DOI: 10.5433/1679-0359.2020v41n3p985

Productive, behavioral and physiological performance of feedlot Guzerat and ½ Guzerat × ½ Aberdeen Angus cattle

Desempenho produtivo, comportamentais e fisiológico de bovinos Guzerá e ½ Guzerá x ½ Aberdeen Angus criados em confinamento

Diogo Alves da Costa Ferro[1*]; Rafael Alves da Costa Ferro[1]; Aracele Pinheiro Pales dos Santos[1]; Rodrigo Zaiden Taveira[1]; Bruna Paula Alves da Silva[1]; Klayto José Gonçalves dos Santos[1]; Geovana Gonçalves Rosa[2]; Lídia Mendes de Aquino Contijo[3]

Highlights:
Productive variables are affected by different breed groups.
The genetic composition of cattle influences their playful behavior.
New possibilities of crossbreeding in beef cattle should be examined.

Abstract

The objective of this study was to compare the productive, behavioral and physiological performance of feedlot Guzerat and ½ Guzerat × ½ Aberdeen Angus cattle. The experiment was conducted in a commercial feedlot for 80 days, between April and June 2016. Fifteen male Guzerat and 15 male ½ Guzerat-Aberdeen Angus cattle, both at the same age, with respective average initial weights of 381.27 and 401.34 ± 54.70 kg, were used. The animals were kept in collective pens, one for each breed group, with 14 m^2 available per animal. Environmental conditions, respiratory frequency and behavior were evaluated for 12h00, starting at 06h00 and ending at 18h00. Feeding, rumination, rest, other activities and social, body care, anomalous, playful and locomotion behavior were observed. To examine the productive responses, initial weight, final weight, average daily weight gain, total weight gain, carcass yield, conformation and fatness were measured. Behaviors referring to feeding, rumination and other activities did not differ between the breed groups, except for the rest, playful and locomotion behaviors. A significant difference was detected ($p < 0.05$) for respiratory frequency and productive characteristics between the breed groups. In conclusion, ½ Guzerat × ½ Aberdeen Angus were superior to Guzerat cattle in productive performance. However, for behavioral and physiological variables, Guzerat animals exhibited better performance.

Key words: Ambience. Breed groups. Carcass. Etology. Confinement system.

[1] Profs. Drs., Curso de Zootecnia, Programa de Mestrado em Desenvolvimento Rural Sustentável, Universidade Estadual de Goiás, UEG, São Luís de Montes Belos, GO, Brasil. E-mail: diogo.ferro@ueg.br; rafael.ferro@ueg.br; aracele.pales@ueg.br; rodrigo.zaiden@ueg.br; bruna.silva@ueg.br; klayto.santos@ueg.br

[2] Discente do Curso de Graduação em Zootecnia, UEG, São Luís de Montes Belos, GO, Brasil. E-mail: geo_zootecnista@hotmail.com

[3] M.e em Desenvolvimento Rural Sustentável, UEG, São Luís de Montes Belos, GO, Brasil. E-mail: lidiamendes_aquino@hotmail.com

[*] Author for correspondence

Received: May 28, 2019 - Approved: Dec. 07, 2019

Resumo

Objetivou-se comparar o desempenho produtivo, comportamental e fisiológico de bovinos Guzerá e ½ Guzerá x ½ Aberdeen Angus criados em confinamento. O experimento foi conduzido em um confinamento comercial, durante 80 dias, entre os meses de Abril e Junho de 2016. Utilizaram-se 15 bovinos machos Guzerá e 15 machos ½ Guzerá-Aberdeen Angus, ambos com a mesma idade, com peso inicial médio de 381,27 e 401,34 ± 54,70kg, respectivamente. Os animais foram mantidos em baias coletivas, sendo uma para cada grupo racial, com 14 m² disponíveis por animal. Quinzenalmente foram realizadas avaliações ambientais, frequência respiratória e avaliação de comportamento realizada com 12h00 de duração, tendo início às 6h00 e término às 18h00. Observaram-se o comportamento alimentar, ruminação, descanso, outras atividades, social, cuidados corporais, anormal, lúdico e locomoção. Para verificação das respostas produtivas foi identificado o peso inicial, peso final, ganho de peso médio diário, ganho de peso total, rendimento de carcaça, conformação e acabamento. Os comportamentos referentes à alimentação, ruminação e outras atividades não diferiram em função do grupo genético, observando diferença nos comportamentos de descanso, lúdico e locomoção. Foi verificado diferença significativa ($p < 0,05$) entre a frequência respiratória e características produtivas dos diferentes grupos genéticos. Conclui-se que os bovinos ½ Guzerá x ½ Aberdeen Angus apresentaram desempenho produtivo superior aos bovinos da raça Guzerá. Entretanto, para a variável comportamental e fisiológica os animais da raça Guzerá apresentaram melhor desempenho.

Palavras-chave: Ambiência. Carcaça. Etologia. Grupos genéticos. Sistema confinado.

Introduction

The Brazilian beef cattle industry needs techniques and alternatives that increase the economic and productive efficiency of production systems in order to maintain their competitiveness and sustainability. In this scenario, crossbreeding and feedlotting stand out as effective tools for this purpose (Camargo et al., 2010).

In tropical countries, the adoption of crosses involving Indian (zebu) and European (taurine) breeds is recommended as a viable alternative that enables a rational combined use of the adaption of Indian breeds to the tropical climate and the productive potential of taurine breeds. An important result of crossbreeding is the manifestation of heterosis, which generates crossbred progeny whose performance is superior to that of their parents, in addition to favoring adaption to the environmental conditions (Ferro, Silva, & Miyagi, 2012).

Guzerat is considered the least demanding of all zebu breeds. It does, however, possess marked characteristics such as hardiness, high carcass yield and earliness (Vieira, 2011).

Aberdeen Angus stands out among the taurine breeds for comprising a number of positive traits that ensure excellent economic results. The combination of said traits makes it a high-efficiency breed, which is an option for the feedlot-finishing of crossbred cattle by virtue of its earlier slaughter age (Vaz, Restle, Metz, & Moletta, 2008).

Considering that no breed is perfect and that each has its strengths and weaknesses, the production potential and tropical adaptation ability of crossbred animals may be combined with their environment. The more complementary the breeds are, the greater their yield and, consequently, the profitability achieved with the herd.

An animal subjected to stress displays physiological responses such as adrenaline production and increased heart rate and respiratory frequency. This stress may originate from physical activities, fear, changes of routine or thermal stress-causing environmental variables. According to Takahashi, Biller and Takahashi (2009), the normal respiratory frequency of adult cattle should not exceed 60 respiratory movements per minute (mov min^{-1}).

The most commonly observed behavioral changes in response to heat stress are increased water intake, decreased rumination, reduced feeding time, and increased time spent on other activities (Vilela et al., 2013).

Souza et al. (2012) stated that productive indices can vary according to the breed and cross used, which influence weight gain and carcass yields. Monitoring and evaluating the productive indices of a system allow the producer to identify the critical points, set resolutive goals and attain better results in less time.

In view of the scarcity of information on the production of animals originating from crosses between the Guzerat and Aberdeen Angus breeds, the present study proposes to compare the productive, behavioral and physiological performance of feedlot Guzerat and ½ Guzerat × ½ Aberdeen Angus cattle.

Material and Methods

The experiment was conducted over 80 days in a commercial feedlot in the municipality of Trindade, GO, Brazil (Latitude: 16º 38' 58" S, Longitude: 49º 29' 20" W), from April to June 2016. The climate of Trindade is a tropical type with average annual temperature and precipitation of 23.2 ºC and 1467 mm. The research was approved by the State University of Goiás (approval no. 1788).

Fifteen male Guzerat and 15 male ½ Guzerat × ½ Aberdeen Angus cattle, all at the same age, with an average initial weight 381.27 and 401.34 ± 54.70 kg, composed the experimental cattle herd. The cattle were kept in collective pens in a feedlot. Two pens were used in total, one for each breed group, with 14 m^2 per animal.

The diet was composed of corn silage, ground corn grain, soybean meal, soybean hulls, livestock urea and a mineral-vitamin mixture, with an average roughage-to-concentrate ratio of 40:60. Feed was supplied four times daily, at 06h00, 10h00, 13h00 and 18h00.

Ambient temperature and relative air humidity were measured fortnightly by a thermohygrometer. These variables were recorded three times daily (00h00, 13h00 and 18h00) throughout the predetermined day. Dry bulb temperature (DBT) and wet bulb temperature (WBT) were collected using a psychrometer to later determine the temperature humidity index (THI). As described by Baêta and Souza (2010), THI can be calculated by the following formula: THI= DBT + 0.36 × WBT + 41.5. These collections and determinations were performed on the same days and at the same times as temperature and air relative humidity.

Respiratory frequency (RF) was observed on the days and at the times established for the collection of environmental variables. The variable was determined by counting the number of flank movements during one minute, before any other management action was performed.

Feeding, rumination, rest and sleeping behaviors and other behavioral activities (which include social, body care, playful, anomalous and locomotion behaviors) were measured alongside RF. These observations lasted 12 h, during which time the observers would record which activity the animals displayed at every 15 min, as illustrated in the ethogram (Table 1).

Table 1
Ethogram with the behaviors observed in feedlot Guzerat and ½ Guzerat × ½ Aberdeen Angus cattle

Behavioral category	Description
Feeding	Animal observed while feeding.
Rumination	Process in which the swallowed feed returns to the mouth for a new breaking of particles through movements promoted by chewing.
Rest and sleep	Animal lying, resting, or sleeping while possibly performing another activity such as rumination.
Other activities	Performing any activity other than those described, comprising social, body-care, playful, locomotion and anomalous behaviors
Social	Playing with, rubbing against, dominating, or making contact with others.
Body care	Self-cleaning, cleaning others, urination, defecation, and rubbing.
Anomalous	Related to stereotypies; anomalous behavior self-directed or directed towards the environment or another animal, such as sodomy, lignophagia, and geophagia.
Playful	Playful behavior.
Locomotion	Moving around inside the feedlot.

Respiratory frequency and behavior were assessed visually by six trained evaluators, who worked in pairs that were positioned strategically so as not to disturb the animals. Digital watches were used to record the time spent on each activity.

To examine the productive responses, the animals were weighed on the first and last day in the feedlot to determine the initial and final weights, respectively. Final weight was measured prior to transporting to the slaughterhouse, with the animals on a solid-feed fasting (6 h) with free access to water. The cattle were weighed on a digital scale that was placed immediately after the restraining chute. Final weight, total weight gain and average daily weight gain (ADG) were obtained at the end of the experiment.

Carcass yield (CY) was also calculated, using fasting live weight (LW) and hot carcass yield (HCY), by the following formula: CY = (HCW/LW) × 100 (Pascoal et al., 2011).

Conformation and fatness were measured subjectively. In the evaluation of conformation, the carcasses were classified as convex, sub-convex, straight, sub-straight or concave.

Fatness was assessed visually based on fat deposition on the 6th, 9th and 12th ribs, with categories defined as follows: lean (1) - zero fat; sparse fat (2) - 1 to 3 mm thickness; medium fat (3) - 3 to 6 mm thickness; uniform fat (4) 6 to 10 mm thickness; and excess fat (5) - over 10 mm thickness (Vaz et al., 2012).

The experiment was laid out in a completely randomized design with two treatments and 15 replicates. For the environmental variables and animal behavioral responses, analysis of variance, F test and Tukey's mean comparison test were applied for the parametric data and the Kruskal-Wallis test for non-parametric data. R software version 2.15.2. (R Core Team [R], 2015) was used for statistical analysis.

Results and Discussion

Mean temperature, humidity and THI during the experimental period were 28.0 ºC, 47% and 78, respectively. According to Azevêdo and Alves (2009), for an animal to express its maximum productive potential, it is important that climatic conditions include temperature between 10 and

27 ºC and relative humidity between 60 and 70%. For adult European cattle, the lower critical temperature (LCT) is below -10 ºC and the upper critical temperature (UCT) is above 27 ºC, with the optimal range being between -1 and 16 ºC. When working with adult zebu cattle, the LCT is around 0 ºC, whereas the UCT is around 35 ºC, with optimal performance obtained in the range between 10 and 27 ºC.

In accordance with the classification of thermal environment for cattle described by Bertoncelli, Martin, Ziech, Paris and Cella (2013), the mean THI values observed in the present experiment indicate mild stress (72 to 78). Within this range, healthy animals are normally not negatively influenced. However, weight gain may be reduced, which is explained by nutrient intake and utilization. Furtado et al. (2012) observed a THI of 74.28 and found no negative effects on the physiological variables or productive performance of young Guzerat and Sindi bulls.

In the analysis of feeding behavior, no significant difference was detected ($p > 0.05$) between the evaluated groups, with the Guzerat group spending 175 min and the ½ Guzerat × ½ Aberdeen Angus cattle spending 160 min eating (Table 2). Ferro et al. (2016) evaluated the feeding time of feedlot Nellore cattle and observed values that ranged from 161.17 to 176.17 min.

Table 2
Behavioral performance of feedlot Guzerat and ½ Guzerat × ½ Aberdeen Angus cattle

Behavior	Guzerat	½ Guzerat × ½ Aberdeen Angus	p[1]	CV%[2]
Feeding (min)	175.00a	160.00a	0.678	8.98
Rest (min)	375.00b	420.00a	0.038	11.32
Rumination (min)	135.00a	150.00a	0.078	13.74
Other activities (min)	170.00a	140.00a	0.087	10.32

[1]Probability value of the F test in analysis of variance. [2]Coefficient of variation.

Marques et al. (2007) stated that a lack of differences for the feeding behavior may be explained by the fact that animals receive the feed at the same time and in similar quantity. The feeding behavior of feedlot cattle remains constant when diets are provided at fixed and predetermined times; thus, the animal becomes habituated to consuming feed at those times.

Rumination behavior did not differ significantly ($p < 0.05$) between the genetic groups, with the Guzerat and ½ Guzerat × ½ Aberdeen Angus spending 135 and 150 min on the activity, respectively. These findings agree with the reports of Ferro et al. (2016), who found that Nellore cattle ruminated for 135 to 159.17 min.

The cattle were found to ruminate in the fresher hours of the day dawn and twilight, lying down on most occasions (over 90%, in both breed groups) and in the shade whenever possible, which agrees with Broom and Fraser (2010). This finding also corroborates the observations of Marques, Pinto, Abrahão and Nascimento (2008), who reported that feedlot young bulls would ruminate while lying during 90% of their rumination time.

When the rest behavior was evaluated, the ½ Guzerat × ½ Aberdeen Angus animals were found to rest longer (420 min) than the Guzerat cattle (375 min). In most cases, the animals rested while lying, because cattle are not capable of satisfactorily resting while standing and thus assume the positions

of prone or lateral recumbency. The animal may utilize this rest time to perform another activity, e.g., rumination.

Ferro et al. (2016) evaluated feedlot Nellore cattle and found rest values ranging from 362.33 and 432.67 min, with the animals spending most part of those times resting in lateral or prone recumbency while ruminating or just lying still.

The behaviors herein termed "other activities" did not differ between the breed groups (170 × 140 min for the Guzerat and ½ Guzerat-Aberdeen Angus cattle, respectively). Social, body care, anomalous, playful and locomotion behaviors were evaluated (Table 3). There was no significant difference for the frequencies of social, anomalous and body care activities. A significant difference was, however, detected for the playful and locomotion behaviors.

Cases of anomalous behavior were seen in both treatments, Guzerat and ½ Guzerat × ½ Aberdeen Angus, which may be explained by the stress suffered in the confinement due to restricted space compared to the grazing system, which limits the array of normal behaviors expected for the species. In the observation of anomalous behavior, the acts of sodomy, lignophagia and geophagia were seen. According to Malafaia, Barbosa, Tokarnia and Oliveira (2011), sodomy is a behavioral disorder characterized by the act of an animal mounting another/others. Sodomy may be more closely related to lack of welfare than to sexual desire.

Table 3
Mean values for frequency of observations of social, body care, anomalous, playful and locomotion behaviors of feedlot Guzerat and ½ Guzerat × ½ Aberdeen Angus cattle

Behavior	Guzerat	½ Guzerat × ½ Aberdeen Angus	p[1]	CV%[2]
Social	23.34a	24.89a	0.758	10.25
Body care	11.51a	13.00a	0.952	9.89
Anomalous	6.67a	8.05[a]	0.647	12.65
Playful	12.00a	9.25b	0.042	11.20
Locomotion	116.48a	84.81b	0.035	15.26

[1]Probability value of the F test in analysis of variance. [2]Coefficient of variation.

The animals that performed lignophagia chewed and ingested splinters off the fence posts, while geophagia corresponded to the act of eating earth. Ferro et al. (2016) observed anomalous behaviors in confined Nellore cattle, with highest frequency of sodomy, followed by geophagia, wire biting and lignophagia (61.5, 17.7 10.5 and 10.3%, respectively).

In the analysis of playful and locomotion behaviors, a significant difference was found between the frequencies observed in the animals. Playful behavior is understood as the act of playing with other animals, with characteristics such as jumps, runs, among others (Broom & Fraser, 2010). Ferro et al. (2016) stated that this type of behavior does not have an apparent purpose and is more often observed in younger animals, although adult animals may occasionally also display it.

Table 4 describes the physiological and productive performance of feedlot Guzerat and ½ Guzerat-Aberdeen Angus. Significant differences were observed for RF, initial weight, final weight, weight gain, ADG and carcass yield. No difference was detected for fatness.

Table 4
Physiological and productive performance of feedlot Guzerat and ½ Guzerat × ½ Aberdeen Angus cattle

	Genetic composition		p[1]	CV%[2]
	Guzerat	½ Guzerat × ½ Aberdeen Angus		
RF (mov min^{-1})	29.67b	34.35a	0.032	7.65
Initial weight (kg)	381.27b	401.34a	0.038	13.98
Final weight (kg)	497.27b	541.34a	0.035	10.52
ADG (kg day^{-1})	1.45b	1.75a	0.029	8.63
Carcass yield (%)	53.14b	54.81a	0.045	6.15
Conformation	Straight	Sub-convex	-	-
Fatness	3.17b	4.15a	0.043*	7.94

[1]Probability value of the F test in analysis of variance. [2]Coefficient of variation. *Nonparametric Kruskal-Wallis test. RF - respiratory frequency. ADG - average daily weight gain.

The ½ Guzerat-Aberdeen Angus animals showed an average RF of 34.35 mov min^{-1}, whereas the Guzerat cattle averaged 29.67 mov min^{-1}, indicating that neither breed group showed thermal stress in response to the environmental conditions. The adaptation of the Guzerat breed to the tropical climate was also observed by Furtado et al. (2012), who studied Guzerat cattle and found 23.65 mov min^{-1} at an average THI of 74.28.

As stated by Takahashi et al. (2009), RF should be around 60 mov min^{-1}, which is indicative of lack of thermal stress. Animals showing a RF of 60 to 80 mov min^{-1} are under mild stress; a RF from 80 to 120 mov min^{-1} means the animals are under moderate stress; and a RF of over 120 mov min^{-1}, indicates an excessive heat load.

In the evaluation of productive performance, the Guzerat animals exhibited initial weight, final weight and ADG values of 381.27, 497.20 and 1.45 kg, respectively, which were all lower than those obtained by the ½ Guzerat-Aberdeen Angus cattle (401.34, 541.34 and 1.75 kg, respectively). These findings agree with Souza et al. (2012), who reported that crossbred animals were superior in productive performance; and Pitombo et al. (2013), who stated that productive performance depends on factors such as breed, management and others.

In terms of ADG, the ½ Guzerat × ½ Aberdeen Angus cattle showed better performance (1.75 kg day^{-1}) than the Guzerat (1.45 kg day^{-1}). This 300 g difference demonstrates the better performance of the F1 generation originating from the cross between *Bos Taurus* and *Bos Indicus*. These results agree with those published by Mesquita, Castagnara, Oliveira and Figueiredo (2016), who also observed a higher ADG in F1 ½ Nellore × ½ Angus compared to ¼ Nellore × ¼ Angus × ½ Guzerat.

Mourthé et al. (2013) and Moreira et al. (2015) worked with four breed groups, namely, Guzerat, F1 Guzerat × Holstein (Guzolando), F1 Guzerat × Nellore (Guzonel) and ½ Simental + Guzonel (three-cross), and obtained ADG of 1.51, 1.65, 1.39 and 1.56 kg day^{-1}, with the highest value found in the F1 Guzerat × Holstein cattle.

Clímaco et al. (2011) evaluated the performance and carcass characteristics of *Bos Indicus* and F1 *Bos Taurus* × *Bos Indicus* cattle and observed a higher ADG in crossbred animals compared to *Bos Indicus*, which had respective gains of 0.925 and 0.630 kg day^{-1}.

Carcass yield (CY) in the crossbred animals (½ Guzerat × ½ Aberdeen Angus) was slightly higher (1.67%) than in the Guzerat group, which resulted in a significant difference ($p < 0.05$) between the

two, demonstrating benefits of crossbreeding in the crossbred progeny. Similar yields were observed by Camargo et al. (2010) in the carcass of feedlot-finished ½ Guzerat × ¼ Simental × ¼ Nellore and ½ Guzerat × ¼ Limousin × ¼ Nellore heifers: 55.43% and 53.16%, respectively. Superiority of the F1 animals from the cross between the *Bos Taurus* and *Bos Indicus* groups was also noted by Mesquita et al. (2016), who evaluated the CY of ½ Nellore × ½ Angus (53%) and ¼ Nellore × ¼ Angus × ½ Guzerat (50%) animals.

Diverging results were found by Clímaco et al. (2011) for the CY of *Bos Indicus* and F1 *Bos Taurus* × *Bos Indicus* cattle, which the authors attributed to the lower digestive tract capacity of zebu animals.

In terms of carcass conformation, the Guzerat group showed straight carcasses, whereas the carcasses of the ½ Guzerat × ½ Aberdeen Angus animals were sub-convex, the latter being preferred by the meat-packing industry because of the greater indication of muscle mass. According to Sartor et al. (2011) and Ferro et al. (2016), straight carcasses are considered normal for zebu cattle.

In the evaluation of carcass fatness, a significant difference was observed between the groups, with 3.17 and 4.15 mm found in the Guzerat and ½ Guzerat × ½ Aberdeen Angus cattle, respectively, which represents a 0.98 mm superiority for the crossbred. The better fatness observed in the crossbred was because the Angus breed participated in the crosses that produced it. This trait is extremely important for the meat-packing industry during carcass chilling and increases meat tenderness.

The better carcass fatness in Angus or Angus crossbred cattle is an important trait in the genetic composition of the breed. Clímaco et al. (2011) did not find significant differences between the carcass fatness values of *Bos Indicus* and F1 *Bos Taurus* × *Bos Indicus* (3.2 × 3.8, respectively).

Crossbred cattle can have their productive traits improved through the manifestation of heterosis, especially when a cross between animals of the *Bos Taurus* and *Bos Indicus* groups is used. Therefore, when it occurs, superiority is observed in the crossbred progeny compared to the mean of their parents. As described by Freitas, Pereira and Peixoto (2010) heterosis is manifested in many reproduction, production and resistance traits; additionally, the more genetically distant the lines or breeds used in the crosses are, the more intense heterosis is.

Conclusions

The ½ Guzerat × ½ Aberdeen Angus cattle showed superior productive performance to the Guzerat cattle. However, for the behavioral and physiological variables, the Guzerat animals were superior.

References

Azevêdo, D. M. R., & Alves, A. A. (2009). *Bioclimatologia aplicada à produção de bovinos leiteiros nos trópicos*. Teresina: EMBRAPA Meio-Norte.

Baêta, F. C., & Souza, C. F. (2010). *Ambiência em edificações rurais: conforto animal*. Viçosa, MG: EDUFV.

Bertoncelli, P., Martin, T. N., Ziech, M. F., Paris, W., & Cella, S. (2013). Conforto térmico alterando a produção leiteira. *Enciclopédia Biosfera*, *9*(17), 762-779.

Broom, D. M., & Fraser, A. F. (2010). *Comportamento e bem-estar de animais domésticos*. Barueri: Manole.

Camargo, A. M., Rodrigues, V. C., Sousa, J. C. D., Morenz, M. J. F., Ramos, K. C. B. T., & Cabral, O., Neto. (2010). Características da carcaça de novilhas de diferentes grupos genéticos terminadas em confinamento. *Revista ACTA Tecnológica*, *5*(2), 103-114.

Clímaco, S. M., Ribeiro, E. L. A., Mizubuti, I. Y., Silva, L. D. F., Barbosa, M. A. A. F., & Bridi, A. M. (2011). Desempenho e características de carcaça de bovinos de corte de quatro grupos genéticos terminados em confinamento. *Revista Brasileira de Zootecnia*, *40*(7), 1562-1567. doi: 10.1590/S1516-35982011000700023

Ferro, D. A. C., Arnhold, E., Bueno, C. P., Miyagi, E. S., Ferro, R. A. C., Santos, A. P. P.,… Silva, B. P. A. (2016). Physiological and behavioral responses of Nellore steers to artificial shading in an intensive production system. *Semina: Ciências Agrárias*, *37*(4), 2785-2792. doi: 10.5433/1679-0359.2016v37n4Supl1p2785

Ferro, R. A. C., Silva, R. M., & Miyagi, E. S. (2012). Modelos de cruzamento na bovinocultura leiteira. In R. A. C. Ferro, D. A. C. Ferro, K. J. G. Santos, & L. S. Silva (Eds.), *Tópicos aplicados á bovinocultura de leite* (pp. 43-50). Goiânia: Kelps.

Freitas, A. F., Pereira, M. C., & Peixoto, M. G. C. D. (2010). Melhoramento genético. In A. M. Auad (Ed.), *Manual de bovinocultura de leite* (pp. 49-84). Brasília: LK Editora.

Furtado, D. A., Peixoto, A. P., Regis, J. E. F., Nascimento, J. W. B., Araújo, T. G. P., & Lisboa, A. C. C. (2012). Termorregulação e desempenho de tourinhos Sindi e Guzerá, no agreste paraibano. *Revista Brasileira de Engenharia Agrícola e Ambiental*, *16*(9), 1022-1028. doi: 10.1590/S1415-43662012000900014

Malafaia, P., Barbosa, J. D., Tokarnia, C. H., & Oliveira, C. M. C. (2011). Distúrbios comportamentais em ruminantes não associados a doenças: origem, significado e importância. *Pesquisa Veterinária Brasileira, 31*(9), 781-790. doi: 10.1590/S0100-736X2011000900010

Marques, J. A., Ito, R. H., Zawadzki, F., Moggioni, D., Bezerra, G. A., Pedroso, P. H. B., & Prado, I. N. (2007). Comportamento ingestivo de tourinhos confinados com ou sem acesso à sombra. *Campo Digital*, *2*(1), 43-49.

Marques, J. A., Pinto, A. P., Abrahão, J. J. S., & Nascimento, W. G. (2008). Intervalo de tempo entre observações para avaliação do comportamento ingestivo de tourinhos em confinamento. *Semina: Ciências Agrárias*, *29*(4), 955-960. doi: 10.5433/1679-0359.2008v29n4p955

Mesquita, E. E., Castagnara, D. D., Oliveira, N. T. E., & Figueiredo, A. C. O. (2016). Growth performance and carcass characteristics of Nelore Angus and Nelore Angus Guzera crossbreed cows fed with supplemented pasture during the yearling and feedlot stages. *Semina: Ciências Agrárias*, *37*(4), 2701-2710. doi: 10.5433/1679-0359.2016v37n4Supl1p2701

Moreira, F. S., Oliveira, M. M. N. F., Villela, S. D. J., Barbasa, F. A., Mourthé, M. H. F., & Diniz, F. B. (2015). Desempenho produtivo e econômico de três grupos genéticos de bovinos recriados a pasto com suplementação e terminados em confinamento. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, *67*(1), 140-148. doi: 10.1590/1678-7250

Mourthé, M. H. F., Diniz, F. B., Villela, S. D. J., Barroso, J. A., Pires, A. V., & Oliveira, L. L. A. (2013). Desempenho de bovinos de quatro grupos genéticos terminados em confinamento. *Anais do Simpósio Brasileiro de Melhoramento Animal*, Uberaba, MG, Brasil, 10.

Pascoal, L. L., Vaz, F. N., Vaz, R. Z., Restle, J., Pacheco, P. S., & Santos, J. P. A. (2011). Relações comerciais entre produtor, indústria e varejo e as implicações na diferenciação e precificação de carne e produtos bovinos não-carcaça. *Revista Brasileira de Zootecnia*, *40*(Supl. Esp.), 82-92.

Pitombo, R. S., Souza, D. D. N., Ramalho, R. O. S., Figueiredo, A. B. A., Rodrigues, V. C., Freitas, D. D. G. C., & Ferreira, J. C. S. (2013). Qualidade da carne de bovinos superprecoces terminados em confinamento. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, *65*(4), 1203-1207. doi: 10.1590/S0102-09352013000400036

R Core Team (2015). *R: A language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing. Retrieved from http://www.R-project.org/

Sartor, A., Neto, Ribeiro, E. L. A., Mizubuti, I. Y., Pereira, E. S., Cunha, G. E., Silva, L. D. F.,... Bumbieris, V. H., Jr. (2011). Desempenho e características de carcaça de bovinos Nelore confinados recebendo dietas de alto teor de concentrado com diferentes níveis de tanino. *Semina: Ciências Agrárias*, *32*(3), 1179-1190. doi: 10.5433/1679-0359.2011v32n3p1179

Souza, E. J. O., Valadares, S. C., Fº., Guim, A., Valadares, R. F. D., Paulino, P. V. R., Ferreira, M. A.,... Lage, J. F. (2012). Taxa de deposição de tecidos corporais de novilhas Nelore e suas cruzas com Angus e Simental. *Revista Brasileira de Saúde e Produção Animal*, *13*(2), 344-359. doi: 10.1590/S1519-99402012000200005

Takahashi, L. S., Biller, J. D., & Takahashi, K. M. (2009). *Bioclimatologia zootécnica*. Jaboticabal: UNESP.

Vaz, F. N., Restle, J., Metz, P. A. M., & Moletta, J. L. (2008). Características de carcaça de novilhos Aberdeen Angus terminados em pastagem cultivada ou confinamento. *Ciência Animal Brasileira*, *9*(3), 590-597. Recuperado de https://revistas.ufg.br/vet/article/view/930

Vaz, F. N., Vaz, R. Z., Pascoal, L. L., Pacheco, P. S., Miotto, F. R. C., & Teixeira, N. P. (2012). Análise econômica, rendimentos de carcaça e dos cortes comerciais de vacas de descarte 5/8 Hereford 3/8 Nelore abatidas em diferentes graus de acabamento. *Ciência Animal Brasileira*, *13*(3), 338-345. doi: 10.5216/cab.v13i3.17572

Vieira, L. (2011). Investimento garantido. *Revista Guzerá*, 4, 16-19.

Vilela, R. A., Leme, T. M., Titto, C. G., Fantinato, P., Neto, Pereira, A. M. F., Balieiro, J. C. C., & Titto, E. A. L. (2013). Respostas fisiológicas e comportamentais de vacas Holandesas mantidas em sistema adiabático evaporativo. *Pesquisa Veterinária Brasileira*, *33*(11), 1379-1384. doi: 10.1590/S0100-736X2013001100015