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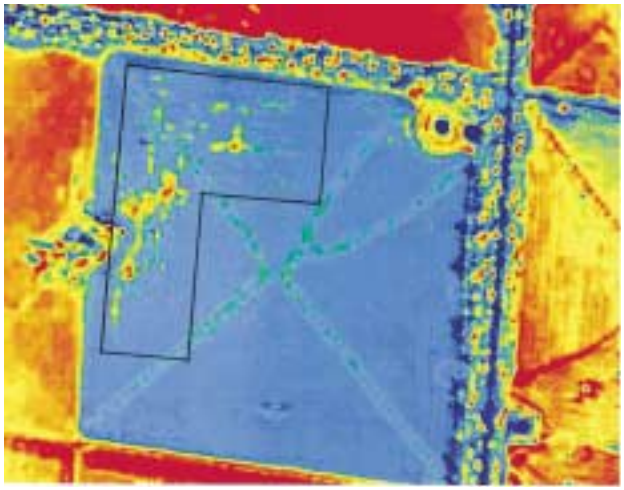

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# Productivity, carcass and meat quality of lot-fed *Bos indicus* cross steers grouped according to temperament

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*Abstract.* One hundred and twenty *Bos indicus* cross steers were allocated to 3 treatments (good, mixed and poor) on the basis of flight speed, as a measure of cattle temperament. The cattle were lot-fed for 100 days and data collected at intervals on their temperament (flight speeds) and productivity (liveweight changes, body condition, pen feed intakes) during this time. After slaughter, data were collected on carcass traits and meat quality. Eating-quality attributes were measured in meat samples from 22 carcasses from each treatment.

Flight speeds were highly correlated across animals and within treatments, showed little change in variability over time and were highly repeatable. Flight speed indicated a slight deterioration in temperament with time in the feedlot until day 70, suggesting an increasing fearfulness in the steers. Differences in flight speeds between treatments were maintained throughout the feedlotting period; poor-temperament animals retained poor temperaments and good retained good.

Flight speed was correlated with measures of production, and flight speed measured at feedlot induction was a predictor of performance. Correlations and treatment effects showed that cattle with poor temperaments had poorer average daily gains, feed conversion efficiencies, body conditions and dressing percentages compared with those with good temperaments. Reduced performance in the poor-temperament animals may have resulted from their fearfulness and state of high arousal.

Treatment (temperament grouping) did not influence carcass traits, but there was evidence of lower initial pH levels and indicators of 'heat-shortening' in the meat of steers with poor temperament compared with those with good temperament. These findings suggest that the poor temperament steers were more susceptible to pre-slaughter stressors than the good temperament animals. However, the meat quality differences were not detected in eating-quality measurements.

## Introduction

Temperament has been defined and measured in numerous ways (see review by Burrow 1997), but the majority of the definitions and tests have, as a common element, the response of an animal to handling by humans. Animals that are calm and docile during handling are said to have good temperaments, while those that are nervous and flighty are said to have poor temperaments. Evidently, if temperament is defined in such a way that it involves the response of an animal to being handled by humans, then an animal's temperament will have a profound effect on the way it reacts in any situation that involves contact with humans. This contact may not be just physical, but also visual, auditory and possibly olfactory. Indeed, many of the methods of handling and moving livestock rely on the animals moving away from aversive stimuli, such as humans shouting (Pajor *et al.* 2000) or waving sticks with plastic or cloth attached (Grandin 1987). Indeed, livestock handling commonly induces a fear response in animals (Hemsworth and Coleman 1998). Virtually every aspect of cattle management, from conception to slaughter, involves proximity to humans and induces fear to a greater or lesser extent. Thus, temperament is a significant factor in cattle production. There is evidence that temperament influences ease of handling (Fordyce *et al.* 1988*a*; Matthews *et al.* 1997), liveweight gains in feedlots (Voisinet *et al.* 1997*a*; Fell *et al.* 1999) and at pasture (Fordyce *et al.* 1985, 1988*a*), carcass damage (Fordyce *et al.* 1988*b*) and aspects of beef quality (Fordyce *et al.* 1988*b*; Voisinet *et al.* 1997*b*).

Temperament has been shown to be a heritable trait (Burrow and Corbet 2000), but also experiences are known to influence it (see review by Burrow 1997). According to Grignard *et al.* (2000), cattle responses to handling depend on aspects of the environment in addition to the presence of

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humans, including the social environment. Generally, cattle tend to be less agitated during handling if they are grouped rather than single (Grandin 1987), probably because they are less fearful. Indeed, many tests to assess fear incorporate social isolation (Mason 2000). Furthermore, cattle exposed to potentially fear-inducing situations appeared less fearful when peers were present compared with when individuals were isolated (Boissy and Le Neindre 1990; Veissier and Le Neindre 1992). However, we do not know whether there are longer-term changes to temperament as a result of the social environment. There are contradictory anecdotal reports from the Australian cattle industry as to whether or not group mates influence the temperament of individuals. It has been suggested that the presence of 1 or 2 nervous, flighty animals in a group of calm, docile ones will result in the entire group becoming nervous and flighty. The opposite has also been suggested; that the presence of 1 or 2 calm, docile animals in a group of otherwise nervous, flighty ones will result in all becoming calm and docile. If such assertions are true then there are significant implications for the cattle industry. If cattle do influence each others' temperaments then there could be opportunities to produce greater numbers of good temperament cattle, without the delays associated with breeding programs, and to rapidly improve production and meat quality.

This experiment was conducted (i) to assess whether the temperament (as measured by flight speed) of cattle changes during feedlotting, (ii) to assess whether temperament is influenced by that of group mates, and (iii) to investigate the relationships between temperament, productivity and carcass and meat quality.

## Materials and methods

*Ethical animal use*

The use of animals in this experiment was approved by an Animal Ethics Committee in accordance with the 'Australian Code of Practice for the Care and Use of Animals for Scientific Purposes, 6th edition'. Animal care and management complied with the 'Australian Model Code of Practice for the Welfare of Animals. Cattle.'

*Location and animals*

The experiment was conducted at Brigalow Research Station (24°50′S, 149°48′E) in the brigalow region of Central Queensland. It is a subhumid subtropical environment with mean maximum and minimum temperatures ranging from between 21 and 33°C for January to between 4 and 22°C for July. The annual average rainfall for the station is 730 mm with about 50% of it falling in the November–February period.

The cattle were stabilised 5/8 Brahman × 3/8 Shorthorn steers bred at Swan's Lagoon Research Station (20°05′S, 147°13′E), situated in the subcoastal speargrass region of North Queensland.

All of the steers had been mustered and handled through cattle yards on Swan's Lagoon at least twice annually from the time that they were weaned. Some of the steers had been used in other studies and had been mustered and handled through the yards on about a dozen occasions since weaning. When the steers were about 2 years of age (mean liveweight of about 335 kg), they were transported about 850 km from Swan's Lagoon Research Station to Brigalow Research Station, arriving in December.

On arrival at Brigalow, the cattle were grazed as a single group for about 5 months on improved pasture of a mixture of buffel grass (*Cenchrus ciliaris*), bluegrass (*Dichanthium sericeum*), Rhodes grass (*Chloris gayana*) and green panic grass (*Panicum maximum*). During this period, they were mustered to the yards for weighing and the recording of their flight speeds (see below) on 3 occasions between early February and late April. One hundred and twenty animals from this group were selected for the experiment on the basis of their liveweight recorded in April. Using the mean of the 3 flight-speed measures, the steers were allocated to 4 replicate pen groups (10 head per pen) of 3 treatments with liveweights matched as closely as possible in the pen groups. The treatments were the following: good temperament — flight-speed range 0.80–1.69 m/s, with a liveweight (mean ± s.d.) of 448 ± 27 kg; poor temperament — flight-speed range 1.89–4.41 m/s, with a liveweight (mean ± s.d.) of 446 ± 23 kg; mixed temperament — on this treatment half of the animals were good temperament and half were poor, flight-speed range 0.86–3.70 m/s, with a liveweight (mean ± s.d.) of 445 ± 27 kg.

The pen groups were allocated to 12 feedlot pens in a randomised block design. Allocation to treatments and feedlot pens took place 17 days before feedlot induction. In addition, 4 animals, representing a range of flight speeds from the group, were selected from each pen group as 'focal animals' for blood sampling. The data relating to these samples are not presented in this paper.

*Weather conditions during the experiment*

The experiment took place during the period from the middle of May to the end of August. Climatic data were collected daily at 0900 hours from a weather station about 3 km from the feedlot. During the experimental period, rain fell on 8 days (total of 124.4 mm). The mean maximum and minimum temperatures (and ranges) over the experimental period were 22.8°C (17.4–27.0°C) and 7.8°C (–0.5–16.6°C), respectively. A summary of the weather conditions during the feedlotting period is given in Table 1.

*Experimental procedures*

The cattle were inducted over a 2-day period, from about 0800 to 1800 hours on the first day and from 0700 to 1030 hours on the second day. All animals were placed into their pens by 1100 hours of the second day. During the induction process, all animals were weighed, condition-scored (see below) and had their flight speeds recorded. They were then moved into a crush where they were ear-tagged for ease of individual identification; had a controlled-release anabolic implant (Compudose100, Elanco Animal Health, Sydney) placed in the ear; and

**Table 1. Temperature, relative humidity and rainfall during feedlotting period**

| | 16–31 May | June | July | 1–26 August |
|---|---|---|---|---|
| Mean max. temp. (°C) | 23.5 | 21.7 | 22.0 | 24.1 |
| Mean min. temp. (°C) | 9.8 | 8.0 | 6.9 | 6.6 |
| Mean relative humidity (%) | 83.2 | 73.6 | 71.4 | 61.5 |
| Rainfall (mm) | 112.8 | 0.2 | 5.2 | 6.2 |

were ear-marked to indicate the presence of the growth promotant. They were vaccinated against bovine ephemeral fever [Websters bovine ephemeral fever vaccine (living), Cyanamid Websters Pty Ltd, Sydney] (and given a booster 5–6 weeks later) and against the common clostridial diseases (Websters 5 in 1 vaccine for cattle and sheep, Cyanamid Websters Pty Ltd). A blood sample was taken from the coccygeal vein of the focal animals. For the first day all of the animals were held in the yards on feed (hay) and water. On the second day they were drafted into their pen groups and put into the feedlot pens. Feed was available in the feedbunks at the time of feedlot entry. After entry the cattle were left undisturbed for the remainder of the day (day 1). At feedlot entry the cattle weighed, on average, 455 kg.

*Measuring flight speed*. Flight speed was based on the principle developed by Burrow *et al.* (1988). It is the time taken for an individual animal to cover a set distance when it is released from a weighing crate, expressed in m/s. The measuring device consisted of 2 sets of light-beam generators and reflectors on stands and a timer. The stands were set up at the side of the race leading from the weighing crate, so that the light beams projected to the reflectors at 90° to the direction of travel of the animal. The first stand was 1.5 m from the exit of the weighing crate and the stands were 2.6 m apart. On release from the crate, an animal would move forward along the race, breaking the first light beam, which would start the timer. When the animal broke the second beam the timer stopped, displaying the time that the animal had taken to cover the 2.6 m. This value was converted to m/s for analysis.

*Routine for measuring and sampling*. On days 21, 45 and 70 the cattle were measured and sampled as follows: starting at about 0700 hours, the cattle were removed from the first 3 pens, with the pen groups remaining separated at all times. They moved to the yards, through the race to the weighing crate where they had their liveweights, body-condition scores and flight speeds recorded. Body condition was scored on a scale of 1–9, where 1 is emaciated and 9 is over-fat (Holroyd 1985). Each pen group was then moved through the yards a second time and confined in a different race so that blood samples could be collected from the focal animals. When blood sampling was completed for each pen group they were returned to their home pen. The next 3 pens of cattle were then moved to the yards, and so on until all cattle had been measured. The order in which the pen groups were removed and worked through the yards was always the same (i.e. pens 12B to 7A, see below). The process for all pens took about 4.5 h.

On day 101, the cattle were weighed, body condition scored and flight speeds recorded, but no blood samples were taken from the focal animals. This process took about 1.5 h. A blood sample was collected from all animals at exsanguination on day 103.

*Feedlot pens*. The feedlot pens were 7.5 by 20 m, with a 4.8 m long feed bunk positioned centrally at the eastern end of the pen. An area of concrete extended 3 m from the feed bunk and 2.5 m from the water trough, with the remainder of the pen surface being an earth-manure 'pad'. The water trough, 2.5 by 1.0 m, was shared between adjacent pens and was located on the pen division towards the western end of the pens. Shade cloth (75% exclusion), which was 3.6 m wide (18% of the pen area), ran across the middle of all pens (north–south) at a height of about 3.6 m from the ground. Pens were divided by either steel cables running between posts, or temporary fencing panels. Gates between pens at the western end allowed the entry and exit of cattle. To reduce the influence of cattle on each other, rubber belting was used to cover pen dividers as far as the water troughs. The belting also extended to the front of the feedbunk, so producing a solid barrier between the feedlot pens.

The 12 pens were adjoining and were numbered from south to north, from 7 to 12, with each number given the letter A or B, i.e. 7A, 7B, 8A, 8B and so forth to 12B. Pen 12B was adjacent to the entrance of the feedlot. Feeding always occurred in the order of 7A to 12B.

*Feedlot management—ration*. The feedlot ration was 13.9% crude protein and 13.4 ME MJ/kg and it comprised on a dry matter basis, 68% sorghum grain, 8% whole cottonseed, 14.5% roughage, 3% molasses, 2% added fat and 4.5% Farmstock '400 Plus' (a proprietary supplement mixture of minerals, vitamins and rumen modifier). The cattle were introduced to this ration over a 21-day period, with increasing levels of grain (from 26%) and decreasing levels of roughage made at weekly intervals. The cattle were on the final ration by day 22.

*Feedlot management—feeding*. The cattle were fed twice daily, starting at about 0800 and 1400 hours, with 30–40% of their expected intake delivered in the morning and the remainder in the afternoon. New feed-outs were adjusted from previous intakes with the aim that animals have access to feed at all times. The feed ration was mixed before each feeding session, with a sample of the mix taken at each session. These samples were bulked for each week of the trial and a subsample of the weekly sample tested for dry matter content. All feed bunks were cleaned out weekly with a sample of the residue feed taken for dry matter analysis. All pen residues were individually weighed and pen-group intakes calculated on a wet and dry feed basis for each week. Residues were also collected and weighed following rainfall and at the end of the trial on day 102. Water troughs were scrubbed and refilled at least weekly.

*Feedlot management—inspection of cattle*. The cattle were inspected for signs of injury, illness and lameness daily, both from the tractor-cab during feeding, and a person walking through them, when any animal that was lying down was encouraged to stand and move.

*Transportation to abattoir*. The cattle were given extra feed at the afternoon feeding on day 100 and most food had been eaten on the morning of day 101. The cattle were given no further feed this day. On the morning of day 102, 2 loads of cattle were transported, on the same truck, about 120 km to the abattoir (a journey time of about 2 h 15 min, including 1 stop to check the cattle). The truck comprised 3 compartments on both the upper and lower deck. Each pen group of animals went into a separate compartment with treatments balanced, as far as possible, for deck and compartment position. Loading on both occasions took about 20 min.

Unloading and penning at the abattoir took about 15 min each time. Each pen group was put in separate pens, but overnight 2 of the pen groups (1 each of the poor and mixed replicates) were accidentally combined into 1 pen.

*Slaughter*. The following morning (day 103) the trial cattle were moved into the abattoir from the lairage pens at about 0800 hours. Each group was moved into a washing pen where they were sprayed with water under high pressure for 3–4 min. They then moved to a second pen where they were held until they were moved up in single file to the stunning box. The kill order was by pen groups as for weighing during the trial.

Stunning was by means of a captive bolt pistol then the animals were hoisted onto the processing chain by 1 hind leg and the throat cut for exsanguination. A 10-mL blood sample was collected from each animal at this stage. The first steer was slaughtered at 0850 hours and the last at 1050 hours. About 5 min after slaughter, each body was electrically stimulated via nasal and rectal probes for about 45 s, using low-voltage stimulation (45 V, 36 pulses/s). The number of permanent incisors (dentition) was recorded and the carcasses were split into sides and weighed. From the carcass weight and the pre-trucking liveweight, the dressing percentage (carcass weight/liveweight × 100) was calculated. Carcasses were scored for bruising (1–9, depending on number, position and severity of bruises), had butt profile recorded (A to E, where B and C are the preferred shape for aesthetic reasons), P8 fat depth measured (mm) (AUS-MEAT 1998) and were graded according to market specifications. The carcasses entered the chillers about 40 min after slaughter.

*Carcass data*. Carcass pH and temperature were measured with a hand-held device in the *M. longissimus dorsi* (LD) at the 12–13th-rib area according to the procedure described by Meat Standards Australia (MSA 2001). A 2-point calibration (at pH 6.88 and 4.00) of an approved meter was carried out at the beginning of the day, before measurements were taken on the carcasses (MSA 2001). An incision about 10 mm wide was made and the dual probe inserted to a depth of about 20–30 mm into the LD. This was on the right side of the carcass on entry into the chiller. Second recordings of carcass pH and temperature were made about 1 h after chiller entry. After overnight chilling all sides were sliced at the 12–13th rib and a qualified Aus-Meat assessor carried out a standard 'chiller assessment' (AUS-MEAT 1998) for marbling (0, no marbling, to 6, heavy marbling), meat colour (1A, 1B, 1C to 7, very light red to very dark red); and fat colour (0, white, to 9, creamy yellow). Twenty-two sides from each treatment group were selected based on a representative range of initial flight speeds and liveweights (measured on day 70 of feedlotting) of the steers within each pen (5 or 6 per pen). On this subset of 66 sides, third carcass pH and temperature ('ultimate' values) recordings were made between 0600 and 0830 hours (i.e. between 21 and 24.5 h after slaughter) by inserting the probe into the exposed muscle.

*Eating-quality measurements*. The LD from the right side of the subset of 66 sides was collected in the boning room, stored at 1°C, and sent to the Brisbane Laboratory, Food Science Australia, where the samples were aged for 14 days, sliced and frozen. The eating quality of the LD samples was assessed as part of the MSA grading scheme and the 4 sensory dimensions of tenderness, juiciness, flavour and overall acceptability were combined into a single Meat Quality Score (MQ4) (Polkinghorne *et al.* 1999).

*Data analyses*

All analyses were performed using the statistical package Genstat (Genstat 5 Committee 1993). Initial analyses indicated that blocks were not significant for any variables. In all subsequent analyses the block factor was not included. Variates recorded once only, e.g. average daily gain, carcass- and meat-quality measures, were subjected to a 1-way analysis of variance with the residual estimated from variation between pens within treatments. Variates measured repeatedly over time, e.g. flight speed, body-condition score, liveweight and feed intake, were subjected to split-plot in time analysis of variance with pens as the main plots and times as the subplots. The degrees of freedom in the pen × time stratum were adjusted for lack of compound symmetry of the variance–covariance matrix using the method of Greenhouse and Geisser (1959). The variance of flight speed within each pen at each time of measurement during feedlotting was analysed using the split-plot in time analysis of variance after taking logs of the pen variances.

A chi-squared test was applied to discrete variables such as dentition, marbling and muscle colour to compare the distributions of classes across treatments.

Since some steers lost weight in the early phase of feedlotting, feed conversion efficiency (FCE) was calculated as the inverse of the common method, i.e. inverse FCE (*i*FCE) = average daily gain/average daily intake. Inverse FCE over various periods were subjected to 1-way analysis of variance.

In all analyses of variance, the treatment sum of squares was partitioned into 2 orthogonal contrasts: Poor *v.* good treatment; and mixed *v.* the other 2 treatments ('the rest'). These comparisons made biological sense, as the mixed treatment comprised animals with poor and good temperaments and, thus, it was unlikely that this treatment would differ from the others. On the other hand, effects of temperament would be revealed by comparing the poor and good treatments. For the same reason, we believed that the accidental mixing of a poor and mixed treatment pen group during lairage was unlikely to influence the results, and so the mixing was ignored for the purposes of analyses.

Correlations between flight speeds of steers at different times were calculated. The repeatability of flight speed over time was calculated using the method of residual maximum likelihood to calculate variance components. The model used was:

$$Y_{ij} = \mu + \text{date}_i + \text{steer}_j + \text{error}_{ij}$$

where $Y_{ij}$ = the measurement for the *j*th steer on the *i*th date; μ = overall mean; $\text{date}_i$ = fixed effect for the *i*th date; $\text{steer}_j$ = random effect of the *j*th steer; $\text{error}_{ij}$ = random variation. Repeatability was calculated as: repeatability = animal variance component/(animal + error variance components).

To investigate possible relationships between flight speed and production measures, correlations were calculated. Pearson's correlations were calculated between flight speeds and average daily gains, carcass traits, meat-quality and eating-quality measures using data from individual animals. Spearman's rank correlation was used to assess the correlations between flight speeds and body-condition scores of individual animals. Pearson's correlations between flight speed and intake and *i*FCE were based on data from each pen, since intakes were measured on a pen basis.

## Results

*Flight speed*

The correlations between flight speeds taken before feedlot entry (the mean of which was used to allocate animals to treatments), together with those recorded during feedlotting, ranged from 0.53 to 0.78 ($P<0.01$ for all). Correlations between flight speeds recorded on days 0–101 for the treatments were the following: poor 0.33–0.71 ($P<0.05$), mixed 0.21–0.83 ($P<0.05$ for all except the lowest) and good 0.34–0.73 ($P<0.05$).

The repeatabilities (± s.e.) of flight speeds for all steers for the periods before and after feedlot entry, before feedlot entry and during feedlotting were 0.68 ± 0.03, 0.72 ± 0.04 and 0.69 ± 0.03, respectively.

There were no differences ($P>0.05$) between treatments or times for variance of pen flight speeds (log-transformed). Overall means of log (variance) were 0.583, 0.574 and 0.349 (s.e. is 0.089) for poor, mixed and good treatments, respectively.

There was a significant ($P<0.001$) effect of day on flight speed, with a trend for flight speeds to increase up to day 70 and then decrease on day 101. Treatment had no effect on changes in flight speed and the patterns of flight speeds during feedlotting were similar for the 3 treatments (see Fig. 1). There was also a significant ($P<0.001$) effect of treatment that demonstrated that the differences in flight speeds in the treatment groups were maintained throughout the experimental period.

*Liveweight*

All steers gained little liveweight from day 0 to day 21, but gained weight linearly thereafter (Fig. 2). Throughout the feedlotting period (days 0–101), treatment tended to affect liveweight ($P = 0.10$) and the contrast between poor and good was significant ($P<0.05$), whereas the contrast between mixed and the rest was not.

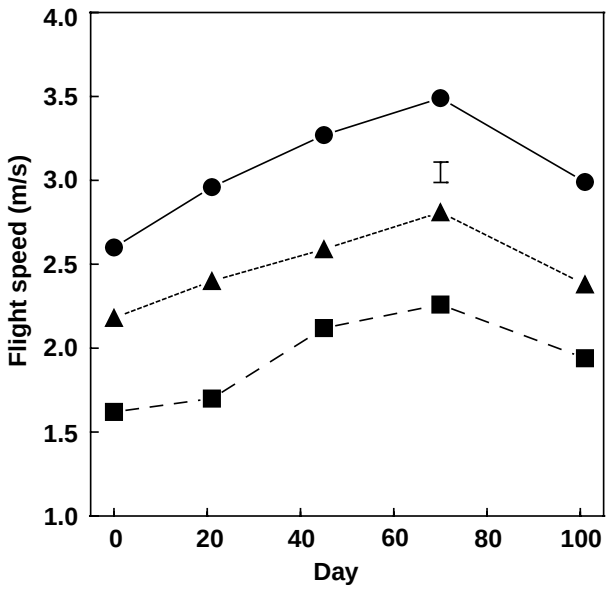


**Figure 1.** Mean flight speed of steers on poor (●), mixed (▲) and good (■) treatments during feedlotting. The vertical bar is the s.e. of the means.

*Average daily gain*

There was no significant effect of treatment on ADGs during days 0–21 or from day 21 to day 101. However, there was a trend for a difference between the poor and good over the whole period ($P = 0.07$; Table 2), but not for mixed and the rest.

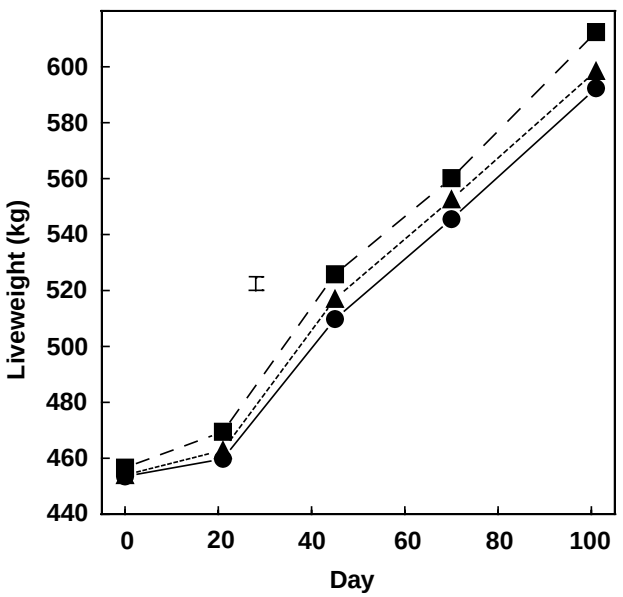


**Figure 2.** Mean liveweight of steers on poor (●), mixed (▲) and good (■) treatments during feedlotting. The vertical bar is the s.e. of the means.

*Body-condition score*

There was a significant ($P<0.05$) effect of treatment on body-condition score during the feedlotting period, with the contrast between poor and good also being significant ($P = 0.01$), but that between mixed and the rest was non-significant ($P = 0.92$). At induction, there was no difference between the treatments ($P = 0.57$), with the mean values being 6.03, 6.08 and 6.15 (s.e. is 0.11) for poor, mixed and good, respectively. On day 101, the mean values were 7.13, 7.42 and 7.48 (s.e. is 0.13) for poor, mixed and good, respectively ($P = 0.054$). Body-condition scores increased ($P<0.01$) consistently across treatments during the feedlotting period.

*Feed intake*

There was no effect of treatment on feed intake (kg DM/head.day). However, there was a significant ($P<0.001$) effect of week on intake. Intakes were 8.48, 13.16, 12.29, 12.39, 13.17, 13.56, 13.64, 13.24, 12.67, 12.71, 12.22, 12.40, 12.17, 12.03 and 12.29 kg DM/head.day (s.e. is 0.14) for weeks 1–15, respectively, with the major difference being between week 1 and the remaining weeks.

*Inverse food conversion efficiency*

There was a trend for treatment to affect *i*FCE during the feedlotting period ($P = 0.12$), with mean values being 0.111, 0.116 and 0.123 (s.e. is 0.004) for poor, mixed and good, respectively. The contrast between poor and good was significant ($P<0.05$), while mixed *v.* the rest was not ($P = 0.92$).

*Carcass and meat quality*

Analysis of the time interval between stunning and electrical stimulation revealed no difference between the treatments groups, with the mean interval being 5 min for all treatments. There were no differences between treatments in the interval between the recording of the first and second carcass temperatures and pH values, with the means being 97.4, 85.4 and 89.9 min for the poor, mixed and good groups, respectively.

Some of the data collected (butt shape, grade, bruising and fat colour) could not be statistically analysed because there was little to no variability. There were 3 butt shapes of B and the remainder were type C. All but 1 animal graded as

**Table 2. Average daily gains for steers on the poor, mixed and good treatments during different phases of feedlotting**

| Treatment | Day 0–21 | Day 21–101 | Day 0–101 |
|---|---|---|---|
| Poor | 0.30 | 1.66 | 1.37 |
| Mixed | 0.42 | 1.70 | 1.43 |
| Good | 0.61 | 1.79 | 1.54 |
| s.e. | 0.15 | 0.07 | 0.06 |
| *P*-value (poor *v.* good) | 0.19 | 0.20 | 0.07 |
| *P*-value (mixed *v.* rest) | 0.87 | 0.76 | 0.71 |

**Table 3. P8 fat depth, total carcass weight, dressing percentage, and carcass temperature and pH values of all carcasses on entry to, and 1 h after, in the chiller and a subset of 66 carcasses ('ultimate') from poor, mixed and good treatments**

| Treatment | P8 fat (mm) | Carcass wt (kg) | Dressing (%) | Temp. on entry | pH on entry | Temp. 1 h after | pH 1 h after | Ultimate temp. | Ultimate pH |
|---|---|---|---|---|---|---|---|---|---|
| Poor | 14.8 | 314.7 | 53.17 | 36.5 | 5.74 | 29.2 | 5.43 | 10.1 | 5.49 |
| Mixed | 15.5 | 316.9 | 52.95 | 37.6 | 5.85 | 31.0 | 5.43 | 11.2 | 5.46 |
| Good | 15.7 | 324.9 | 53.03 | 37.4 | 5.92 | 30.8 | 5.45 | 10.3 | 5.48 |
| s.e. | 0.8 | 4.6 | 0.4 | 0.6 | 0.06 | 1.1 | 0.02 | 1.2 | 0.03 |

suitable for the Japanese market. Bruising scores were 0 (no bruising) except for 1 animal that scored 3 (1 serious bruise in the loin). All animals had a fat colour of 0.

Treatment had no effect on dentition, muscle colour and marbling scores. Of the steers, 49.2% were 2-toothed, 48.3% were 4-toothed and 2.5% were 6-toothed. Most (91.2%) of the carcasses had a marbling score of 0, with 8.8% having a score of 1. Most (96.5%) carcasses had a muscle colour score of 1B and the remainder had a score of 1C.

Treatment did not affect P8 fat depth, total carcass weight and dressing percentage (Table 3). The temperature and pH values for all carcasses, on chiller entry and after 1 h in the chiller, and for the subset of 66 carcasses ('ultimate') are also given in Table 3. There was no effect of treatment on any of these measures.

*Eating quality*

Treatment did not affect any of the variables contributing to eating quality. Treatment did not affect the MQ4 scores, the values of which were 55.0, 56.6 and 55.4 for poor, mixed and good treatments, respectively (s.e. is 1.8).

A number of carcasses achieved pH values below 6.0 while temperatures were above 35°C, and there was evidence ($\chi^2$ = 12.1; $P$<0.01) for fewer of these carcasses to be from the good treatment (Table 4).

*Correlations*

*Flight speed and ADG*. Flight speed on day 0 was significantly ($P$<0.05) negatively correlated with ADG during days 0–45 ($r$ = –0.20), 0–70 ($r$ = –0.19) and 0–101 ($r$ = –0.18). Flight speed on day 21 was significantly negatively correlated with ADG during days 0–21 ($r$ = –0.36; $P$<0.01), on day 45 with ADG during days 0–45 ($r$ = –0.32; $P$<0.01), on day 70 with ADG during days 0–70 ($r$ = –0.20; $P$<0.05), and on day 101 with ADG during days 0–101 ($r$ = –0.25; $P$<0.01).

**Table 4. Distribution of carcasses in pH–temperature windows from poor, mixed and good treatments at the time of entry to the chiller**

Data are missing for 1, 5 and 1 carcasses from the poor, mixed and good treatments, respectively

| Treatment | Temperature >35°C | | Temperature <35°C | |
|---|---|---|---|---|
| | pH <6 | pH >6 | pH <6 | pH >6 |
| Poor | 28 | 3 | 8 | 0 |
| Mixed | 27 | 8 | 0 | 0 |
| Good | 21 | 18 | 0 | 0 |

*Flight speed and body-condition score*. Flight speed on day 0 was significantly negatively correlated with body condition score on day 0 ($r$ = –0.26; $P$<0.01), day 21 ($r$ = –0.25; $P$<0.01), day 70 ($r$ = –0.33; $P$<0.01) and day 101 ($r$ = –0.23; $P$<0.05). On days 21, 70 and 101, flight speed was significantly ($P$<0.01) negatively correlated with body-condition scores on those days ($r$ = –0.29, $r$ = –0.24 and $r$ = –0.38 for 21, 70 and 101, respectively).

*Flight speed and intake*. There were no significant correlations between flight speed and pen intakes.

*Flight speed and iFCE*. Flight speed on day 0 was significantly ($P$<0.05) negatively correlated with *i*FCE during days 0–45 ($r$ = –0.68) and 0–101 ($r$ = –0.60). Flight speed on day 21 was significantly negatively correlated with *i*FCE during days 0–21 ($r$ = –0.60; $P$<0.05), on day 45 with *i*FCE during days 0–45 ($r$ = –0.73; $P$<0.01), on day 70 with *i*FCE during days 0–70 ($r$ = –0.63; $P$<0.05) and on day 101 with *i*FCE during days 0–101 ($r$ = –0.73; $P$<0.01).

*Flight speed and carcass traits*. Flight speed on day 0 was significantly ($P$<0.05) negatively correlated ($r$ = –0.20) with dressing percentage. There were no significant correlations between flight speed and carcass weight and P8 fat depth.

*Flight speed and meat quality.* While there were some low–moderate correlations between flight speed on different days of the trial and aspects of meat quality, there was only 1 that was consistent. There were significant negative correlations between flight speed on days 0 ($r$ = –0.26; $P$<0.05), 21 ($r$ = –0.25; $P$<0.05), 45 ($r$ = –0.35; $P$<0.01) and overall mean ($r$ = –0.31; $P$<0.05) and the first pH value.

*Flight speed and eating quality.* There were no significant correlations between flight speed and MQ4 scores.

## Discussion

As discussed by Burrow (1997), a large number of tests have been used to assess the temperament of cattle. A major difficulty with temperament tests is that we are unsure as to what is actually being assessed. For example, is the animal reacting to being socially isolated, being in an unfamiliar place, confined, restrained or the presence of, or close proximity to people? Different tests of temperament could

give markedly different results depending on which of these factors are incorporated into the test situation. Indeed, some authors have suggested that temperament depends on the situation in which measuring takes place (Fordyce *et al.* 1982). We would suggest, however, that temperament reflects how fearful an animal is and, therefore, temperament *per se* does not change with the situation, but rather, different tests measure different aspects of an animal's fear response to the test situation.

As with any trait, both genetic composition and environmental aspects (such as the previous experiences of the animals) will determine temperament. It may be that some tests of temperament are more likely to reflect the intrinsic fearfulness of an animal, while others reflect situation-specific fear resulting from the environmental conditions at the time of testing and whether or not an animal has experienced those, or similar conditions previously. Flight speed is a heritable trait (Burrow and Corbet 2000), while other tests of cattle temperament tend to have low heritabilities and be very variable (Fordyce *et al.* 1982; Burrow 1997).

In this trial, flight-speed measurements were moderately to highly correlated across all animals and within treatments. Flight-speed measurements showed little change in variability over time and were also highly repeatable before and during feedlotting, and for all steers. We suggest that a possible reason for the repeatability and heritability of flight speed is that it largely measures the intrinsic (genetic) fearfulness of the animal and is, thus, an appropriate and reliable measure of temperament.

Based on anecdotal reports from the feedlot industry we had anticipated that the steers would become increasingly docile during the feedlotting period. However, our data showed that flight speed increased up to day 70, with a decrease on day 101. We have seen a similar trend for flight speed to decrease in the later stages of 100-day feedlotting in a previous study (J. C. Petherick and R. G. Holroyd unpublished data). This slowing may simply reflect the high liveweight of the animals and a concomitant reduction in agility. We hypothesised that the increase in flight speed up to day 70 in the current trial may have been due to the focal animals increasing their flight speed, as previous work has shown that repeated restraint and sampling of weaner cattle leads to increased flight speeds (Petherick *et al.* 1998). When the data were separated into non-focal and focal animals and investigated there was no evidence to support our hypothesis. We, therefore, suggest that the increase in flight speed was a result of the repeated handling of all of the animals. This finding indicates that, despite our efforts to handle the cattle as calmly and quietly as possible, the cattle found the handling process aversive and it increased their fearfulness. Recent work by Pajor *et al.* (2000) on the handling of dairy cattle adds support to this suggestion. These workers found that handling treatments that may be regarded as fairly innocuous (e.g. shouting) appeared to be aversive to cows. Our findings, also, add objective support to the opinion of some members of the feedlotting industry that cattle should be minimally handled during feedlotting, although the reasons for doing so may differ. Members of the industry suggest that repeated handling should be avoided to ensure good production; our results indicate that handling increases the fearfulness of the animals. There is, however, strong evidence that production and fearfulness are linked (e.g. see Hemsworth and Coleman 1998).

Our results also showed that the differences in flight speeds established at allocation to the good-, mixed- and poor-treatment groups were maintained throughout feedlotting, and that changes in, and patterns of, flight speeds were no different between these groups. Thus, animals with poor temperaments continued to have poor temperaments, while those with good temperaments maintained their good temperament. This was further demonstrated when the data from the mixed treatment were examined. Within these groups, animals with good temperaments maintained their good temperaments and, similarly, so did those with poor temperaments (Holroyd *et al.* 2000). These results indicate that long-term changes to the temperament of cattle are unlikely to be made simply by grouping cattle of different temperaments. However, it must be borne in mind that these animals were group-mates for only 100 days and they were adult at the time of grouping. It is possible that changes to temperament may occur in younger animals learning from others over a long period of time. An alternative explanation for these findings is that flight speed is a completely insensitive measure of the extrinsic (learning) component of temperament.

In a number of studies, temperament, measured in a variety of ways, has been found to be correlated with improved production (Fordyce *et al.* 1985, 1988*a*; Voisinet *et al.* 1997*a*; Fell *et al.* 1999) and our results agree with those findings. Flight speed was negatively correlated with ADG, *i*FCE, body condition and dressing percentage, and flight speed, as measured on day 0 (as well as on other days during the trial), was a reliable predictor of the performance of the animals.

The groups of animals on the poor treatment had lower liveweights than those on the good treatment throughout the feedlot period, despite having similar weights at the start. There was also a trend for ADGs to be greater for the good treatment than for the poor. All animals improved in body-condition score during feedlotting, as would be anticipated, but body condition was significantly better for the groups of good-temperament animals than for the groups of poor. While intakes did not differ, feed conversion efficiency (as analysed using *i*FCE) was significantly better for the good treatment than for the poor treatment. For all of these measures, the mixed treatment fell between the good and poor treatments. It is likely that this was a result of the

treatment being a mix of poor- and good-temperament animals, with the poor-temperament animals in the groups having a poorer performance than the good-temperament animals (Holroyd *et al.* 2000). However, this suggestion is tentative, as the analysis of the mixed treatment involved small numbers of animals in some cells.

There have been few attempts to explain the mechanism for the relationship between temperament and production, although, as stated above, there is ample evidence that fear of humans has a significant effect on production. Fear is a highly potent stressor (Boissy 1995), so highly fearful animals are likely to expend considerable energy from being in a state of high arousal, which would affect FCE, liveweight gain and body condition. Indeed, we have found that ADGs are greater in feedlot cattle that tend to spend a greater proportion of their time relaxed and ruminating compared with those being alert (Petherick *et al.* 2000).

Temperament grouping had no effect on any of the carcass attributes, but there was a significant negative correlation between flight speed and dressing percentage. We had expected differences between treatments in view of the findings by Fordyce *et al.* (1988*b*) that temperament affected the amount of bruising to carcasses. Also, the differences in liveweights between the treatment groups may have been expected to translate into heavier carcasses in the good-temperament groups. The carcasses from the good treatment were on average 10 kg heavier than those from the poor treatment, but differences were not statistically significant. The correlation between flight speed and dressing percentage was significant and it is likely that this negative relationship reflected the higher weight gain, better body condition and heavier carcasses of the good-temperament animals compared with the poor.

Carcasses were handled in the same way and there were no differences between treatment groups in the times at which temperatures and pH values were measured. After slaughter, there is breakdown of muscle glycogen to lactic acid and good-quality beef requires an ultimate pH value close to 5.5 (Tarrant 1989; Immonen and Puolanne 2000). At this pH level, glycogen breakdown ceases even if undegraded (residual) glycogen remains in the muscle (Tarrant 1989). Any stressor that results in a pre-slaughter depletion of glycogen below a certain threshold level will cause a progressive increase in ultimate pH, as post-mortem acidification is curtailed (Tarrant 1989). Dark-cutting beef occurs at pH levels above 5.8 and is a consequence of low muscle glycogen at the time of slaughter (Tarrant 1989). In this experiment, temperament grouping did not affect carcass temperatures and pH levels, and normal ultimate pH levels (5.46–5.49) were achieved in the subsample of 66 carcasses measured. Thus, there was no indication of dark-cutting, which contrasts with the findings of Voisinet *et al.* (1997*b*) who found that cattle with poor temperaments were more likely to produce dark-cutting beef.

The relationship between carcass temperature and pH is critical in preventing 'shortening' of muscle fibres, which causes a toughening of the meat (Locker and Hagyard 1963; Hertzman *et al.* 1993; Olsson *et al.* 1994; Devine *et al.* 1999). Cold-shortening can result if pH levels are above 6.0 when the carcass temperature is below 12°C, while heat-shortening results if pH falls below 6.0 when the carcass temperature is above 35°C (MSA 1999, 2000). All of the carcasses achieved pH levels below 6.0 by the time that carcass temperature reached 12°C and, so, cold-shortening was not an issue. However, a significant proportion of the carcasses had pH levels below 6.0 when carcass temperatures were above 35°C, indicative of heat-shortening. Heat-shortening appears to be more of a problem when electrical stimulation is applied within 5 min of slaughter (Hwang *et al.* 1999), as was the case at this abattoir. However, a comparison of the distribution of 'heat-shortened' carcasses for all 120 carcasses and the subsample of 66 carcasses showed evidence of less heat-shortening in the carcasses from the good treatment than in those from the mixed and poor treatments. All carcasses were treated the same, so this differential effect is unlikely to result from the electrical stimulation *per se*. The difference could have arisen in a number of ways. First, there were higher concentrations of lactic acid in the muscles of the animals from the poor and mixed treatments before and/or at slaughter than in those from the good treatment. Second, the carcasses from the different treatment groups were chilled at different rates. Third, the rate of glycolysis differed. There was no evidence that carcasses were of different temperatures when the first and ultimate temperatures and pH levels were recorded, so a difference in the rate of chilling appears an unlikely explanation. However, either an initial high level of lactic acid or a rapid rate of glycolysis would have resulted in high levels of lactic acid when carcasses were still warm. Although not strong, there was a significant negative correlation between flight speed and the first pH value and, although not significantly different, initial pH levels tended to be lower in the poor and mixed treatments than in the good treatment (5.72, 5.84 and 5.91, respectively). These findings suggest that carcasses from poor-temperament animals had higher initial lactic acid levels than carcasses from good temperament animals.

Initial high concentrations of lactic acid in muscles could have arisen because muscle glycogen had already been converted to lactic acid immediately before slaughter, as a result of the animals experiencing stress. Adrenalin is involved in the glycogenolytic process, with some evidence that the response to adrenalin is greatest in slow-twitch muscle fibres (Tarrant 1989). It appears, therefore, that there is some evidence that a greater proportion of the animals from the poor and mixed treatments experienced stress before slaughter than from the good treatment. One mechanism by which this could operate is that cattle with

poor temperaments have greater proportions of slow-twitch muscle fibres. Certainly, there appears to be some evidence that muscles with a high proportion of these glycolytic fibres show an increased propensity for dark-cutting, with these fibres being more common in bulls which exhibit more dark-cutting (Young and Foote 1984).

Another explanation of this result relates to the considerable variability of residual glycogen and glucose in muscle at low pH levels, with the potential for the production of so-called 'medium-stress' beef (Immonen and Puolanne 2000). According to Immonen and Puolanne (2000) this beef has a normal ultimate pH, but may contain the same low concentrations of residual glycogen and glucose as the most severe dark-cutters. These authors state that this phenomenom is an indication that the cattle have experienced pre-slaughter stress resulting in low muscle glycogen concentrations. Whatever the mechanism, our results indicate that the poor-temperament cattle were more susceptible to the various stressors involved in pre-slaughter handling and transportation. The increased stress susceptibility of these animals is probably directly related to the high level of innate fearfulness in them.

The meat samples averaged an MQ4 score of about 55, which would be graded as 3 star on the MSA system (Polkinghorne *et al.* 1999), and is the grade expected for animals with this growth path and proportion of *Bos indicus* content, and the carcass processing procedure (Thompson *et al.* 1999; Thompson and Polkinghorne 2000). Thus, the potentially toughened meat appeared not to be detected in the eating-quality tests. Furthermore, there was no correlation between flight speed and eating quality.

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