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Effect of good handling on stress indicators and behaviour in beef cattle

Efeito de boas práticas de manejo sobre indicadores de estresse e comportamento em bovinos de corte

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Highlights

Welfare indicators reflect the stress level under different forms of handling.
The implementation of good handling practices with animals reduces stress.
Plasma glucose is a potential physiological indicator of stress in beef cattle.
Cattle temperament is influenced by the quality of human-animal-facility interaction.

Abstract

Aspects related to good handling practices have significant impacts on animal behaviour with positive effects on the productivity and profitability of production systems. This study investigated the impact of good handling practices on the modification of stress indicators and the behaviour of beef cattle. Thirty-six male castrated bovines at the growth stage were evaluated for 490 days and submitted to two different production systems in Southern Brazil: good handling practices (GHP) and a traditional handling system of beef-cattle farming (THS). Body weight, reactivity indicators (flight distance and composite behaviour score), and blood indicators of stress (glucose and cortisol) were measured. An analysis of variance was carried out with measurements repeated over time, and Pearson's correlation applied between the variables mentioned above. No differences were found (P>0.05) for body weight in any of the

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evaluations, with initial weights of 196.2 and 196.3 kg and final weights of 431.0 and 413.8 kg for the GHP and THS steers, respectively. The GHP determined better values for the stress and behavioural indicators compared to THS (P<0.05). The flight distance of the GHP animals decreased from 11.33 to 5.22 metres from the first to the last evaluation, while in the THS animals the values were 10.17 and 11.89 metres, respectively. The behaviour composite score differed in the evaluations at 372 and 490 days, with values of 1.77 and 1.47 for GHP animals and values of 2.92 and 2.83 points for THS animals, respectively. Glucose and cortisol levels decreased with the advancing evaluations in GHP animals, with values from 94.80 to 74.22 mg/dL and from 6.08 to 3.68 μg/dL, respectively. In THS animals, glucose and cortisol levels were similar in the initial and final evaluations, with values of 89.30 and 91.28 mg/dL and 5.34 and 5.80 μg/dL, respectively. Regardless of the handling, the final body weight of the animals correlated negatively with the reactivity indicators and physiological stress indicators. The reactivity of the cattle is influenced by the quality of the human-animal interaction but has no effect on the performance of animals raised on pasture. Good handling practices reduce the reactivity and stress indicators of cattle.
Key words: Animal welfare. Behaviour score. Cortisol. Flight distance. Glucose.

Resumo

Aspectos relacionados às boas práticas de manejo têm impactos significativos no comportamento animal com efeitos positivos na produtividade e lucratividade dos sistemas de produção. Este estudo investigou o impacto das boas práticas de manejo na modificação de indicadores de estresse e no comportamento de bovinos de corte. Trinta e seis bovinos, em fase de crescimento, foram avaliados por 490 dias e submetidos a dois diferentes sistemas de produção no sul do Brasil: boas práticas de manejo (BPM) e sistema de manejo tradicional da pecuária de corte (SMT). Foram avaliados o peso corporal, indicadores de reatividade (distância de fuga e escore composto de comportamento) e indicadores fisiológicos de estresse (glicose e cortisol no sangue). Foi realizada análise de variância com medidas repetidas ao longo do tempo e aplicada a correlação de Pearson entre as variáveis citadas anteriormente. Não foram encontradas diferenças para peso corporal em nenhuma das avaliações (P>0,05), com pesos iniciais de 196,2 e 196,3 kg e pesos finais de 431.0 e 413.8 kg para os novilhos BPM e SMT, respectivamente. O BPM determinou melhores valores para os indicadores fisiológicos de estresse e indicadores comportamentais em relação ao SMT (P<0,05). A distância de fuga dos animais BPM diminuiu de 11,33 para 5,22 metros da primeira avaliação para última avaliação, enquanto nos animais SMT os valores foram de 10,17 e 11,89 metros, respectivamente. O escore composto de comportamento diferiu nas avaliações aos 372 e 490 dias, com valores de 1,77 e 1,47 para animais BPM e valores de 2,92 e 2,83 pontos para animais SMT, respectivamente. Os níveis de glicose e cortisol diminuíram com o avanço das avaliações nos animais BPM com valores de 94,80 para 74,22 mg/dL e de 6,08 para 3,68 μg/dL, respectivamente. Nos animais SMT os níveis de glicose e cortisol foram semelhantes nas avaliações inicial e final com valores de 89,30 e 91,28 mg/dL e de 5,34 e 5,80 μg/dL, respectivamente. Independentemente do manejo ao qual os animais foram submetidos, o peso corporal final se correlacionou negativamente com os indicadores de reatividade e indicadores fisiológicos de estresse. A reatividade dos bovinos é influenciada pela qualidade da interação homem-animal, mas não tem efeito sobre o desempenho dos animais criados a pasto. Boas práticas de manejo reduzem a reatividade e os indicadores fisiológicos de estresse dos bovinos.
Palavras-chave: Bem-estar animal. Escore de comportamento. Cortisol. Distância de fuga. Glicose.

Introduction

Brazil, as the largest beef exporter in the world, reaches important and strategic markets that demand safe food, of recognised quality and from sustainable production systems. Market demand prioritises production systems that respect animal welfare during the different stages of animal production. During the various production stages, the cattle are influenced by the environment (Francisco et al., 2015; Grandin, 2016), the facilities and the handling (Valadez-Noriega et al., 2020), the health care and quality of the food and water (Baumgard & Rhoads, 2013; Neel & Belesky, 2017), the pre-slaughter GHP and transport (Bethancourt-Garcia et al., 2019a; Mendonça et al., 2019).

The individual differences between animals that make up the herds show distinct productive performance and types of behaviour, directly influencing the human-animal relationship during handling. These differences are the result of the biology and psychology peculiar to cattle. In recent years, the characteristics of temperament and reactivity have gained importance for researchers and breeders in studies of animal behaviour in relation to humans. According to Barbosa-Silveira et al. (2012) and Francisco et al. (2015, 2020), reactivity can be considered as the interaction between the animal and its environment and can be evaluated by analysing the reaction of the cattle to routine handling situations. In addition, blood glucose and cortisol measurements show positive correlations with an increase in the stress level of the animals (Cobanovick et al., 2020).

As such, the present study evaluated the impact of GHP on the modification of stress indicators and behaviour of beef cattle kept in extensive livestock farming systems (grazing), managed under good practices or traditional livestock production systems.

Material and Methods

Location of the experiment

The study was carried in the 2nd District of Alegrete, Rio Grande do Sul, in Southern Brazil (29º 67′ 33″ S, 55º 50′ 27″ W, altitude of 104 meters). The climate in the region is humid subtropical, with an average annual rainfall of 1500 mm, an average temperature of 18.6ºC and a relative humidity of 75%, according to the Köppen classification, the climate is humid subtropical (Cfa) (Alvares et al., 2013).

Animals

Aberdeen Angus steers (n=36), with an initial mean age of 210 ± 9 days and an initial body weight of 196.27 ± 7.23 kg, were randomly distributed in equal groups of 18 animals in two different types of production systems, on the same farm, in two similar areas of pasture separated by a fence: 1 - Animals submitted to GHP, as recommended by the manual "Good Agricultural Practice" (GAP): beef cattle; and 2 - Animals submitted to the traditional system (THS) of beef-cattle ranching in the West-Frontier region of Rio Grande do Sul.

Installations and systems management

The GAP system is based on actions related to handling facilities and animal welfare. As such, corrections were made in the handling facilities when they were not in accordance with good practice. All fences were laid out using plain wire, mesh and stakes with no protrusions, splinters, barbs or screws. The electrified fences were properly earthed and insulated, and carried the correct voltage. Corridors were adapted to facilitate moving the animals between the areas of pasture and the handling facilities. The enclosure had sufficient capacity and the proper structure to carry out, efficiently, safely and comfortably, all the practices necessary for handling the cattle. The floors and ramps were adapted, and any spaces were removed from between the boards interspersed throughout the handling areas.

The areas of pasture were provided with shade and natural shelters, offering 18 m2 per animal in each batch. The use of prods, sharp objects and sticks was eliminated, with flags used as the only tool for driving the animals. The animals were driven by the keepers on horseback in more-distant areas, and on foot when travelling over short distances or inside the enclosure, always calmly, without shouting and without hurrying. In no activity was the use of dogs allowed.

The THS was reproduced in the research, characterised by questions of tradition, conservatism and culture, establishing various paradigms that are difficult to change. Under the THS, various types of handling were maintained, such as the use of dogs during trips to the field and handling practices in the pens; accelerated movements, always on horseback and without any care for the animals' blind spots; with no use of aggressive implements (whips, rods, sticks, rope) or shouting. In each activity, the handlers sought to behave aggressively, using violent domination in an effort to reproduce traditional behaviour. The original structure of the facilities was maintained, including the spaces between the boards in the pen and aisle.

Nutritional management of the animals

Nutritional management throughout the experimental period was the same for the two batches of animals, which were placed in native pasture during spring-summer and a pasture of oats (*Avena sativa*) intercropped with ryegrass (*Lolium multiflorum*) during the autumn-winter months. Animal load in the paddocks was established based on the supply of dry matter, measured through double sampling (exclusion cages + visual estimate). During the spring, summer and autumn, forage was offered at a rate of 8%, 12% and 12%, respectively, in the native pasture. In the cultivated pasture, during the winter, the supply of forage was 10% (Pinto et al., 2007).

Regardless of the production system, the animals were guaranteed a supply of mineral supplements *ad libitum*, containing 60 ppm of phosphorus, as mixture of sodium chloride and dicalcium orthophosphate. Drinkers were strategically located, and sized according to the number of animals served, considering an average consumption of 50 litres/animal/day. In each paddock, sufficient space was made available for the animals to express their normal behaviour (average stocking during grazing on native pasture was AU ha^{-1} (AU = animal unit, equivalent to 450 kg of body weight [BW]).

Characterisation of the pastures

To ensure that the feed did not interfere in the results, areas of pasture with very similar botanical characteristics, soil and shelter were used in the two treatments. The paddocks were rotated, to allow the two batches to have alternate access to the same areas of pasture, with all the paddocks having access to the handling centres. Management practices were always carried out at the same facility, and performed with one group at a time, with no contact between animals from the different treatments.

All the handling practices were carried out by the same handlers, who simulated non-aversive behaviour (as recommended by GHP) in the production system that used GHP, and aversive behaviour to reproduce the THS of beef-cattle ranching.

Health management of the animals

Vaccination followed the proposal of the Secretary for Agriculture of Rio Grande do Sul (three applications). The control of endoparasites was preventive (four applications), and ectoparasites were controlled according to the infestation (eight applications), using products authorised by the Ministry of Agriculture, Livestock and Supply. These activities used the same products and procedures for both systems. The activities were carried out on the same dates, at similar times, avoiding the times of greatest stress for the animals and were always carried out by the same individuals (three people) trained to differentiate and execute both managements.

Behavioural and performance variables

The effect of the treatments was measured by the behavioural indicators, flight distance and composite behaviour score, adapted from Barbosa-Silveira et al. (2012), and by the physiological indicators, plasma glucose and blood cortisol, repeatedly evaluated over time. To evaluate the influence of the systems on the productive performance (weight gain) of the animals, they were weighed at intervals of 21 days using electronic scales, to adjust the animal load in the paddocks. At the same time, the measurements taken to determine behaviour were repeated six times throughout the experimental period, being carried out at the start of the treatments, at 21; 138; 255; 372 and 490 days. The first measurements of weight, composite behaviour score (BS) and flight distance (FD) were taken when the experiment was set up (M0). Blood samples for measuring plasma glucose and cortisol was taken at 21; 138; 256; 372 and 490 days.

The composite behaviour score was evaluated in six repetitions over the experimental period, and carried out during the individual weighing of each animal, ten seconds after the animal entered the scales, assigning the following values: BS1 = calm, no movement, no audible breathing; BS2 = restless, alternating the position of the feet; BS3 = squirming, shaking, moving the scales, audible breathing; BS4 = continuous and vigorous movements, moving the scales, audible breathing; BS5 = continuous vigorous movements, moving the scales, turning or fighting violently, audible breathing. Evaluations with low BS values mean a less reactive animal, while a high BS indicates a very reactive animal.

The tests for flight distance were carried out when weighing the animals and evaluating the behaviour score, and were determined immediately after weighing. The enclosure at the exit of the scales had previously been marked out into square metres for calculating the distance the animal allows the observer to approach. Once weighed, each animal was released into the demarcated pen where it remained alone for 30 seconds, after which time the evaluator entered the enclosure for a period of 90 seconds and tried to approach the animal, noting the distance allowed by the animal. The greater the distance before trying to escape, the more reactive the animal.

Plasma glucose was checked for five different periods (21, 138, 256, 372 and 490 days) using a portable blood glucose monitor (Accu-Chek Active). Blood samples to determine capillary glycaemia were collected by puncturing the medial surface of the outer ear using a disposable hypodermic needle. The test strip was then immediately placed in contact with the blood drop and after 20 to 30 seconds, inserted in the portable blood glucose monitor, which displayed the blood glucose concentration in mg dL^{-1}.

Blood samples were collected for four different periods (21, 138, 256 and 372 days) by jugular venepuncture, using vacuum equipment, in a test tube with no anticoagulant, then cooled and sent to the laboratory. Plasma glucose was measured by blood test in the laboratory (Enzymatic Colorimetric method). Blood cortisol was analysed by chemiluminescence (ECL) with the use of analysers (Elecsys, Cobas and 411, Roche Diagnostics GmBH, Sandhofer Strasse, Germany). All the samples were collected after the behavioural measurements had been taken.

Statistical design and analysis

The experimental design was completely randomised, with each animal considered one experimental unit within the two groups. The groups were randomly structured, and standardised according to age and body condition score at the start of the experiment. The data were tested for normality and subjected to analysis of variance. The mathematical model consisted of measurements repeated over time and can be represented as follows:

$$Y_{ij} = \mu + M_i + MP_j + M_i * MP_j + e_{ij}$$

where: Y_{ij} is the dependent variable (Body weight, composite behaviour score, flight distance, glucose and cortisol), μ is the general mean, Mi is the evaluation period effect (i=1... i=6 classes); MP_j is the system production effect (j=1 and j=2); M*MP is the interaction between variables M and MP and E_{ij} is the residual term. A correlational study between the variables was also carried out by calculating the Pearson correlation coefficients. The results were subjected to analysis of variance and correlation at a level of 5%.

Results and Discussion

The body weights of the animals did not differ in any of the evaluations comparing the different production systems including or not the use of good management practices with cattle (Table 1). This can be attributed to identical feeding in the two treatments, in addition to the similar genetic base of the animals used (Valente et al., 2017). The literature is contradictory in associating temperament with animal performance, with similar results between different animal temperaments, or with results that correlate animals of less reactive temperament with increased productivity (Brandão & Cooke, 2021; Francisco et al., 2015; Sant'Anna et al., 2015).

The non-consistency of the results is due to variations in the environments in which they were carried out. In more extensive environments, or those in which the animals are not in completely ideal situations, greater reactivity may not be the factor determining bad animal performance. Menezes et al. (2019), evaluating the flight speed of calves at weaning, found that animals with a lower speed were those with the smallest weight gains compared to animals with higher flight speeds, also noting that females were more reactive than males. In the above experiment, animals crossed with zebu achieved the highest flight speeds, their heterozygosity being beneficial when the environmental conditions are not ideal (Menezes et al., 2019).

On the other hand, when the environmental conditions are favourable (Valadez-Noriega et al., 2020), especially nutrition, less-reactive animals show better productive performance (Francisco et al., 2015). When evaluating the performance of animals with acceptable or reactive temperaments under conditions of confinement, Francisco et al. (2015) found higher daily weight gains, final weights and carcase weights in animals with acceptable temperaments compared to reactive animals. This shows that under ideal environmental conditions, selecting cattle for acceptable temperament and less reactivity can favour better performance (Sant'Anna et al., 2019).

Regarding the behaviour score and flight distance, both were affected by the production systems (Table 1). Values decreased progressively in the animals kept under GHP over the course of the evaluations. These results can be explained by habituation and sensitisation of the animals to the type of management used (Grandin, 2016). Over time, GHP facilitates animal handling, reducing their reactivity, whereas the THS of beef-cattle farming has a negative influence on cattle behaviour, maintaining or increasing reactivity. This shows that animals adapt to handling by reacting less intensely when they are treated well in the pens. However, these same indicators (behaviour score and flight distance) increased at 372 days and at 490 days in animals kept under the THS system ($P<0.05$). The greater reactivity of the animals under the THS system is due to their memorising the bad handling, which increases as the bad handling is repeated. Irrespective of the sex of the animals, different reactions occur when they are mistreated or treated aversively (Petherick & Phillips, 2009). Negative handling between man and animal, including beating and shouting, induce withdrawal behaviour in the animals in relation to their handler (Brandão & Cooke, 2021).

Table 1

Mean values, standard deviations (SD), and maximum (Max) and minimum (Min) values for weight, composite behaviour score, flight distance, plasma glucose and cortisol in animals from different production systems in each evaluation period (M)

System Variable	Good Practice					Traditional			
	M	Mean[1]	SD	Max	Min	Mean[1]	SD	Max	Min
Body Weight, kg	M_0	196.2[a]	33.7	290	144	196.3[a]	28.1	294	158
	M_{21}	222.4[a]	36.7	329	167	222.6[a]	31.7	323	180
	M_{138}	269.7[a]	43.5	391	187	273.1[a]	35.8	398	219
	M_{256}	315.0[a]	46.0	438	233	324.7[a]	42.2	442	247
	M_{372}	350.4[a]	45.5	476	267	363.8[a]	38.9	486	265
	M_{490}	431.0[a]	47.3	540	338	413.8[a]	42.1	532	289
Composite Behaviour Score, Points	M_0	2.92[a]	1.19	5.0	1.0	2.53[a]	0.92	5.0	1.0
	M_{21}	2.92[a]	1.07	5.0	1.0	2.53[a]	1.09	4.0	1.0
	M_{138}	2.61[a]	0.79	4.0	1.0	2.88[a]	0.92	4.0	1.0
	M_{256}	2.00[a]	0.72	3.0	1.0	2.38[a]	0.66	5.0	1.0
	M_{372}	1.77[b]	0.58	3.0	1.0	2.92[a]	0.77	4.0	1.0
	M_{490}	1.47[b]	0.52	2.5	1.0	2.83[a]	0.83	5.0	1.0
Flight Distance, meters	M_0	11.33[a]	2.55	18	3.0	10.17[a]	2.61	18	3.0
	M_{21}	10.89[a]	3.22	18	5.0	11.39[a]	3.54	19	5.0
	M_{138}	9.44[b]	2.44	16	6.0	12.11[a]	3.34	19	7.0
	M_{256}	7.67[a]	2.04	12	4.0	9.72[a]	3.02	20	4.0
	M_{372}	6.94[b]	1.72	12	4.0	11.78[a]	3.36	18	6.0
	M_{490}	5.22[b]	1.47	11	3.0	11.89[a]	3.66	19	5.0
Glucose, Mg dL^{-1}	M_{21}	94.80[a]	13.50	119	75	89.30[a]	12.22	113	69
	M_{138}	89.20[a]	10.50	114	67	94.11[a]	12.88	114	68
	M_{256}	79.06[a]	10.50	98	66	84.78[a]	7.66	110	72
	M_{372}	77.39[b]	7.68	96	67	92.50[a]	9.72	108	70
	M_{490}	74.22[b]	5.44	83	66	91.28[a]	9.72	118	70
Cortisol, µg dL^{-1}	M_{21}	6.08[a]	1.83	9.2	3.7	5.34[a]	1.62	8.6	2.5
	M_{138}	5.42[a]	1.42	8.9	2.6	6.12[a]	1.81	9.2	2.8
	M_{256}	3.98[a]	1.94	6.1	2.5	4.60[a]	0.95	8.2	3.0
	M_{372}	3.68[b]	0.90	5.8	2.4	5.80[a]	1.22	8.1	2.4

[1]Least square means; a-b on the same line differ ($p<0.05$) by Tukey's test; M -Evaluation period in days from the start of the experiment.

There was a progressive reduction in the levels of physiological indicators of stress glucose and cortisol in the animals subjected to GHP (Table 1). On the other hand, when comparing physiological indicators in the animals subjected to THS, there was an increase (P<0.05) in both variables, showing differences in plasma glucose levels at 372 days and at 490 days, and at 372 days of management for cortisol levels (P<0.05). These results show that animals require good handling practices, and that these are memorised. When repeatedly subjected to proper management, the animals become conditioned, shown by the reduced concentrations of the physiological indicators of stress.

The high concentrations of cortisol in species subjected to stressors, can be caused by energetic stress and the increased levels of cortisol and glucose seen as simultaneous physiological responses (Grandin, 2016), together with the relationship to the environment and the handling routines (Carvalho et al., 2020). As such, the results of the present study, which showed lower levels of glucose and cortisol over time in the animals submitted to GHP, indicate a reduction in the stress levels of these animals throughout the experimental period; whereas the lack of reduction in both physiological indicators in animals subjected to THS, show that such practices act as a stressor. This demonstrates that cattle are able to memorise the handling they receive (Ceballos et al., 2016, 2018) and by means of these experiences, react adversely or favourably when exposed to these experiences again. The more reactive the animal, the greater the concentration of plasma cortisol during moments which are different to its natural environment or to the type of handling used against it (Carvalho et al., 2020; Moura et al., 2021). Plasma glucose concentrations, on the other hand, increase during moments of peak stress (Carvalho et al., 2020).

The results show that as the animals get used to a certain situation or type of handling, for which their homeostasis is not disturbed, the tendency is to become less stressed. As the evaluations advanced, the GHP animals showed a reduction of 98.63% and 117.04% in flight distance and the composite behaviour score, respectively. Barbosa Silveira et al. (2012) point out that for cattle, an event can elicit fear because it is associated with an earlier experience. Temperament is a characteristic that undergoes important environmental action, particularly when related to the quality of the handling, making it possible to reduce reactivity in the case of non-aversive handling (Braga et al., 2018). The opposite may also occur, since in situations of improper handling, there may be an increase in animal reactivity (Braga et al., 2018), which can vary according to the frequency, duration and nature of the interactions during handling (Coleman et al., 1998).

Studies show that animals with the best temperament gain more weight (Barbosa Silveira et al., 2012; Francisco et al., 2015). Lower levels of reactivity may also be associated with a reduction in lesions which reflect in bruises on the carcase, resulting in economic loss and a reduction in the quality of the end product (Mendonça et al., 2016, 2019; Bethancourt-Garcia et al., 2019a,b). The more-reactive animals generate higher production costs due to greater depreciation of the facilities, the occurrence of bruises, and a loss of quality of the end product, in addition to a greater risk of accidents for employees and for the animals themselves (Mendonça et al., 2017).

When analysing the correlation between behavioural variables, physiological indicators and animal performance irrespective of the production system, body weight was negatively correlated (P>0.05) with the behaviour score and flight distance, and with the levels of plasma glucose and blood cortisol (Table 2). In addition, a high correlation (P<0.001, with C equal to 0.99738) was found between the two physiological stress indicators, glucose and cortisol (Table 2).

Table 2
Correlation coefficients between body weights, behavior score, flight distance, blood plasma glucose and cortisol levels of steers submitted to good handling practices and traditional handling system

	Weight	Behaviour score	Flight distance	Glucose
Behaviour score	-0.18			
Flight distance	-0.21	0.57		
Glucose	-0.26	0.64*	0.42	
Cortisol	-0.25	0.62*	0.39	0.99*

*P<0,05.

The high correlation between these two physiological stress indicators confirms the hypothesis that plasma glucose is a potential physiological indicator of stress. The release of cortisol in response to a stressful situation results in a high concentration of glucose in the plasma, which can be affected by various factors (Mudroñ et al., 2005). However, Brown-Brandl (2018) states that hyperglycaemia occurs in response to some, but not all stressors, and is invariably present in the response to severe stress.

The adoption of GHP, in addition to introducing ethical responsibility to human-animal interactions, can have a direct economic impact by reducing the losses caused by lesions and bruises, through a reduction in the amount of damage to the facilities, and in the number of handlers. Improvements in the end product, with the same carcase yield and meat quality from animals submitted to less aversive handling, is fundamental (Romero et al., 2017). This research proposes to contribute to the other studies of ethology that have produced important results: a greater degree of animal welfare, easier handling, improvements in the quality of the handler-animal relationship, and increased profit by reducing losses (Bethancourt-Garcia et al., 2019a,b; Kilgour et al., 2006; Mendonça et al., 2019). Furthermore, the social and economic appeal that the use of GHP represents is undeniable, considering the growing concern of society with animal welfare (Grandin, 2016; Sánchez-Hidalgo et al., 2019).

Conclusion

Behavioural and physiological stress indicators show a significant reduction in beef cattle under good handling practices.

Cattle temperament is influenced by the quality of the human-animal interaction; however, weight gain in the animals is not influenced by the temperament of cattle grazing on native pasture.

Conflict of interest

The authors declare there to be no conflict of interest.

Statement of animal rights

The animals and people involved in the research were treated according to ethical principles, with the project submitted to, and approved by, the Ethics Committee for Animal Experimentation (CEEA) at UFPel, under Process no 3843-2012.

References

Alvares, C. A., Stape, J. L., Sentelhas, P. C., Gonçalves, J. L. M., & Sparovek, G. (2013). Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift, 22*(6), 711-728. doi: 10.1127/0941-2948/2013/0507

Barbosa Silveira, I. D., Fischer, V., Farinatti, L. H. E., Restle, J., Alves, D. C., F., & Menezes, L. F. G. (2012). Relationship between temperament with performance and meat quality of feedlot steers with predominantly Charolais or Nellore breed. *Revista Brasileira de Zootecnia, 41*(6), 1468-1476. doi: 10. 1590/S1516-35982012000600022

Baumgard, L. H., & Rhoads, R. P. (2013). Effects of heat stress on postabsorptive metabolism and energetics. *Annual Review of Animal Biosciences, 1*(1), 311-337. doi: 10.1146/annurev-animal-031412-103644

Bethancourt-Garcia, J. A., Vaz, R. Z., Vaz, F. N., Restle, J., & Mendonça, F. S. (2019b). Pre-slaughter factors associated with severe bruising in different primary commercial cuts of bovine carcasses. *Revista Ciência Agronômica, 50*(4), 681-690. doi: 10.5935/1806-6690.20190080

Bethancourt-Garcia, J. A., Vaz, R. Z., Vaz, F. N., Silva, W. B., Pascoal, L. L., Mendonça, F. S., Vara, C. C. da., Nuñez, A. J. C., & Restle, J. (2019a). Pre-slaughter factors associated with severe bruising in different primary commercial cuts of bovine carcasses. *Livestock Science, 222*(1), 41-48. doi: 10.1016/ J.LIVSCI.2019.02.009

Braga, J. S., Faucitano, L., Macitelli, F., Sant'Anna, A. C., Méthot, S., & Paranhos da Costa, M. J. R. (2018). Temperament effects on performance and adaptability of Nellore young bulls to the feedlot environment. *Livestock Science, 216*(1), 88-93. doi: 10.1016/j.livsci.2018.07.009

Brandão, A. P., & Cooke, R. F. (2021). Effects of temperament on the reproduction of beef cattle. *Animals, 11*(11), e3325. doi: 10.3390/ani11113325

Brown-Brandl, T. M. (2018). Understanding heat stress in beef cattle. *Revista Brasileira de Zootecnia, 47*(1), e20160414. doi: 10.1590/rbz4720160414

Carvalho, C. C. S., Oliveira, E. M., Costa, M. D., Maranhão, C. M. A., Santos, T. C., Monção, F. P., Rocha, V. R., Jr., Ruas, J. R. M., & Soares, T. E. (2020). Handling, reactivity and price of beef cattle. *Journal of Animal Behaviour Biometeorology, 8*(2), 111-119. doi: 10.31893/jabb.20015

Ceballos, M. C., Góis, K. C. R., Sant'Anna, A. C., & Paranhos da Costa, M. J. R. (2016). Frequent handling of grazing beef cattle maintained under the rotational stocking method improves temperament over time. *Animal Production Science, 58*(2), 307-313. doi: 10.1071/AN16025

Ceballos, M. C., Sant'Anna, A. C., Boivin, X., Costa, F. O., Carvalhal, M. V. D. L., & Paranhos da Costa, M. J. R. (2018). Impact of good practices of handling training on beef cattle welfare and stockpeople attitudes and behaviors. *Livestock Science, 216*(1), 24-31. doi: 10.1016/j.livsci.2018.06.019

Cobanovick, N., Stankovick, S. D., Dimitrijević, M., Suvajdžić, B., Grković, N., Vasilev, D., & Karabasil, N. (2020). Identifying physiological stress biomarkers for prediction of pork quality variation. *Animals, 10*(4), 1-18. doi: 10.3390/ani10040614

Coleman, G. J., Hemsworth, P. H., & Hay, M. (1998). Predicting stockperson behaviour towards pigs from attitudinal and job-related variables and empathy. *Applied Animal Behaviour Science, 58*(1), 63-75. doi: 10.1016/S0168-1591(96)01168-9

Francisco, C. L., Castilhos, A. M., Silva, D. C., Silva, F. M., Meirelles, P. R., Cooke, R. F., & Jorge, A.M. (2020). Temperament of Nelore growing steers receiving supplementation in grazing system: Performance, ultrasound measures, feeding behavior, and serum parameters. *Livestock Science, 241*(1), e104203. doi: 10.1016/j.livsci.2020.104203

Francisco, C. L., Resende, F. D., Benatti, J. M. B., Castilhos, A. M., Cooke, R. F., & Jorge, A. M. (2015). Impacts of temperament on Nellore cattle: physiological responses, feedlot performance, and carcass characteristics. *Journal of Animal Science, 93*(11), 5419-5429. doi: 10.2527/jas.2015-9411

Grandin, T. (2016). Evaluation of the welfare of cattle housed in outdoor feedlot pens. *Veterinary and Animal Science, 2*(1), 23-28. doi: 10.1016/j.vas.2016.11.001

Kilgour, R. J., Melville, G. J., & Greenwood, P. L. (2006). Individual differences in the reaction of beef cattle to situations involving social isolation, close proximity of humans, restraint and novelty. *Applied Animal Behaviour Science, 99*(2), 21-40. doi: 10.1016/j.applanim.2005.09.012

Mendonça, F. S., Vaz, R. Z., Cardoso, F. F., Restle, J., Vaz, F. N., Pascoal, L. L., Reimann, F. A., & Boligon, A. A. (2016). Pre-slaughtering factors related to bruises on cattle carcasses. *Animal Production Science, 58*(2), 385-392. doi: 10.1071/AN16177

Mendonça, F. S., Vaz, R. Z., Vaz, F. N., Restle, J., Gonçalves, G. B., & Vara, C. C.V. (2017). Breed and carcass characteristics on losses by bruises and meat pH in beef of steers and culling cows. *Ciência Animal Brasileira, 18*(10), e-45295. doi: 10.1590/1089-6891v18e-45295

Mendonça, F. S., Vaz, R.Z., Vaz, F. N., Leal, W. S., Silveira, I. D. B., Restle, J., Boligon, A. A., & Cardoso, F. F. (2019). Causes of bruising in carcasses of beef cattle during farm, transport, and slaughterhouse handling in Brazil. *Animal Science Journal, 90*(2), 288-296. doi: 10.1111/asj.13151

Menezes, L. M., Barbosa-Silveira, I. D., & Cardoso, F. F. (2019). *Temperamento, e genética em bovinos de corte: conceitos e resultados experimentais.* Editora Novas Edições Acadêmicas. https://www.morebooks.de/shop-ui/shop/product/9786139756377

Moura, S. V., Barbosa Silveira, I. D., Ferreira, O. G. L., Mendonça, F. S., Moreira, S. M., Restle, J., Bethancourt-Garcia, J. A., & Vaz, R. Z. (2021). Lairage periods on temperament score and meat quality of beef cattle. *Pesquisa Agropecuária Brasileira, 56*(1), e02349. doi: 10.1590/S1678-3921.pab2021.v56.02349

Mudroñ, P., Rehage, J., Sallmann, H. P., Höltershinken, M., & Scholz, H. (2005). Stress response in dairy cows related to different blood glucose. *Acta Veterinaria Brno, 74*(1), 37-42. doi: 10.2754/avb200574010037

Neel, J. P. S., & Belesky, D. P. (2017). Herbage production, nutritive value and animal productivity within hardwood silvopasture, open and mixed pasture systems in Appalachia, United States. *Grass and Forrage Science, 72*(1), 137-153. doi: 10.1111/gfs.12211

Petherick, J. C., & Phillips C. J. C. (2009). Space allowances for confined livestock and their determination from allometric principles. *Applied Animal Behaviour Science, 117*(2), 1-12. doi: 10.1016/j.applanim.2008.09.008

Pinto, C. E., Carvalho, P. C. F., Frizzo, A., Fontoura, J. A. S., Jr., Nabinger, C., & Rocha, R. (2007). Ingestive behaviour of steers on natural grasslands of Rio Grande do Sul. *Revista Brasileira de Zootecnia, 36*(2), 319-327. doi: 10.1590/S1516-35982007000200007

Romero, M. H., Uribe-Velásquez, L. F., Sánchez, J. A., Rayas-Amor, A. A., & Miranda-de La Lama, G. C. (2017). Conventional versus modern abattoirs in Colombia: Impacts on welfare indicators and risk factors for high muscle pH in commercial Zebu young bulls. *Meat Science, 123*(1), 173-181. doi: 10.1016/j.meatsci.2016.10.003

Sánchez-Hidalgo, M., Rosenfeld, C., & Gallo, C. (2019). Associations between pre-slaughter and post-slaughter indicators of animal welfare in cull cows. *Animals, 9*(9), 642-649. doi: 10.3390/ani9090642

Sant'Anna, A. C., Baldi, F., Valente, T. S., Albuquerque, L. G., Menezes, L. M., Boligon, A. A., & Paranhos da Costa, M. J. R. (2015). Genetic associations between temperament and performance traits in Nellore beef cattle. *Journal of Animal Breeding and Genetics, 132*(1), 42-50. doi: 10.1111/jbg.12117

Sant'Anna, A. C., Valente, T. D. S., Magalhães, A. F. B., Espigolan, R., Ceballos, M. C., Albuquerque, L. G., & Paranhos da Costa, M. J. R. (2019). Relationships between temperament, meat quality, and carcass traits in Nellore cattle. *Journal of Animal Science, 97*(12), 4721-4731. doi: 10.1093/jas/skz324

Valadez-Noriega, M., Méndez-Gómez-Humarán, M. C., Rayas-Amor, A. A., Sosa-Ferreyra, C. F., Galindo, F. M., & Miranda-de La Lama, G. C. (2020). Effects of greenhouse roofs on thermal comfort, behavior, health, and finishing performance of commercial zebu steers in cold arid environments. *Journal of Veterinary Behavior, 35*(1), 54-61. doi: 10.1016/j.jveb.2019.10.012

Valente, T. S., Albito, O. D., Sant'anna, A. C., Carvalheiro, R., Baldi, F., Albuquerque, L. G., & Paranhos da Costa, M. J. R. (2017). Genetic parameter estimates for temperament, heifer rebreeding, and stayability in Nellore cattle. *Livestock Science, 206*(1), 45-50. doi: 10.1016/j.livsci.2017.10.010