, animals do get used to being handled (Della Rosa et al. 2019; Parham et al. 2019). Calves born on a dairy farm are usually taken off their dams within 24 hours of birth and reared by humans. These calves are intensively handled at early ages and see the human as a source of feed rather than a threat. Phenotypic temperament may change because of this hand-rearing, and therefore, the relationship between temperament and performance is unclear for hand-reared beef-cross-dairy calves.

The aim of this experiment was to analyse measurements of temperament throughout the lifetime of Angus- and Hereford-sired cattle born to dairy-breed cows, and to evaluate the value of these measurements as predictors of growth and meat quality traits for beef-cross-dairy cattle reared by humans.

Materials and methods

This experiment uses the same animals for which growth and carcass traits were previously reported (Martín et al. 2020, 2021). This experiment was conducted at Limestone Downs, near Port Waikato, New Zealand (37°28'S, 174°45'E) with approval from the Massey University Animal Ethics Committee (15/65 and 18/50).

Animals and management

Angus-sired and Hereford-sired cattle born on Limestone Downs farm, in spring 2016 (n=564) and 2017 (n=513) were included in the study. The calves were born to dairy-breed cows which were predominantly Holstein-Friesian or Holstein-Friesian-cross-Jersey crossbred. For full details, refer to Martín et al. (2020). Angus (n=31) and Hereford (n=34) sires for the mixed-aged cows were selected on the basis of their estimated breeding values for birth weight, gestation length and live weight at 600 days of age (d), but docility was not included in the selection process, with very few sires (n=17 Angus) having a record for this trait. Angus (n=6) and Hereford (n=6) sires for the 15-month-old heifers were selected to be in the lightest 15% of breed for birth weight.

Mean birth date was 3 August 2016 and 5 August 2017 for the calves included in the present experiment, with an overall mean birth weight of 36.4 kg (SD 4.7). Calves were artificially reared on an allowance of 4-6 litres of milk/head/day, fed twice daily for the first three weeks and once daily afterwards, and calf meal was offered during the transition from milk to pasture (Coleman 2020). Calves were weaned at a minimum of 85 kg live weight, resulting in a mean age at weaning of 82 d (SD 11). Once weaned, calves were moved from the dairy platform to the sheep and beef hill-country platform of the same farm. Male calves were castrated before four months of age.

At four months of age, at a mean age of 131 d (SD 17), calves were allocated to six grazing herds based on live weight (light, intermediate and heavy) and sex (female and male) and balanced for sire so that, where possible, all sires were represented in each grazing herd within year. In total, there were 12 grazing herds (two years x two sexes x three liveweight groups), and animals remained in those herds throughout the experiment until slaughter. All cattle were grazed on summer-dry hill-country pasture on the coastal farm under commercial conditions (Martín et al. 2020).

Each grazing herd was slaughtered as a complete group on the same day, when the herd reached the slaughter target weight of 500 kg for heifers and 600 kg for steers (full details in Martín et al. (2021)). Heifers included in this study were slaughtered at a mean age of 823 d (range 693-934 d, 27 months old) and 520 kg (SD 38) live weight on-farm, whilst steers were slaughtered at a mean age of 887 d (range 821-955 d, 29 months old) and 614 kg (SD 42). Animals were processed commercially through Greenlea Premier Meats Ltd, Hamilton plant, according to standard New Zealand industry practice (Animal and Animal Products Directorate 2017), with Halal certification.

Measurements

Live weight. Animals were weighed from entry to the beef platform at a minimum of two-monthly intervals, as described by Martín et al. (2020). The live weights closest to 200 d, 400 d, 600 d and 800 d for each herd were used to estimate growth as average daily gain (ADG, in kg/d), calculated as the difference in live weight divided by the difference in days between the two ages.

Temperament. Temperament was assessed as a visual crush score (CS) and exit velocity (EV). The CS was assessed while animals were loosely restrained for weighing (20 seconds) in the weigh crate (cattle crush model Cattlemaster Titan, made by Te Pari Products Ltd, Oamaru, New Zealand; internal dimensions H 203.2 cm x L 300.6 cm x W 75.0 cm) at 200 d, 400 d, 600 d, 800 d and on the day of slaughter (mean age 856 d), within one hour after yarding. All CS assessment were made by the same person, on individual cattle based on the behavioural scoring system described by Grandin (1993) and adapted by Cafe et al. (2011): [1] Calm – none or slow movements, head mostly still; [2] Slightly restless - shifting, looking around more quickly, moving feet; [3] Restless - moving backwards and forwards, occasional shaking crate, squirming, may try to put head through bale; [4] Nervous - continuous vigorous movement backwards and forwards, snorting, shaking crate; and [5] Very nervous - continuous violent movement, attempting to jump out, rearing, twisting or violently struggling.

Exit velocity was measured as the time required to traverse 1.83 m distance after exiting the crush, once animals had been weighed at 200 d, 400 d, 600 d and 800 d. The time was measured using infrared photogates (TCi Wireless Timing System, Brower Timing Systems, UT, USA), and then converted to EV (m/sec). The first gate was 1.7 m in front of the weigh crate and the second was 1.83 m distance subsequently. This methodology was based on that of Burrow et al. (1988) and adapted by Behrends et al. (2009) and Boles et al. (2015).

Carcass and meat traits. Animals were slaughtered and bodies were dressed to commercial specifications as described by Martín et al. (2021). Carcasses were chilled (4±1ºC) overnight and, the following morning, one side of the carcass was cut between the 12th and 13th rib to expose the eye muscle (*M. longissimus thoracis*) for in-chiller assessment of ultimate pH and meat colour score. Ultimate pH was measured by pH spear (Eutech Instruments, Singapore) on the eye muscle and the mean of three measurements was used for analysis. Meat colour was scored against the AUS-MEAT / MSA reference standards (AUS-MEAT Limited 2018). Possible meat colour scores ranged from 1 (light) to 7 (dark).

Statistical Analysis

Data cleaning. Animals born to sires with a minimum of five progeny were included in analysis (excluded n=9 progeny of three sires in 2016 and n=3 progeny of one sire in 2017). Animals that went missing, were recorded to have ill health, were removed from their grazing herd for more than two months, or that died, were excluded from analysis of traits measured after they first left their herd (n=55 from 200 d to slaughter). For animals that had to be chased out of the exit race because they stopped within the 1.83 m, EV was considered 0 for that age (n=8 at 200 d, n=36 at 400 d, n=93 at 600 d, n=43 at 800 d). Animals that turned around and went through the exit race backwards were not considered for measures of EV at that age (n=17 at 200 d, n=4 at 600 d). The final dataset consisted of 1077 animals.

Statistical models. Means and histograms were used to analyse the spread and distribution of the individual temperament measurements (EV and CS) at 200 d, 400 d, 600 d, 800 d and pre-slaughter, with the MEANS and SGPANEL HISTOGRAM procedures (SAS 9.4, SAS Institute Inc., Cary, NC, USA). Pearson correlations coefficients among individual temperament measurements across age, were calculated with the CORR procedure.

General linear models were used to estimate the association of temperament measurements (either EV or CS) at 200 d with ADG between 200-800 d and 200-400 d, temperament at 400 d with ADG between 400-600 d, and temperament at 600 d with ADG between 600-800 d, with the GLM procedure. Similarly, the GLM procedure was used to estimate the association of temperament measures at 800 d and pre-slaughter (mean age 856 d), with ultimate pH and meat colour scores. All models included the fixed effects of breed of sire (Angus and Hereford) and grazing herd (12 herds), and the random effect of sire within breed (73 sires).

Table 1 Number, mean (±SD) and range of temperament measurements as exit velocity (in metres per second) and crush score (scale 1 to 5) of beef-cross-dairy cattle at 200, 400, 600, 800 and 856 (mean age at slaughter) days of age.

Trait	Age	N	Mean	Range
Exit velocity (m/s)	200 d	492	1.15 ± 0.44	0 - 3.05
	400 d	1036	1.06 ± 0.49	0 - 3.10
	600 d	1004	0.76 ± 0.50	0 - 2.65
	800 d	744	0.96 ± 0.51	0 - 2.69
Crush score	200 d	512	1.43 ± 0.62	1 - 3
	400 d	1067	1.79 ± 0.78	1 - 5
	600 d	1036	1.50 ± 0.70	1 - 4
	800 d	763	1.40 ± 0.65	1 - 4
	856 d	1025	1.38 ± 0.63	1 - 4

Results

Cattle in this study grew at 0.58 kg/d (SD 0.07) from 200 d to 800 d, achieving a live weight of 505 kg (SD 47) at 800 d and a carcass weight of 278 kg (SD 31) at a mean age of 856 d. Growth rates varied over the time of the experiment, with an ADG for 200-400 d of 0.61 kg/d, for 400-600 d of 0.77 kg/d and for 600-800 d of 0.39 kg/d. Meat quality traits were within the expected values for beef, with ultimate pH of 5.68 (SD 0.16, range 5.39-6.55) and a meat colour score of 3.0 (SD 0.6, range 1-6).

Temperament of beef-cross-dairy cattle during their lifetime

Cattle in this study had a mean EV between 0.76 and 1.15 m/s at the different timepoints from 200 d to 800 d (maximum of 3.10 m/s, Table 1), and a mean CS between 1.38 and 1.79 at the different timepoints from 200 d to slaughter (maximum of CS 5 on a 1-5 scale). Distribution of the data was right skewed for both traits (data not shown), but more pronounced for CS, with the majority of animals scoring 1 (calm) at any age, and only 22 records (from 4403 records, <0.5%) of 19 animals scoring 4 or 5 (nervous or violent).

Temperament measurements were correlated at all ages (P<0.05, Table 2). Measurements of EV had Pearson correlation coefficients between 0.16 to 0.35 (P<0.001) with the greater correlations at closer ages and decreasing over time. Measurements of CS had Pearson correlation coefficients between 0.28 to 0.60 (P<0.001), also with greater correlations at closer ages but increasing over time. Correlations between trait measurements had coefficients from 0.14 to 0.34 (P<0.001, except for CS200 d-EV800 d with P<0.01), with the greatest correlations between EV and CS at the same age.

Temperament effects on production

Temperament at 200 d and 400 d was not related with the growth of the cattle in the study (P>0.05, Table 3). There was a small association of CS at 600 d with ADG from 600-800 d, such that cattle with higher CS grew less during this period (-0.011 kg/d for a 1-point increase in CS,

Table 2 Pearson correlation coefficients between temperament measurements as exit velocity (in metres per second) and crush score (scale 1 to 5) of beef-cross-dairy cattle at 200, 400, 600, 800 and 856 (mean age at slaughter) days of age. All values are significant to P<0.001, except for the coefficient indicated with * (P<0.01).

		Exit velocity			Crush score				
	Age	400 d	600 d	800 d	200 d	400 d	600 d	800 d	856 d
Exit velocity	200 d	0.35	0.21	0.16	0.30	0.24	0.17	0.21	0.15
	400 d		0.33	0.25	0.21	0.34	0.24	0.19	0.21
	600 d			0.26	0.18	0.16	0.30	0.22	0.15
	800 d				0.14*	0.25	0.31	0.28	0.23
Crush score	200 d					0.41	0.37	0.28	0.30
	400 d						0.48	0.40	0.39
	600 d							0.51	0.43
	800 d								0.60

Table 3 Estimates of regression coefficients (P value in brackets) of temperament measurements (crush score and exit velocity) on growth (average daily gain, ADG) and meat quality traits (ultimate pH and meat colour scores), and P values for breed, sire and grazing herd effects in beef-cross-dairy cattle at 200, 400, 600, 800 and 856 (mean age at slaughter) days of age.

Trait	Age	Regression coefficient (P value)		Effect P value			N	R^2
		Exit velocity	Crush score	Breed[1]	Sire[2]	Grazing herd[3]		
Growth (kg/d)								
ADG 200-800 d	200 d	-0.003 (0.501)		0.059	<0.001	<0.001	468	0.66
	200 d		-0.001 (0.843)	0.025	<0.001	<0.001	488	0.66
ADG 200-400 d	200 d	-0.004 (0.547)		0.816	0.001	<0.001	487	0.61
	200 d		-0.003 (0.575)	0.626	0.001	<0.001	507	0.61
ADG 400-600 d	400 d	-0.006 (0.320)		0.009	<0.001	<0.001	995	0.33
	400 d		-0.003 (0.360)	0.004	<0.001	<0.001	1026	0.32
ADG 600-800 d	600 d	-0.007 (0.249)		0.428	<0.001	<0.001	914	0.52
	600 d		-0.011 (0.008)	0.665	<0.001	<0.001	939	0.53
Meat quality								
Ultimate pH	800 d	-0.001 (0.899)		0.649	0.651	<0.001	653	0.50
	800 d		-0.004 (0.594)	0.691	0.689	<0.001	670	0.50
	856 d		-0.007 (0.352)	0.253	0.198	<0.001	856	0.47
Meat colour	800 d	0.069 (0.078)		0.142	0.576	<0.001	639	0.22
	800 d		0.015 (0.593)	0.101	0.347	<0.001	658	0.23
	856 d		0.028 (0.367)	0.031	0.151	<0.001	914	0.18

R^2: coefficient of determination. [1]Breed effect P value: n=2 breeds, Angus and Hereford. [2]Sire effect P value: n=73. [3]Grazing herd effect P value: n=3 herds per sex, based on live weight (light, intermediate and heavy) at entry to the beef platform.

$P<0.05$). Temperament at 800 d or prior to slaughter was not related with meat colour scores or ultimate pH ($P>0.05$, Table 3).

Sire and grazing herd were highly associated with ADG at all ages ($P<0.05$), and grazing herd was also associated with both pH and meat colour scores ($P<0.05$).

Discussion

Cattle in this study were calm. This is supported by previous studies in which the temperamental response to handling of *Bos taurus* breeds (such as Angus, Hereford and their crosses) has been low (Burnham et al. 2005; del Campo et al. 2021), particularly when compared with *Bos indicus* breeds or their crosses (such as Brahman, Nellore or other tropical breeds) (Burrow et al. 1997; Cafe et al. 2011). Mean values of EV reported for *Bos Taurus* cattle ranged from 1.10 to 3.69 m/s and for CS from 1.34 to 3.15 (Boles et al. 2015; Cafe et al. 2011; Coombes et al. 2014; Della Rosa et al. 2019; Parham et al. 2019), while the cattle in this study had mean values in the lower bound of the ranges previously reported (EV from 0.76 to 1.15 m/s and CS from 1.38 and 1.79). In addition to the genetic predisposition, animals' responses depend on previous experiences (Grandin et al. 2015), and these cattle were hand-reared, thus they were used to being handled and unlikely to consider humans as a threat. Consequently, the inherited temperament may already not be expressed by 200 d.

Temperament measurements were correlated at all ages, with similar coefficients compared to previous studies (Boles et al. 2015; Cafe et al. 2011; Parham et al. 2019), indicating that these measures are repeatable. Correlations for EV decreased over time, and this has also been shown in earlier experiments (Cafe et al. 2011; Della Rosa et al. 2019). On the other hand, correlations for CS between ages increased as animals got older, while the actual CS decreased over time. Similar effects have been reported in heifers that acclimatised to frequent handling, presenting lower but more consistent CS across time (Parham et al. 2019).

Overall, temperament was not related with growth or meat quality. There was only a small association of CS at 600 d with growth, representing a total potential 2.2 kg for each CS during the 600-800 d period. This is supported by studies with *Bos taurus* breeds, where correlations between temperament and live weight were typically not strong (Boles et al. 2015; Burnham et al. 2005; Cafe et al. 2011; Della Rosa et al. 2019; Haskell et al. 2014). The lack of temperament effects on meat quality has been reported previously for ultimate pH (Burnham et al. 2005; Coombes et al. 2014) and meat colour (Della Rosa et al. 2019), even in animals with higher EV and when comparing both *Bos taurus* and *Bos indicus* breeds (Coombes et al. 2014). It is likely that the animals in this study were too docile for there to be any effect of temperament on performance traits, and the generally good meat quality obtained did not create a range of pH or meat colour to incur a correlation.

In contrast, the effect of contemporary group (grazing herd) was important across all production traits measured. The effect on growth was expected as animals were allocated to grazing herds based on live weight at 131 d. Further, a contemporary group effect has been shown repeatedly in cattle studies, where yarding and handling can affect growth of the animals, and yarding, handling, transportation, and conditions around slaughter can contribute to post-mortem muscle ultimate pH (Dixon et al. 1996; Njisane et al. 2017; Warner et al. 2010; Woiwode et al. 2016). In turn, ultimate pH has significant effects on all the meat quality measurements, including meat colour (Ertbjerg et al. 2017; Hughes et al. 2014; Purchas 1990; Purchas et al. 1993).

In conclusion, beef-cross-dairy cattle in this study were calm and the small variation in EV and CS among animals was likely a result of hand-rearing on the dairy farm and cattle being acclimatised to handling, yarding and the presence of humans. Overall, temperament was not related with growth or meat quality, probably because the animals in this study were too docile for there to be any effect of temperament on performance traits. Therefore, temperament is unlikely to be an issue in hand-reared and frequently handled beef-cross-dairy cattle, so producers can expect temperament to have minimal influence on growth and meat-quality traits.

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