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Breed and selection line differences in the temperament of beef cattle

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ABSTRACT. The temperament of four beef cattle breeds were measured using a flight time test (FT) and a behavior score test (BST). FT was defined as the time taken by animals to cross a distance of 2 m after weight scale. The BST used a visual assessment of cattle behavior in which the results of four categories defined the score: movements, breathing intensity, vocalization and kicking. FT and BST coefficients of heritability were estimated using the restricted maximum likelihood, considering half siblings. Caracu presented a lower BST value than the other breeds. Nellore presented intermediate results, followed by Guzerat and Gyr with similar and higher means ($p < 0.05$). Similar results were observed with FT, but Caracu and Nellore did not differ from each other. A low association between FT and BST was found (r_p= -0.36; $p < 0.01$). The correlation between a sire's ranking, according to the predicted breeding values (p) estimated for FT and BST, was moderate and negative (r_s = -0.63; $p < 0.001$). Heritability estimates for FT and BST were 0.35 and 0.34, respectively. Inside Nellore breed, herds with different selection criteria for weight were compared. Our results show that selection line based on weight might positively modulate temperament of *Bos indicus* cattle.

Keywords: beef cows, behavior, fear, husbandry.

Diferenças de temperamento entre raças e linhas de seleção para gado de corte

RESUMO. O temperamento de quatro raças bovinas foi avaliado utilizando-se o teste de velocidade de fuga (FT) e o escore de comportamento (BST). FT foi definida como o tempo necessário para animais percorrerem uma distância de 2 m após a pesagem. BST foi baseada no comportamento dos animais na balança, amostrando-se quatro categorias de comportamento: movimentos, intensidade de respiração, vocalizações e coices. Os coeficientes de herdabilidade de FT e BST foram estimados com uso de um modelo de máxima verossimilhança restrita, considerando meio irmãos paternos. Caracu apresentou menores médias para BST do que as demais raças. Nelore apresentou resultados intermediários, seguida por Guzerat e Gyr com médias mais elevadas ($p < 0,05$). Resultados similares foram observados para FT, mas as médias de Caracu e Nelore não diferiram entre si. Observou-se baixa associação entre FT e BST (r_p= -0,36; $p < 0,01$). A correlação entre rank de touros ordenados pelos seus valores preditos (p) para FT e BST foi moderada e negativa (r_s = -0,63; $p < 0,001$). A herdabilidade de FT e BST foi de 0,35 e 0,34, respectivamente. A comparação de rebanhos Nelore com diferentes critérios de seleção para peso corporal mostrou que linhas de seleção podem modular positivamente o temperamento de *Bos indicus*.

Palavras-chave: vacas de corte, comportamento, medo, manejo.

Introduction

It is accepted that animals with excitable temperaments are more difficult and dangerous to handle than those with calm temperaments (BURROW, 2001; MARTIN; RÉALE, 2008; RÉALE et al., 2007). It is also accepted that animals with poor temperaments are generally less productive (KING et al., 2006). Animal reactions toward humans have been assessed in numerous ways and studied in different scenarios, which has aimed to solve practical problems during handling or to define which animals should not be selected to reproduce in a breeding program. It is clear that knowledge about cattle temperament has practical and economic implications (BIRO; STAMPS, 2008; RÉALE et al., 2007).

The practical definition of temperament is based on the intensity of a bovine's reactions to specific situations or handling procedures (MAFFEI et al., 2006). Nevertheless, other approaches to animal temperament adopt a wider concept and define the variable as a pool of individual psycho physiological traits that determine emotional reactions (RÉALE et al., 2007). Indeed, such approaches make the practical assessment of temperament much more complex.

In the present study, cattle temperament was assessed using two measures, flight time (FT) and behavior score test (BST), to test the following hypotheses: 1) temperament varies between and within cattle breeds; 2) differences in temperament within breeds can be explained by additive genetic inheritance; and 3) there is a strong relationship between the FT and BST methods of assessing cattle temperament.

Material and methods

This study was conducted on a research farm (*Estação Experimental de Zootecnia de Sertãozinho*, EEZS; 21º09' S, 48º05'W) in Sertãozinho city, State of São Paulo, Brazil.

Four breeds of beef cattle were raised in the EEZS, under similar handling conditions: three *Bos indicus* breeds (Nellore, Guzerat and Gyr) and one native breed, Caracu, a *Bos taurus* that originated in Brazil through the crossing-breeding of Iberian cattle. The herds had been selected based on live weight selection criteria since 1981. Reproductive failure and old age were the criteria normally used to define which cows would be culled. However, in some cases, health, udder problems and bad temperament were also considered. More details of the EEZS cattle selective breeding program have been described in Souza et al. (2010).

There were three herds of the Nellore breed in the EEZS, which were defined according to different selection criteria for live weight. In the Selection herd (NeS), selective breeding was applied using only sires and cows with live weight performance above the herd average. In the control herd (NeC), no selective breeding was applied. In the traditional herd (NeT), selective criteria were similar to those used in the selection herd (MERCADANTE et al., 2003). Prior to this work, carried out during the years of 1996 and 1997, no temperament trait had been considered in the EEZS selection program. The percentage of maiden female heifers was approximately 20%, and the stocking rate was approximately two Animal Unit (cow) per ha.

Cows observed in this study were at least 3 years old; pasture grazed and had received mineral supplementation. The herds were kept in different paddocks and went to the corral six times per year. The cows were handled separately during temperament assessment. All farm cows were submitted to similar conditions and experienced the same handling routines.

The calving season coincides with the end of the dry season, which is characterized by high air temperature, low air humidity, high intensity of solar radiation, and low availability and poor quality of grass. Approximately 30 days before calving, the cows were driven into the paddocks where they remained in groups until 24h after calving. All paddocks were situated next to the farmyard in places with intense movements of people and animals around them. In the calving paddocks, cows were fed once a day with silage of corn or sorghum with hay and cotton seeds as concentrate.

Temperament measurements

The temperament assessments were conducted during weighing handling procedures, which started in the calving season (April of 1996, when cows and calves were weighed just after calving), and included assessments at the beginning of the breeding season (around 2 months later), at the end of breeding season (3 months after the previous assessment) and during weaning procedures (approximately 3 months after the end of breeding season). Two methods were used to assess cattle temperament: the BST for the reactions of cows during weighing, adapted from Fordyce et al. (1982), and the FT as described by Burrow (1997). All measurements were conducted during and immediately after weighing. BST was scored first, followed by FT.

The BST included four variables. The first of these variables was cow movement intensity (CM), which was scored from 1 to 5. CM = 1 when the cow remained quiet most of the time inside the weigh-scale, presenting only occasional head and tail movements. CM = 2 when the cow changed its position inside the weigh-scale only a few times but did not keep its hooves in the same position for more than few seconds; occasional movements of head and tail were present. CM = 3 when the cow presented frequent movements inside the weigh-scale, with frequent and vigorous head and tail movements. CM = 4, when the cow rarely remained still inside the weigh-scale, presenting frequent, vigorous and abrupt movements of the head and tail. CM = 5, when the cow was in continuous movement, presenting strong head and tail movements that included jumping and forcing the weigh-scale walls with its head. The second BST variable was breathing intensity (BI), which was scored from 0 to 3, where BI = 0 for no audible breath, BI = 1 for audible breath, BI = 2 for very deep breath, or BI = 3 for snorting or snoring. The third variable was vocalization (VO), where VO = 0 for no vocalization or VO = 1 for one or more vocalizations. The final BST variable was kicking (KIC), where KIC = 0 for no kicking or KIC = 1 for one or more kicks. The repeatability within and between observers had been tested previously for all measurements, and high correlations (from 90 to 95%) were achieved before initiating BST data collection. BST was recorded for 1550 cows, including 364 Nellore, 536 Guzerat, 257 Gyr and 393 Caracu.

Each behavioral variable was recorded independently during weighing, and the final BST was defined by the combination of these measurements, according to the following criteria:

BST = 1 when: CM = 1, BI = 0 or 1, VO = 0 or 1 and KIC = 0;

BST = 2 when: CM = 1 and BI ≥ 2; or CM = 2 and BI = 0, 1 or 2 (if VO or KIC = 0); or CM = 2 and BI = 3, independent of VO and KIC results.

BST = 3 when: CM = 2 (if BI ≥ 2); or CM = 3 and BI = 0, 1 or 2 (if VO or KIC = 0); or CM = 3 and BI = 3, independent of VO and KIC results.

BST = 4 when: CM = 3 (if BI ≥ 2); or CM = 4 and BI = 0, 1, 2 (if VO or KIC = 0); or CM = 4 and BI = 3, independent of VO and KIC results.

BST = 5 when: CM = 4 (if BI ≥ 2); or CM = 5, independent of the other results.

FT was measured as the time taken by a cow to cross a 2 m distance immediately after leaving the weigh-scale. Times were recorded by a digital chronometer connected to photoelectric cells fitted just after the scale exit and 2 m ahead. The chronometer was switched on when the cow crossed the first pair of photoelectric cells and switched off when it reached the second pair of cells. The reasoning behind this methodology is that cattle with an undesirable temperament (more reactive) will run when leaving the scale, presenting lower times than those with good temperaments. We recorded FT for 345 cows (88 Nellore, 113 Guzerat, 50 Gyr and 94 Caracu) during the calving season.

The waiting time in the corral (TW), defined as the length of time from arrival in the corral until release from the weigh-scales was also measured. During weighing, the farm employees scored the cows according to their body condition (BC). Because BC did not vary, it was represented by two classes of condition: poor and good.

Data analyses

The adherence of BST and FT distribution of probability to the normal distribution was tested by the procedure PROC Univariate, and the components of variance were estimated using the restricted maximum likelihood methodology (REML) by the procedure, Proc Varcomp, using the SAS software (LITTEL et al., 1991), according the following model:

$$Y_{ijklm} = \mu + r_i + c_j + p_{ik} + a_{ijl} + e_{ijklm}$$

where:

Y_{ijklm} = dependent variable BST or FT, μ = general average, r_i = fixed effect of breed, c_j = fixed effect of body condition, p_{ik} = random effect of sire within breeds, a_{ijl} = random effect of animal within sires and breeds, and e_{ijklm} = random error.

Three other variables (TW = waiting time in the corral, EO = entrance order, and AGE = cow age) were included in the model as covariables for adjustment purposes. The heritability of BST and FT considered the information of paternal half-sisters (FALCONER; MACKAY, 1996), and the heritabilities were calculated according to the following equation:

$$h^2 = 4\sigma^2 p / (\sigma^2 pe + \sigma^2 \text{ error})$$

where:

h^2 = heritability coefficient, $\sigma^2 p$ = sire effect, and $\sigma^2 pe + \sigma^2$ error = total variance.

Sires with fewer than four progeny in the population were not considered in the statistical analysis. The standard error of h^2 was estimated according to Falconer (1989).

The data analyses performed only for the Nellore breed considered the fixed effect of herd instead of the breed fixed effect in the model and did not consider the component of variance of animal within sire and breed.

The predicted breeding values (p) of sires for FT and AS were calculated by:

$$P = Pc + Rh^2 \, [n / 1+(n-1)t] \, (Ps - Pc)$$

where:

N = number of offspring, R =0.25 (half sibling relationships), h^2 = heritability, t = $0.25h^2$ (for paternal half sibling), Ps = average of sibling, and Pc = average of the contemporary group.

The Spearman coefficient of correlation was used to compare the rankings of 30 sires sorted by their predicted breeding values (p) estimated by FT and BST. The Pearson correlation coefficient between FT and BST was also estimated. Tukey test were used to compare BST and FT means between breeds and between herds within the Nellore breed.

Results and discussion

The BST statistical analysis showed significant effects of breed, sire within breed and animal within sire and breed ($p < 0.01$), but no significant effects of body condition ($R^2 = 0.72$, CV = 37.17%). There was a significant effect of breed ($p < 0.01$, $R^2 = 0.36$, CV = 58.86%) on FT.

The Guzerat and Gyr breeds presented the highest scores for BST, which did not differ between each other. These breeds were followed by Nellore and Caracu (Table 1).The Gyr and Guzerat breeds had the lowest flight times, and their means did not differ from each other. Nellore and Caracu had higher FT means and did not differ from each other (Table 1).

Table 1. Behavior score test (BST) and flight time (FT) means and standard errors, according to cattle breed.

Breeds	BST	BST	FT	FT
	Mean ± SE	N	Mean±SE	N
Caracu	$1.52^{c} \pm 0.83$	393	$2.52^{a} \pm 1.21$	94
Gyr	$2.48^{a} \pm 1.22$	257	$1.51^{b} \pm 0.97$	50
Guzerat	$2.59^{a} \pm 1.33$	536	$1.64^{b} \pm 1.18$	113
Nellore	$2.20^{b} \pm 1.21$	364	$2.14^{a} \pm 1.18$	88

BST = Behavioral score test, FT = Flight time (seconds). Means followed by the same letter do not differ from each other (Tukey, $p < 0.05$).

For the Nellore breed, we found significant effects of AGE and TW ($p < 0.05$ and $p < 0.01$, respectively) only for BST. The mean age (± SD) of the studied cows was 6.28 ± 2.76 years. The average time waiting in the corral was of 2.34 ± 1.54h. Significant effects ($p < 0.05$) of herd and sire within herd were found in Nellore (Table 2).

Table 2. Behavior score test (BST) means and standard errors according to herds within the Nellore breed.

Herds	N	Mean ±SE
Control	68	$2.69^{a} \pm 1.437$
Selection	147	$2.13^{bc} \pm 1.185$
Traditional	189	$1.97^{c} \pm 1.038$

Means followed by the same letter do not differ from each other (Tukey, $p < 0.05$).

The BST and FT heritability estimates (± SE) were 0.34 ± 0.000244 and 0.35 ± 0.000764, respectively. The Pearson's correlation coefficient between BST and FT was negative and significant ($r_p = -0.36$; $p < 0.01$). The sire rank according to predicted breeding values estimated for FT and BST was negatively correlated and significant ($r_s = -0.63$; $p < 0.001$; N = 30).

Both temperament measures indicated significant differences among the breeds. The *Bos taurus* breed (Caracu) scores were better than the *Bos indicus* breeds (Nellore, Guzerat and Gyr). These results are in agreement with the opinion of EEZS livestock workers, who indicated, prior to data collection, that the Caracu herd was easier to handle than the other breeds and that the Guzerat and Gyr breeds were more difficult to handle. These conclusions indicate that BST and FT assessments have practical utility as indicators of cattle temperament, and they can be used for selection of cattle with better temperament.

The data analysis of the Nellore breed confirmed that age and waiting time in the corral were also important in the expression of cattle temperament. Similar results were reported by Burrow (1997).Two possibilities were considered to explain the significant effect of waiting time in the corral on the temperament of the Nellore breed: cattle with more excitable temperaments are the last to leave the corral because they try to avoid going through the facilities, or the cattle get more excitable as time passes due to a negative environmental effect on them.

The difference in temperament between the selection herd (NeS) and control herd (NeC) of the Nelore breed suggests that breeding selection based on live weight could affect cattle temperament in a desirable way. Although this was not planned, it may be that a genetic correlation exists. As a result, differences among line selection herds could be a side effect of the breeding program to increase live weight at 378 days of age in the EEZS. The Nellore Selection herd has been submitted to the highest selection pressure for live weight for decades. The observed status of temperament is, in part, a consequence of the selection criteria adopted in the past. Favorable correlated responses in temperament following selection for live weight at 378 days in Nellore cattle was conferred from the comparison between herds. This result is in agreement with studies in which poor temperaments were associated with low performances (BURROW; PRAYAGA, 2004; PRAYAGA et al., 2009). Hence, the observed response may be specific only to these herds (e.g., it may be due to the use of one or two sires that happened to have a high expected breeding value for live weight and also good temperament).

Even thought feel animals have been evaluated in this study (345), the FT heritability coefficient found was similar to those estimated by Burrow (2001) and Nkrumah et al. (2007), who reported h^2 from 0.40 to 0.44 and from 0.31 to 0.67, respectively. The same occurred with BST, which is also in agreement with the heritability estimates reported in the literature. In the literature, values of heritability range from 0.16 (FIGUEIREDO et al., 2005) to 0.67 (FORDYCE et al., 1982), when subjective scores were adopted. The maximum value of heritability determined was 0.70 (FORDYCE et al., 1996) when using the flight distance test. Independent of the method to measure temperament, previous studies found moderate to high heritability coefficients when estimated by mixed models of analysis (BURROW, 2001; GAULY et al., 2001). The heritability values presented here corroborates evidence of additive genetic factors controlling cattle responses to human handling. These results assure that temperament can be controlled by selection and are useful knowledge for Brazilian farmers, who usually raise Zebu or Zebu cross-breed cattle.

The analyses determined a low association between BST and FT. If we consider that the behavior score is a measurement that restricts bovine movements and that flight time does not involve restriction, our results are comparable with the reported by Curley Jr. et al. (2006), which found low association between measurements with and without cattle movement restriction.

The correlation between sire ranking according to predicted breeding values estimated for FT and BST was moderate and negative. Sire selection based on these measures might not achieve similar results.

Although it is possible and useful to include cattle temperament as a criterion for selective breeding, it is still not common in the management of Brazilian herds. This fact is probably because there is no clear definition of which measurement system should be used. Petherick et al. (2009) suggested that FT would be more related to innate components of temperament, while BST is supposed to be more related to the learned components of that trait. If this is the case, then age effects will be significant for BST, whereas they are likely to be less significant with FT. Otherwise, our study corroborates that idea. Consequently, the quality of handling routines and the farm facilities help define which temperament measurement is more suitable.

Another point to consider about cattle reactivity is the consequence of decreasing the cattle response in Brazilian field conditions. It may be that less responsive cows are not desirable in circumstances in which the herd faces predator attack. Such situations are still common in certain parts of Brazil, where young calves can be attacked by pumas (*Puma concolor*), jaguars (*Panthera onca*) and vultures (*Cathartes* spp).

In resume, the temperament varied between and within cattle breeds; differences within breeds can be explained by additive genetic inheritance. Phenotypic association between the flight time and behavior score tests was low, but the association between the predicted breeding values of sires according those traits was moderate to high. Selection focused on live weight did not adversely affect the temperament of *Bos indicus*.

Conclusion

We conclude that breed influences the temperament of beef cattle. On average, *Bos indicus* breeds had poorer temperament evaluations. Our study found those flight time and behavior score test are both indicative of temperament and are moderately heritable. Therefore, these measures could be useful in cattle selection programs to improve both innate temperaments and responsiveness to training.

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