http://dx.doi.org/10.1590/1678-4162-12904

Arq. Bras. Med. Vet. Zootec., v.75, n.4, p.735-743, 2023

Effects of animal type, handling, and transportation conditions on beef cattle temperament pre-slaughter

[*Efeito do tipo animal, manejo e condições de transporte no temperamento pré-abate de bovinos de corte*]

R.Z. *Vaz*[1], H.R. *Silva*[1], C.P. *Ghedini*[2], J.D. *Lucas*[1], M.M.M. *Dutra*[3], F.N. *Vaz*[3], N.P. *Reis*[3], J. *Restle*[4]

[1]Universidade Federal de Santa Maria, *Campus* Palmeira das Missões, Palmeira das Missões, RS, Brasil
[2]Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brasil
[3]Universidade Federal de Santa Maria, *Campus* Santa Maria, Santa Maria, RS, Brasil
[4]Universidade Federal de Goiás, *Campus* Samambaia, Goiânia, GO, Brasil

ABSTRACT

This study aimed to investigate the effects of animal type, on-farm handling, and transport conditions on temperament of beef cattle pre-slaughter. The study evaluated 4,061 cattle batches, averaging 49 animals, with a total of 199,026 cattle. Temperament was evaluated through a behavioral assessment carried out based on the temperament shown by cattle when approached by humans. One of three different temperament scores were assigned to each batch: calm, anxious, or excitable. Excitable temperament was reported in animals subjected to long transport time and distance and high loading density. The degree of carcass fatness was higher in calm animals, followed by anxious animals, with the excited temperament animals having the lowest carcass fatness degree. Older animals showed more excitable temperament, while younger animals showed calmer temperament. The excitable temperament was more evident in horned animals in relation to polled animals. Animal temperament was more reactive in batches with older cattle, low carcass fatness degree, and with more than 20% horned animals. Good handling and loading facilities and procedures at the farm contributed to adequate cattle temperament expression prior to slaughter.

Keywords: cattle reactivity, animal maturity, animal welfare, cattle behavior, loading density

RESUMO

O trabalho teve por objetivo avaliar a influência de variáveis relacionadas às condições de manejo e de transporte na expressão do temperamento pré-abate de bovinos de corte. Foram avaliados 4.061 lotes, com média de 49 animais, totalizando 199.026 bovinos. O temperamento foi avaliado por meio da expressão comportamental dos lotes diante da aproximação humana. Foram atribuídas três diferentes classificações de temperamento: "calmo", "ansioso" ou "excitável". Verificou-se temperamento excitável em animais submetidos a longos tempos de transporte, a grandes distâncias e à alta densidade de carga. O grau de gordura na carcaça foi mais elevado em animais "calmos", seguidos dos animais "ansiosos", e menor em animais de temperamento "excitado". Os animais com temperamento excitável eram mais velhos, e aqueles com temperamento calmo eram mais jovem. O temperamento excitável foi mais evidente em animais com a presença de chifres. O temperamento animal foi mais reativo em lotes de bovinos mais velhos, com baixo grau de gordura de carcaça e com mais de 20% de animais com presença de chifres. Boas instalações e condições apropriadas de manejo e de carregamento dos animais contribuem para a expressão adequada do temperamento dos bovinos no pré-abate.

Palavras-chave: bem-estar animal, comportamento bovino, densidade de carga, maturidade animal, reatividade de bovinos

Corresponding author: rzvaz@terra.com.br
Submitted: October 27, 2022. Accepted: March 27, 2023.

INTRODUCTION

Regarding livestock production, animal welfare is of great concern for consumers. In this sense, animal welfare should be considered, not only within the production system, but also during transportation and pre-slaughter animal handling within the slaughter industry. Pre-slaughter handling is the most stressful period for cattle (Stockman *et al.,* 2012). Exposure to challenges including changes in social structure, water and feed deprivation, fatigue, and fear, leads to increased respiratory frequency and altered animal temperament, where animals become more reactive (Fergunson and Warner, 2008).

In beef cattle and other livestock species, temperament can be defined as the behavioral expression of animals in response to human interaction. In this sense, it is possible to classify cattle according to the level of responsiveness, from calm to excitable, through temperament evaluations (Burrow *et al.,* 1988). Research has demonstrated the impact of temperament on growth, performance, feeding efficiency, carcass characteristics, and meat quality in beef cattle (Francisco *et al.,* 2015; Willian *et al.,* 2019).

More excitable temperament impacts not only meat quality (Moura *et al.,* 2021) but it also has a direct effect on beef production efficiency (Francisco *et al.,* 2015; Willian *et al.,* 2019). Therefore, understanding the factors that negatively impact animal temperament is of great interest to minimize losses associated with undesired animal behavior, which can lead to carcass bruising and injury.

Despite the considerable knowledge gained in recent years on the association of beef cattle temperament to animal performance and meat quality, how factors such as: animal type, on-farm handling and transportation conditions affect cattle temperament pre-slaughter is still not fully elucidated. This study aimed to investigate the effects of animal type, on-farm handling, and transportation conditions on temperament of beef cattle prior slaughter.

MATERIALS AND METHODS

The study was approved by the Ethics Committee on Animal Care and Use of the Federal University of Pelotas, Brazil, case number 3110.008794 /2013-31 (number 8794 CEEA). The study was carried out at a cattle slaughterhouse in south Brazil (53°77'97" W and 29°78'18" S) with Federal Inspection Service, (S.I.F. 1733), from August 2019 to October 2021.

The study evaluated a total of 4.061 cattle batches, being 2.124 batches composed by male and 1.937 batches composed by female cattle, averaging 49 animals per batch (ranging from 6 to 457 animals), with a total of 199.026 animals. For statistical analyses each batch was considered as an experimental unit. Animals were from different regions of Rio Grande do Sul state, being 125.707 (63.16%) male cattle and 73.319 female cattle (36.84%), with slaughter weight and cold carcass weight averaging 495 and 250.0 to 225.0 kg, respectively.

Information regarding on-farm animal handling and loading procedures and facilities conditions, as well as information on transportation conditions were collected prior to slaughter. The data were collected using forms developed by researchers in agreement with the people responsible for animal purchase by the slaughterhouse. Regarding animal transportation, information including animal loading and trip conditions was taken by previously trained drivers. This information was monitored and added to the dataset daily. Inconsistent data or data missing independent variables measurements were excluded from the dataset.

Variables including animal gender, handling and loading facilities conditions and animal handling and loading procedures at the farm, length of transportation time (transport time) and the distance from the farm to the slaughterhouse (transport distance) were analyzed as possible factors impacting cattle temperament pre-slaughter. Loading density, unloading time, animal type, animal age and carcass fatness degree were also evaluated.

Temperament evaluation was done one hour after animals were placed in the lairage pens. This one-hour period was allowed to ensure animal acclimation to the facilities and water consumption. Animal temperament was evaluated through a behavioral assessment carried out based on the temperament shown by the animals, by testing their reaction when approached by humans, this evaluation was carried out by two trained personnel. Three different temperament scores were assigned to each batch: 1) “calm”: animal static, quiet with no resistance to approach; 2) “anxious”: with some resistance and constant movement; and 3) “excitable”: frightened movements, escape attempts, very agitated, wild movements.

Temperature-humidity index (THI) was calculated from noon to 2 pm on the day of animal loading. The THI was calculated according to official data from the meteorological database of the Federal University of Santa Maria, which is located near the slaughterhouse.

Unloading time at the slaughterhouse was the time, expressed in minutes, between arriving at the slaughterhouse and animal unload and accommodation in lairage pens. Slaughter handling was carried out according to Regulation of Industrial and Sanitary Inspection of Products of Animal Origin – RIISPOA (Brasil, 2008).

Animal age and carcass fatness degree were evaluated at slaughter by trained personnel right after removal of ride/skin and head by trained workers, following federal legislation from MAPA. Animal age was determined by examination of the teeth. Carcass fatness degree was determined by visual assessments scored on a scale of five fatness levels (1 – 5 scale), where 1 indicates no fat cover and 5 indicates excess fat cover (Brasil, 2008).

Transport distances were evaluated in km, including the distance traveled on paved and unpaved roads. Length of transport time (transport time) was evaluated in minutes, including the time from animal loading at the farm up to the arrival at the slaughterhouse. Loading density was calculated diving total load weight (kg) by total occupied area (m^2) and expressed as kg/m^2. All vehicles used for animal transportation belonged to the same transport company. Truck maintenance, trailer dimensions and layout, truck driver training, and engine potential were all standardized.

Three scores were used to classify handling and loading facilities conditions and handling and loading procedures at the farms: good, moderate, and poor (Mendonça *et al*., 2016). Handling and loading facilities conditions were evaluated through observation of their conservation conditions. Facility conditions were classified according to the presence of facility defects that could potentially contribute to animal stress during handling, following the procedures described by Mendonça *et al.* (2016). Animal handling and loading procedures were evaluated through the level of aggressive handling applied by handlers. Animal handling was classified according to the use of dogs, sticks, electric prods, canes, whips, or any other object during animal handling that could potentially cause animal stress and injuries (Mendonça *et al.*, 2016).

Batches according to animal type were classified according to horn presence or absence into three groups: “horned”, “mixed” and “polled”. Batches with more than 20% of horned animals were classified as “horned” whereas, batches with less than 20% were classified as “mixed”, and batches with no horned animals were classified as “polled”.

Animal temperament data were submitted to ANOVA and means were compared by Student t test using *lsmean* package. Statistical significance was set at $p \leq 0.05$. Initially, differences between male and female were tested, being the analyses realized combined for both genders. The variables animal gender and batch number of animals were included in the statistical model as covariables, according to the following model:

$$Y_{ijklmnopqr}=MI_i+I_j+G_k+T_l+D_m+DE_n+TD_o+TG_p+N_q+S_r+e_{ijklmnopqr},$$

where: $Y_{ijklmnopqr}$ = dependent variable, temperament; MI_i = effect of ith handling and facilities conditions at loading (i=1 good; i=2 moderate; 3= poor); I_j = effect of jth animal maturity (j=1 deciduos teeth; j=2 two teeth; j=3 fourr teeth; j=4 six teeth; j=5 eight teeth); G_K = effect of kth carcass fatness degree (k=1 absent; k=2 scare, k=3 moderate, k=4 uniform, k=5 excess); T_l = effect of lth transport time; D_m = effect of mth transport distance; DE_n = effect of nth loading density (n = 1, ..., 4 classes); TD_o = effect of oth unloading time at the slaughterhouse; TG_p = effect of pth cattle type

(1= polled; 2= mixed; 3= horned); N_q = effect of covariable batch number of animals; S_r = covariable animal gender; and $e_{ijklmnopqr}$ = error term.

RESULTS

Animal temperament was classified as "calm" (score 1) in 34% (1.381 batches) of the batches, whereas in 48.19% (1.957 batches) of the batches, animal temperament was "anxious" (score 2). Excitable temperament (score 3) occurred in 17.8% (723 batches) of the batches analyzed (Tab. 1). Temperature-humidity index (THI) and unloading time had no effect on animal temperament (*P* >0.05; Table 1).

Table 1. Means ± standard error of variables with potential effects on beef cattle temperament pre-slaughter

Variables	Temperament scores[1] Calm	Anxious	Excited	P value[2]
Temperature-humidity index	57.22±0.39[a]	56.43±0.32[a]	56.93±0.52[a]	0.2826
Unloading time, minutes	40,10±0.98[a]	40.20±0.81[a]	38.01±1.31[a]	0.3351
Animal maturity, teeth	3.74±0.06[c]	4.40±0.51[b]	5.25±0.08[a]	0.0001
Carcass fatness degree, score[3]	2.97±0.008[a]	2.89±0.006[b]	2.80±0.010[c]	0.0001
Transport distance, km	238.66±3.55[c]	249.44±2.96[b]	263.37±4.77[a]	0.0002
Transport time, minutes	326.09±4.25[c]	338.73±3.54[b]	368.23±5.70[a]	0.0001
Loading density, kg/m^2	347.80±1.27[b]	350.49±1.05[ab]	354.01±1.73[a]	0.0153

[a,b,c] Means of the same variable followed by different letters in the same row differ by T test at $P < 0.05$.
[1] Temperament scores = 1) "calm": animal static, quiet with no resistance to approach; 2) "anxious": with some resistance and constant movement; and 3) "excitable": frightened movements, escape attempts, very agitated, wild movements.
[2] Significance was declared at $P \leq 0.05$
[3] Determined by visual assessments scored on a scale of five fatness levels (1 – 5 scale), where 1 indicates no fat cover and 5 indicates excess fat cover (Brasil, 2008).

Animals showing excitable temperament were older than other animals (*P*=0.0001). Whereas the youngest age was reported in animals presenting "calm" temperament (*P*=0.0001). Animal temperament was associated (*P*=0.0001) with carcass fatness degree. Animals with "calm" temperament had higher carcass fatness degree when compared to 'anxious" and "excitable" animals (*P*=0.0001). The degree of carcass fatness was higher in "anxious" animals than in "excitable" animals (*P* = 0.0001; Table 1).

Increasing transport time affected (P=0.0001) batch temperament (Table 1). Animals expressing "excitable" temperament were transported with higher loading density compared to those showing "calm" and "anxious" temperament (*P*=0.0153). No differences (*P*>0.05) were reported for loading density between "calm" and "anxious" groups (Table 1).

Regarding the effects of handling and loading facilities and procedures at the farm on cattle temperament, batches of animals from farms scored as "good" presented a calmer temperament compared to batches of animals from farms assigned as "moderate" and/or "poor" scores for facilities conditions and animal handling procedures (Table 2; *P*=0.0013).

Table 2. Mean ± standard error for cattle temperament scores pre-slaughter according to handling and loading facilities and procedures at the farm and horn presence or absence.

Characteristics	Temperament scores[1]
Handling and loading facilities and procedures, classes[2]	
Good	1.81±0.01[b]
Moderate	1.91±0.03[a]
Poor	1.89±0.01[a]
P-value[2]	0.0013
Horn presence or absence (Animal type)	
Polled[3]	1.72±0.01[b]
Mixed[4]	1.96±0.01[a]
Horned[5]	2.23±0.26[a]
P-value[2]	0.0001

[a,b,c] means of the same variable followed by different letters in the column indicate difference at P <0.05 by T test.
[1]Temperament scores = 1) "calm": animal static, quiet with no resistance to approach; 2) "anxious": with some resistance and constant movement; and 3) "excitable": frightened movements, escape attempts, very agitated, wild movements.
[2]On-farm handling and loading facilities and procedures, classes determined according to Mendonça *et al*., (2016).
[3]Batches with no horned animals.
[4]Batches with less than 20% horned animals.
[5]Batches with more than 20% horned animals.

Animal temperament was more aggressive (excitable temperament) in horned animals compared to polled animals (P=0.05). Horned (more than 20% of horned animals) and mixed batches (less than 20% of horned animals) had more aggressive (excitable) and anxious temperament than polled batches, which showed calm temperament (Table 2).

DISCUSSION

Previous studies have reported a direct impact of weather conditions and temperature on animal behavior (Mader, 2003; Brown-Brandl, 2018). However, the results reported herein suggest no effect of THI on cattle temperament pre-slaughter. Unloading time was similar among temperament scores (calm, anxious and excitable temperament), which indicates that unloading time up to 40 minutes does not pose stress to cattle compromising their temperament. These results suggest that animal temperament pre-slaughter reflects other factors related to pre-slaughter handling and transportation not related to unloading time and/or environmental conditions (weather and temperature).

In this study, adequate tempered cattle ("calm" score) were younger than inadequate tempered cattle ("excitable" score), which agrees with previous studies investigating how cattle maturity can impact temperament. A recent study carried out by Littlenjohn *et al.* (2018) to characterize temperament in cattle across time reported that age impacts animal reactivity, which is related to animal genetic. According to these authors, as the bovine matures, temperament seemed to emphasize the increasing influence of permanent environmental effects and the decreasing influence of additive genetic effects across time (Littlenjohn *et al.*, 2018). A review study conducted by Brandão and Cooke (2021), describes research studies demonstrating the impacts of temperament on reproductive success and overall productivity of beef females. These authors observed that mature beef cows have a more excitable temperament and are less productive than young cows, which can be related to poor handling practices experienced by the cows. It was also suggested that cattle temperament can be improved (temperament can become less excitable) when proper handling procedures are applied to young animals (Brandrão and Cooke, 2021). In addition to its effects on animal temperament, ageing time also impacts meat quality, as more mature and temperamental cattle produce reduced quality meat (Mendonça *et al.*, 2017), and are more prone to carcass bruising (Mendonça *et al.*, 2016; Bethancourt-Garcia *et al.,* 2019; Vaz *et al.,* 2023). The herein study compared animals from different farms, raised in different systems of beef production; therefore, it is likely that young animals at slaughter included in this study are from intensive systems. Beef cattle raised on intensive livestock operations, such as: intensive or semi-intensive beef finishing systems have regular contact with humans (Petherick *et al.,* 2009; Paranhos da Costa *et al.,* 2021; Brandão and Cooke, 2021). However, in this study, it is not possible to determine the effect of feeding systems on animal temperament, as this variable was not studied herein. Therefore, further studies evaluating how animal temperament differs among beef cattle operation systems (feeding systems) are needed to better understand factors within the production systems driving animal behavior.

Carcass degree of fatness is highly affected by feeding systems, mainly regarding nutritional level offered to the animals, which can lead to improved animal performance (Silveira *et al.,* 2012) and contribute to adequate cattle temperament, in both, feedlot systems (Mader, 2003) and/or grazing systems (Francisco *et al.,* 2020). Recent studies have investigated the effects of cattle temperament on feed efficiency. Del campo *et al*. (2021), observed that, independent of feeding system, cattle with adequate temperament (calm temperament) converted dietary energy to BW more efficiently than other cattle. A study carried by Francisco *et al.* (2020) with feedlot-finished cattle evaluated the impacts of temperament on performance, meat, and carcass traits. Adequate tempered cattle had greater average daily gain (ADG), marbling, meat fat content and feed efficiency compared to excitable temperament cattle. These results demonstrate that excitable temperament impairs performance, carcass characteristics, and meat quality traits in finishing cattle. Moreover, in adequate tempered cattle, dietary energy is used to animal performance efficiently, resulting in greater carcass degree of fatness (Marçal-Pedroza *et al.,* 2021; Vaz *et al.*, 2023).

Long distance and length of transport prior to slaughter causes detrimental effects on cattle welfare by causing stress (Burdick *et al.,* 2010; Bethancourt-Garcia *et al.,* 2019). These effects were observed in the herein study, as greater transport distance and length of time resulted in more temperamental animals, showing excitable temperament. During transportation animals suffer stressful conditions which are mainly associated with improper transport environment or conditions, restrictions due to confinement and poor road conditions. Animals under stressful situations spend part of the dietary energy to adapt to these adverse situations. In this case, the amount of energy lost in this processes is impacted by the length of time in which animals are exposed to stress (Mackay *et al.,* 2013). In this study, cattle subjected to long transport time and distance and high loading density had excitable temperament, which agrees with previous studies that have reported that these factors are associated with stress, affecting animal welfare potentially leading to injuries (Bethancourt-Garcia *et al.,* 2019; Vaz *et al.,* 2023). Alterations to animal temperament, due to transport, are likely a result of physiologic changes faced by the animals. Burdick *et al.* (2010) investigated the relationships between temperament and transportation with physiological parameters in Brahman bulls. Most temperamental bulls had greater rectal temperature and serum concentration of cortisol and epinephrine compared to bulls presenting calm or intermediate temperament. A subsequent study conducted by Hulbert *et al.* (2011) evaluated the innate immune response of temperamental and calm cattle after transportation and observed that after transportation, temperamental bulls (excitable temperament) had higher number of defense cells (neutrophils), compared to calm bulls. Stressful conditions faced by cattle during transportation including long transport distance and length of time, confinement condition and exposure to unknown situations, lead to greater energy expenditure by the animals in response to adverse situations, being this factor determinant of greater reactivity in cattle when suffering stress (Mackay *et al.*, 2013).

Inappropriate loading density (high or low) during transportation is also known to impact cattle temperament. Abnormal behaviors are seen at loading densities that fall outside the optimal bounds. Different space allowances in vehicles expose the animals to unknown situations, which can cause fear changing their temperament (Schuetze *et al.*, 2017). In this sense, high loading density impacts air quality inside of the trailer and increases the risk of bruising when falls occur due to the animals' difficulty in standing up when space is limited (Vimiso and Muchenje 2013). These factors closely explain the excitable temperament reported herein in cattle subject to high loading density. Similarly, cattle subjected to low loading density are likely to fall and slip, which also leads to high risk of injuries altering animal temperament (Mendonça *et al.*, 2016).

The quality of handling is directly associated with cattle temperament (Olmos and Turner 2008; Paranhos da Costa *et al.*, 2021). While infrequent and/or poor handling practices (stressful interactions with humans) result in negative behavioral changes in cattle (Petherick *et al.*, 2009), frequent and calm handling (regular pleasant contact with humans) reduce animal fear and reactivity (Paranhos da Costa *et al.*, 2021; Brandão and Cooke, 2021). These factors reported in the literature regarding the association of on-farm handling procedures and facilities condition to temperament explain the results observed herein, where cattle subjected to good handling facilities and procedures had adequate temperament (calm). Grandin and Shiyley (2015) observed that cattle are responsive to handling and can recall challenging situations (stressful situations) for a long period of time. In this sense, pleasant interactions between cattle and humans from the beginning of their lives and especially during the daily handling bring significant, as well as lasting benefits to the production systems. Young cattle can change their behavior when they experience management situations considered more adequate (Brandão and Cooke, 2021). Temperament is impacted by the environment in which animals are raised. When subjected to places without protection from climate change, especially cold and windy rains, animals can become more reactive (Del Campo *et al*., 2021). Animals kept during prolonged time in unknown places in which they are not used to stay, as well as prolonged water and feed deprivation, are likely to change their behavior becoming more temperamental (Moura *et al.*, 2021).

Excitable temperament of batches with high number of horned animals (more than 20% of horned animals) observed in this study, is probably due to greater defensive behavior in horned animals, as they are dominant in the hierarchy of the group, expressing aggressive behavior more easily than polled animals (Reiche *et al.*, 2020). The presence of horned animals increases the risk of accidents during on-farm handling, which can injure other animals, as well as handlers. Chiquitelli Neto *et al.* (2015) reported that the presence of the horn often prevents animals from being restrained during handling, making medication application difficult, increasing the introduction of needles into the animal and the possibility of bleeding. These factors are stressors and affect cattle reactivity directly. In recent years, efforts have been made to reduce the presence of horned animals in cattle herds with the major goal of facilitating animal handling, on-farm, during transport and at slaughter. Except for some breeders of a few breeds who still value the presence of horns, this stressor factor should be minimized with the advancement of animal breeding techniques.

CONCLUSION

Environmental conditions including temperature and humidity, during loading have no effects on cattle temperament pre-slaughter. Temperament is more excitable in batches with high age cattle, low carcass fatness degree and high number of horned animals. Cattle transported at high loading density, long transport time and distance are more reactive showing aggressive temperament. Good handling and loading facilities and procedures at the farm contribute to adequate cattle temperament expression prior slaughter.

ETHICAL STATEMENT

This study design was reviewed and approved by the Ethics Committee on Animal Care and Use of the Federal University of Pelotas, Brazil, case number 3110.008794 /2013-31 (number 8794 CEEA).

ACKNOWLEDGEMENTS

This work was supported by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) grants 310987/2020-2 and 308963/2021-0.

REFERENCES

BETHACOURT-GARCIA, J.A.; VAZ, R.Z.; VAZ, F.N. *et al.* Pre-slaughter factors affecting the incidence of severe bruising in cattle carcasses. *Livest. Sci*., v.222, p.41-48, 2019.

BRANDÃO, A.P.; COOKE, R.F. Effects of temperament on the reproduction of beef cattle. *Animals*, v.11, p.3325, 2021.

BROWN-BRANDL, T.M. Understanding heat stress in beef cattle. *Rev. Bras. Zootec*., v.47, p.e20160414, 2018.

BURDICK, N.C.; CARROLL, J.A.; HULBERT, L.E. *et al.* Relationships between temperament and transportation with rectal temperature and serum concentrations of cortisol and epinephrine in bulls. *Livest. Sci*., v.129, p.166-172, 2010.

BURROW, H.M.; SEIFERT, G.W.; CORBET, N.J. A new technique for measuring temperament in cattle. *Proc. Aust. Soc. Anim. Prod*., v.17, p.154157, 1988.

CHIQUITELLI NETO, M.; CAMERRO, L.Z.; TITTO, C.G. *et al.* Manejo racional eleva o bem-estar de bovinos Guzerá e melhora a eficiência do trabalho de vacinação. *J. Anim. Behav. Biometeorol*., v.3, p.101-106, 2015.

DEL CAMPO, M.; MANTECA, X.; SOARES DE LIMA, J.M. *et al.* Effect of different finishing strategies and steer temperament on animal welfare and instrumental meat tenderness. *Animals.*, v.11, p.859, 2021.

FERGUSON, D.M.; WARNER, R.D. Have we underestimated the impact of pre-slaughter stress on meat quality in ruminants? *Meat Sci.*, v.80, p.12-19, 2008.

FRANCISCO, C.L.; CASTILHOS, A.M.; SILVA, D.C. *et al.* Temperament of Nelore growing-steers receiving supplementation in grazing system: Performance, ultrasound measures, feeding behavior, and serum parameters. *Livest. Sci.*, v.241, p.e104203, 2020.

FRANCISCO, C.L.; RESENDE, F.D.; BENATTI, J.M.B. *et al.* Impacts of temperament on Nellore cattle: physiological responses, feedlot performance, and carcass characteristics. *J. Anim. Sci*., v.93, p.5419-5429, 2015.

GRANDIN, T.; SHIVLEY, C. How farm animals react and perceive stressful situations such as handling, restraint, and transport. *Animals.*, v.5, p.1233-1251, 2015.

HULBERT, L.E.; CARROLL, J.A.; BURDICK, N.C. *et al.* Innate immune responses of temperamental and calm cattle after transportation. *Vet. Immunol. Immunopathol*., v.143, p.66-74, 2011.

LITTLEJOHN, B.P.; RILEY, D.G.; WELSH, J.R. *et al.* Use of random regression to estimate genetic parameters of temperament across an age continuum in a crossbred cattle population. *J. Anim. Sci*., v.96, p.2607-2621, 2018.

MACKAY, J.R.D.; TURNER, S.P.; HYSLOP, J. *et al.* Short-term temperament tests in beef cattle relate to long-term measures of behavior recorded in the home pen. *J. Anim. Sci*., v.91, p.4917-4924, 2013.

MADER, T.L. Environmental stress in confined beef cattle. *J. Anim. Sci.*, v.81, p.e110-e119, 2003.

MARÇAL-PEDROZA, M.G.; CAMPOS, M.M.; SACRAMENTO, J.P. *et al.* Are dairy cows with a more reactive temperament less efficient in energetic metabolism and do they produce more enteric methane? *Animals.*, v.15, p.e100224, 2021.

MENDONÇA, F.S.; VAZ, R.Z.; CARDOSO, F.F. *et al.* Pre-slaughtering factors related to bruises on cattle carcasses. *Anim. Prod. Sci.*, v.58, p. 385-392.

MENDONÇA, F.S.; VAZ, R.Z.; VAZ, F.N. *et al.* Breed and carcass characteristics on losses by bruises and meat pH in beef of steers and culling cows. *Cienc. Anim. Bras.*, v.18, p.e45295, 2017.

MOURA, S.V.; SILVEIRA, I.D.B.; FERREIRA, O.G.L. *et al.* Lairage periods on temperament score and meat quality of beef cattle. *Pesq. Agrop. Bras*., v.56, p.e02349, 2021.

OLMOS, G.; TURNER, S.P. The relationships between temperament during routine handling tasks, weight gain and facial hair whorl position in frequently handled beef cattle. *Appl. Anim. Behav. Sci*., v.115, p.25-36, 2008.

PARANHOS COSTA, M.J.R.; TABORDA, P.A.; LIMA CARVALHAL, M.V. *et al*. Individual differences in the behavioral responsiveness of F1 Holstein-Gyr heifers to the training for milking routine. *Appl. Anim. Behav. Sci*., v.241, p.e105384, 2021.

PETHERICK, J.C.; DOOGAN, V.J.; VENUS, B.K. *et al.* Quality of handling and holding yard environment, and beef cattle temperament: 2. Consequences for stress and productivity. *Appl. Anim. Behav. Sci*., v.120, p.28-38, 2009.

REICHE, A.M.; DOHME-MEIER, F.; TERLOUW, E.C. Effects of horn status on behaviour in fattening cattle in the field and during reactivity tests. *Appl. Anim. Behav. Sci.*, v.231, p.e105081, 2020.

SCHUETZE, S.J.; SCHWANDT, E.F.; MAGHIRANG, R.G. *et al*. Transportation of commercial finished cattle and animal welfare considerations. *Prof. Anim. Sci*., v.33, p.509-519, 2017.

SILVEIRA, I.D.B.; FISCHER, V.; FARINATTI, L.H.E. *et al.* Relationship between temperament with performance and meat quality of feedlot steers with predominantly Charolais or Nellore breed. *Rev. Bras. Zootec*., v.41, p.1468-1476, 2012.

STOCKMAN, C.A.; MCGILCHRIST, P.; COLLINS, T. *et al.* Qualitative behavioural assessment of Angus steers during pre-slaughter handling and relationship with temperament and physiological responses. *Appl. Anim. Behav. Sci*., v.142, p.125-133, 2012.

VAZ, R.Z.; MENDONÇA, F.S.; BETHACOURT-GARCIA, J.A. *et al.* Probability and number of bruises in bovine carcasses according to animal type, handling and transport. Vet. Res. Commun., v.47, p.e10054. 2023.

VIMISO, P.; MUCHENJE, V. A survey on the effect of transport method on bruises, pH and colour of meat from cattle slaughtered at a South African commercial abattoir. *S. Afr. J. Anim. Sci*., v.43, p.105-111, 2013.

WILLIAMS, A.F.; BOLES, J.A.; HERRYGERS, M.R. *et al.* Blood lactate and rectal temperature can predict exit velocity of beef feedlot steers. *Transl. Anim. Sci*., v.3, p.1530-1542, 2019.