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Cattle tick infestation in Brangus cattle raised with Nellore in central Brazil

Infestação de carrapatos em bovinos Brangus criados com Nelore no Brasil central

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Abstract

The present study evaluated the behavior of *Rhipicephalus microplus* naturally infesting Brangus cattle raised with Nellore animals in the municipality of Água Clara, state of Mato Grosso do Sul, Central Brazil. For the field experiment composed of a group with 15 Brangus animals and 15 Nellore animals and a control group with 30 Brangus cattle, all at the post-weaning stage. The 2 groups were kept for 6 months in 2 adjacent paddocks, naturally infested with ticks, at a stocking rate of approximately 0.6 of an animal unit per hectare (AU/ha). Every 18 days, the animals were weighed, and ticks on both sides of each bovine were counted. Every 36 days, blood was collected for hematocrit measurement and molecular diagnosis of the 3 pathogens that cause tick fever. The Brangus animals had 6.8 times more ticks than the Nellore cattle. No significant difference was observed in the weight gain of the Brangus and Nellore animals, and no correlation between the number of ticks and weight was observed in either group. During the 6 months of the study, all animals presented normal hematocrit, were positive for *Babesia bigemina* and *Anaplasma marginale,* and were negative for *Babesia bovis*. Animals in Group 1 produced 27% fewer ticks than the animals in Group 2. The production rate of engorged female ticks in Nellore and Brangus cattle was 0.83% and 2.01%, respectively. Considering the infestation pattern required to produce 10 engorged females/day/animal, the Nellore and Brangus animals required 1,204 and 497 larvae/day, respectively. Our estimates showed that Brangus cattle need only 11.3% of the larvae in the pastures with Nellore cattle to maintain the infestation level observed in the present study. Brangus animals raised with Nellore cattle do not have a lower parasitic load and continue to suffer from tick infestation. Finally, Nellore cattle raised with Brangus cattle do not act as a cleaner because this grouping does not contribute to a reduced infestation in the Brangus animals.

Key words: Bovine. Cattle tick. Control. Infestation.

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Resumo: Este trabalho teve o objetivo de avaliar o comportamento da infestação de carrapatos (*Rhipicephalus microplus)* em bovinos da raça Brangus associado com Nelore no Brasil central em rebanho infestado naturalmente na região do município de Água Clara, MS, Brasil. Para o experimento de campo um grupo de 15 animais em inicio de recria da raça Brangus e 15 animais da raça Nelore e outro grupo controle com 30 animais Brangus, foram mantidos em dois piquetes geminados com lotação de aproximadamente 0,6 unidade animal por hectare (Ua/ha). A cada 18 dias os carrapatos foram contados dos dois lados do corpo dos bovinos após a pesagem dos mesmos. A cada 36 dias foi colhido sangue para realizar o hematócrito e o diagnóstico molecular para os três agentes da Tristeza Parasitária Bovina (TPB). A raça Brangus produziu 6,8 vezes mais carrapatos do que o Nelore e o seu ganho de peso não apresentou diferença estatística quando comparada com a raça Nelore. Ao longo de seis meses os animais não apresentaram hematócrito abaixo do normal e todos os animais foram positivos para *Babesia bigemina* e *Anaplasma marginale*, mas todos foram negativos para *Babesia bovis*. Não houve correlação entre número de carrapatos e ganho em peso para os dois grupos. O Grupo 1 produziu 27% a menos carrapatos que o Grupo 2. O rendimento da taxa de recuperação de carrapatos desenvolvido com animais estabulados mostrou que a raça Angus foi a de maior rendimento, alcançando uma taxa de recuperação de 6,15% do total de teleóginas, seguida pela Brangus com 2,01% e por último constatando a natural resistência da raça Nelore com apenas 0,83% de teleóginas oriundas da infestação artificial. Levando em consideração que o Padrão de Infestação seja de 10 teleóginas/dia/animal o Nelore necessitou de 1.204 larvas/dia enquanto o Brangus de 497 larvas/dia. Estima-se que Brangus necessitou de apenas 11,3% das larvas nas pastagens originadas do Nelore para manter o nível de infestação apresentado neste trabalho. Os animais Brangus criados com Nelore não diminuem a carga parasitária continuando a sofrer os efeitos da ação do carrapato. Os bovinos da raça Nelore não servem como aspiradores da infestação por *R. microplus,* pois eles não reduzem a infestação dos bovinos Brangus.
Palavras-chave: Bovinos. Carrapato-do-boi. Controle. Infestação.

Introduction

Central Brazil is a great environment to produce beef cattle, and in this region, the market for animals with high genetic value seeks the production of cattle breeds with better performance. According to Battistelli et al. (2013), Brangus animals show better performance than the Nellore cattle and other crosses.

The cattle tick, *Rhipicephalus microplus*, which is widely distributed in tropical and subtropical regions worldwide, is one of the major challenges in cattle raising. This tick species is monoxenous and preferentially parasitizes cattle, especially the taurine breeds (ANDREOTTI et al., 2016).

Infestation by the cattle tick is known to adversely affect the productivity of cattle, particularly bodyweight, and when infestation is disregarded, tick-borne disease and direct mortalities arise. Cattle are dipped to prevent deaths due to anemia, to minimize losses in bodyweight due to infestation, and to protect against tick-borne diseases. Ticks that infest cattle, sometimes in vast numbers, will cause debilitation, anemia, weight loss, and death (JONSSON, 2006).

Rhipicephalus microplus is distributed throughout the entire territory of Brazil, and estimates indicate that it causes annual losses of US $3.24 billion from direct and indirect losses to the cattle industry (GRISI et al., 2014).

In Brazil, the cattle tick is one of the main barriers to the introduction of susceptible animals with higher genetic value and better performance that can generate heavier animals with better meat quality (MADRUGA et al., 1985; WAMBURA et al., 1998). Because acaricides have been used for decades to control ticks, resistance is growing in tick populations to the different products used for their control, when used either alone or in combination (HIGA et al., 2015).

In Brazil, reports exist of resistant tick populations, including multiresistant ticks, in all regions of the country, resulting mainly from the indiscriminate use of acaricides (ANDREOTTI et al., 2011; RECK et al., 2014; HIGA et al., 2016). Other problems associated with the use of acaricides that have aroused great concern worldwide are the risks of environmental contamination and the presence of residues in meat, milk, and its derivatives (GAUSS; FURLONG, 2002).The aim of this work was to evaluate the dynamics of parasitism and consequently the impact of the *R. microplus* tick on the associated breeding of *B. indicus* (Nellore) and crosses (Brangus) cattle under the same environmental conditions in central Brazil, using as reference controlled infestation.

Material and Methods

The present study included 2 experiments: pasture-raised Brangus and Nellore animals naturally infested with ticks and Nellore, Brangus, and Angus animals artificially infested and raised in individual stanchions at the Embrapa Gado de Corte (Brazilian Agricultural Research Corporation - Beef Cattle) in Campo Grande-MS, Brazil, located at 20° 26' S and 54° 42' W at 520 m above sea level.

Study area

The naturally infested animals (Brangus and Nellore) were kept at a farm owned by the Agropecuária Sanyo, located southwest of the municipality of Água Clara, state of Mato Grosso do Sul, Brazil (20º46'24''S latitude, 52º32'24''W longitude, and at an altitude of 309 m). The pasture was composed of sandy soil cultivated with *Urochloa* (*Brachiaria) decumbens*.

The climate is characterized as tropical humid with 1-3 months of dry season and an average temperature above 18ºC in all months of the year (IBGE, 2002). The study was performed from June to December 2016, and the weather data were obtained from the database of the Mato Grosso do Sul state government (CEMTEC-MS, 2017).

According to the climatological profile of Flumignan et al. (2015), the rainfall distribution pattern in the municipality of Água Clara follows a very consistent pattern in which most of the rainfall occurs from December to February, decreasing gradually from March to May until the dry season of June, July, and August. Then, from September to November, the rainfall increases gradually until the rainiest months of the year.

Animals

All the procedures performed using animals followed the norms published by the Conselho Nacional de Controle de Experimentação Animal (National Animal Experimentation Control Board, CONCEA), and the project was approved by the Comissão de Ética no Uso de Animais (Ethics Committee for the Use of Animals, CEUA) of the Embrapa Beef Cattle, protocol numbers 01/2016 and 08/2014.

Pasture-raised animals

Sixty post-weaning males naturally infested with ticks were used in the field trials, including 45 Brangus (½ Angus x ½ Nellore) and 15 Nellore. The animals were kept in 2 adjacent paddocks in a continuous grazing system on a *Brachiaria decumbens* pasture at a stocking rate of approximately 0.6 of an animal unit per hectare (AU/ha).

Stanchioned animals

Ten Nellore, 10 Brangus, and 9 Angus males, all in the post-weaning phase, were placed in individual stanchions with feed, silage, and water being provided *ad libitum*. All animals were artificially infested with 10,000 larvae of *R. microplus.*

When the engorged female ticks detached, they were collected once a day, pooled, and weighed. Twenty females from each day's collection were pooled and incubated at 27°C and 80% humidity until egg laying was complete. Eggs collected from each pool were weighed and incubated at 27°C and 80% humidity until hatching was completed to determine the hatch percentage for each pool. The groups were observed for the number of adult female ticks, egg production, and larval hatching.

Tick counting and animal weighing

Ticks measuring 4.5 to 8 mm (WHARTON; UTECH, 1970) were counted from the entire body (both sides) of the animals on days -2 and -1 prior to the beginning of the study. The number of ticks on each side of the animals was summed, and the animals were divided into 2 homogenous groups according to the total number of ticks. Group 1 consisted of 15 Nellore animals and 15 Brangus animals in a paddock, and group 2 (control) included 30 Brangus animals in an adjacent paddock.

Every 18 days, the number of ticks on each animal was counted, the animals were weighed using a Coimma® digital scale from the modal day to the end of the experiment, and the animals were evaluated for the presence of myiasis.

Brangus animals with more than 100 ticks were treated prophylactically with 1.5 mg/kg live weight of imidocarb dipropionate. The crossbreed group in this experiment was considered as being at risk according to Madruga et al. (1987).

Blood collection

Blood collection, performed every 36 days from all pasture-raised animals, was undertaken for PCR analysis and hematocrit measurement. The PCR analysis aimed to detect the DNA of the 3 pathogens responsible for tick fever. The hematocrit concentration was measured using a CM-12000 Daiki® Microhematocrit Centrifuge (ALVES et al., 1986).

Detection of pathogens

DNA extraction

Genomic DNA was extracted from 300 μL of bovine blood by the addition of 2 μL of proteinase K (20 mg/mL) and 500 μL of 20% SDS (sodium dodecyl sulfate). The samples were incubated for 1 hour at 65ºC in a water bath, and then, 800 μL of chloroform was added to each sample. The samples were vortexed vigorously, and 350 μL of protein precipitation solution (6 mL of potassium acetate, 1.1 mL of glacial acetic acid, and 2.9 mL of water) was added, followed by centrifugation at 18,000 g for 10 min. The supernatant was transferred to a new tube, and 1 mL of 100% ethanol was added. The samples were kept at -20ºC overnight for DNA precipitation. Subsequently, the samples were centrifuged at 13,000 rpm for 5 min, the supernatant was discarded, and 1 mL of 70% ethanol was added. The samples were centrifuged once again at 13,000 rpm for 2 min, and the pellet was oven dried at 37ºC. The DNA was resuspended in 50 μL ultrapure water and eluted at 65ºC for 30 min in water bath (CSORDAS et al., 2016). The DNA concentration was measured by spectrophotometry (NanoDrop ND-1000 Uniscience), and the samples were diluted to 100 ng for PCR.

Polymerase Chain Reaction (PCR)

Primer pairs specific for *Anaplasma marginale* (ECHAIDE et al., 1998), *Babesia bigemina,* and *Babesia bovis* (GUERRERO et al., 2007), which amplify fragments of 458 bp, 262 bp, and 217 bp, respectively, were used for the detection of the pathogens. The PCR reaction was performed using the following reagents: 2.5 μL of 10X Buffer, 0.75 μL of $MgCl_2$ (50 mM), 0.5 μL of dNTPs (2.5 mM/ Invitrogen by Life Technologies™), 0.5 μL of forward and reverse primers (10 picomoles), 0.3 µL of Taq (Ludwig Biotec), 1 µL of DNA (100 ng), and ultrapure water to a final volume of 25 µL. The reactions were performed in a BioRad T100™ Thermal Cycler. The following amplification conditions were used for the detection of *Anaplasma marginale* DNA: 95ºC for 3 min, followed by 40 cycles of 95ºC for 30 s, 65ºC for 1 min, and 72ºC for 45 s, with a final extension of 72ºC for 10 min. For the detection of *Babesia bigemina* DNA, the following conditions were used: 95ºC for 2 min, followed by 40 cycles of 95ºC for 1 min, 60ºC for 30 s, and 72ºC for 90 s, with a final extension of 72ºC for 7 min. For *Babesia bovis*, the PCR conditions consisted of 95ºC for 2 min, followed by 40 cycles of 94ºC for 1 min, 60ºC for 30 s, and 72ºC for 1 min, with a final extension of 72ºC for 7 min. After amplification, the products were visualized on a 1.5% agarose gel stained with ethidium bromide.

Statistical analysis

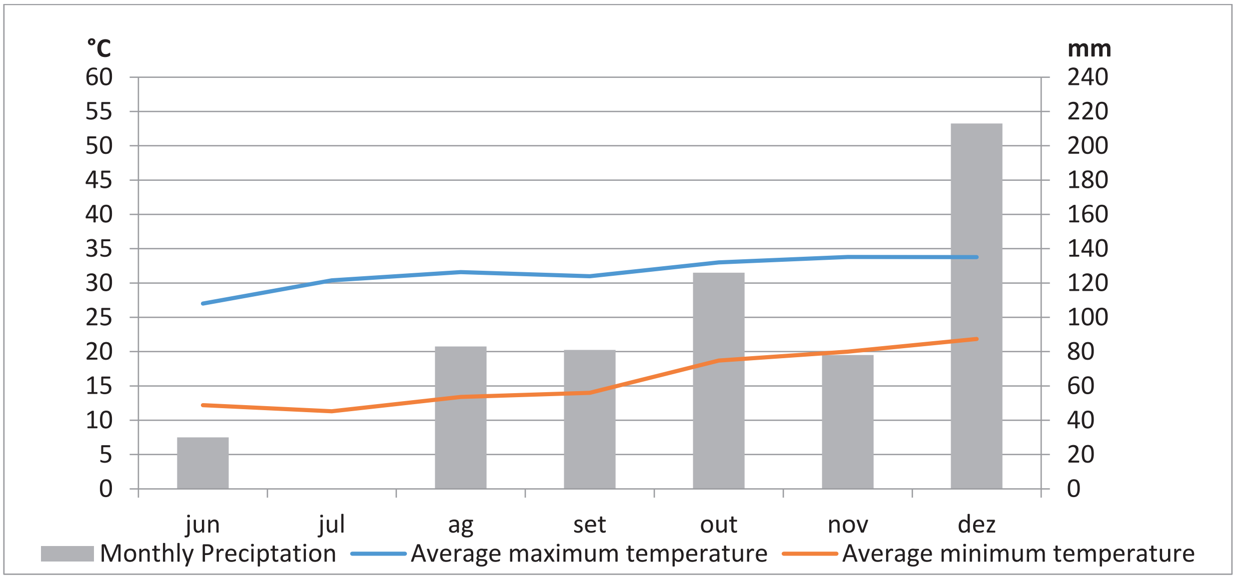
The statistical analysis was performed using the software Bioestat 5.0, and the data were analyzed using the Kruskal-Wallis, Mann-Whitney, and Pearson's linear correlation tests.

Results

Weather profile of the farm

Figure 1 shows the monthly rainfall and the maximum and minimum temperature from June to December 2016 (Figure 1). The first 2 months of the study, June and July, had little or no rainfall, and the rainfall gradually increased from August to December. The mean temperature throughout the study ranged from 20 to 28°C.

Figure 1. Meteorological values of the farm during the study period.



Source: CEMTEC-Ms, rainfall data from the farm weather station.

Tick count in pasture-raised animals

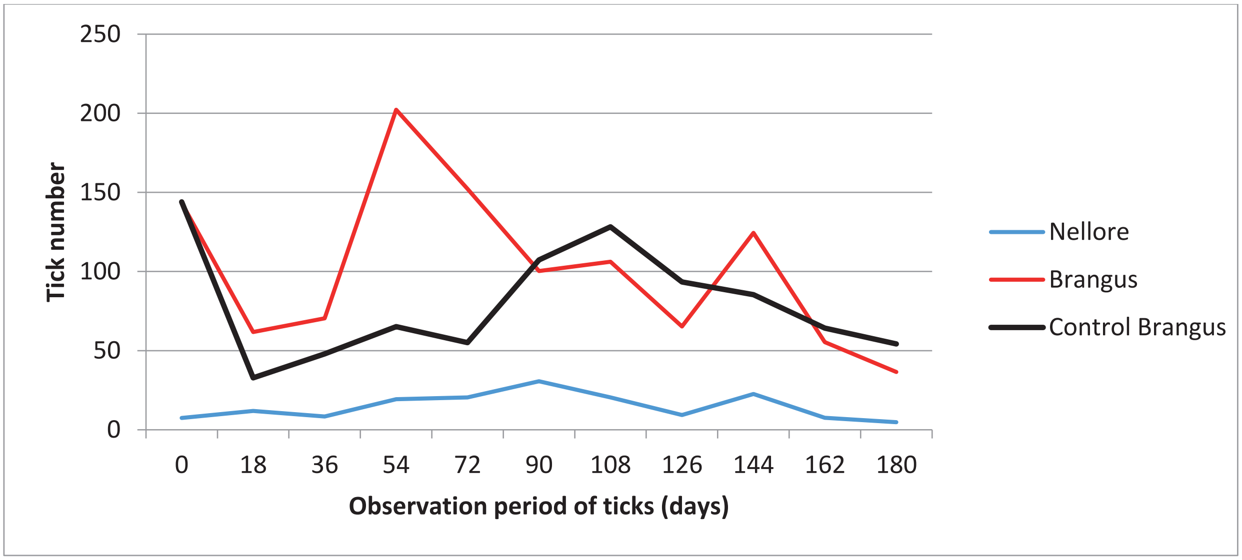
The mean number of ticks on each observation day (every 18 days) is shown in Table 1, and the fluctuation over time is shown in Figure 2.

Table 1. Mean number of ticks in beef cattle under natural infestation.

	Mean daily tick count per breed										
	0	**+18**	**+36**	**+54**	**+72**	**+90**	**+108**	**+126**	**+144**	**+162**	**+180**
Nellore	7	12	8	19	20	31	20	9	23	8	5
Brangus	143	62	70	202	152	100	106	65	124	55	36
Brangus control	144	33	48	65	55	107	128	93	85	64	54

Brangus control, group was raised alone in the paddock; Brangus and Nellore, group where cattle shared the same paddock.

Figure 2. Mean daily population of ticks per animal in the different conditions.



Nellore and Brangus, animals were held in the same paddocks; Brangus (control group), animals were held in adjacent paddocks.

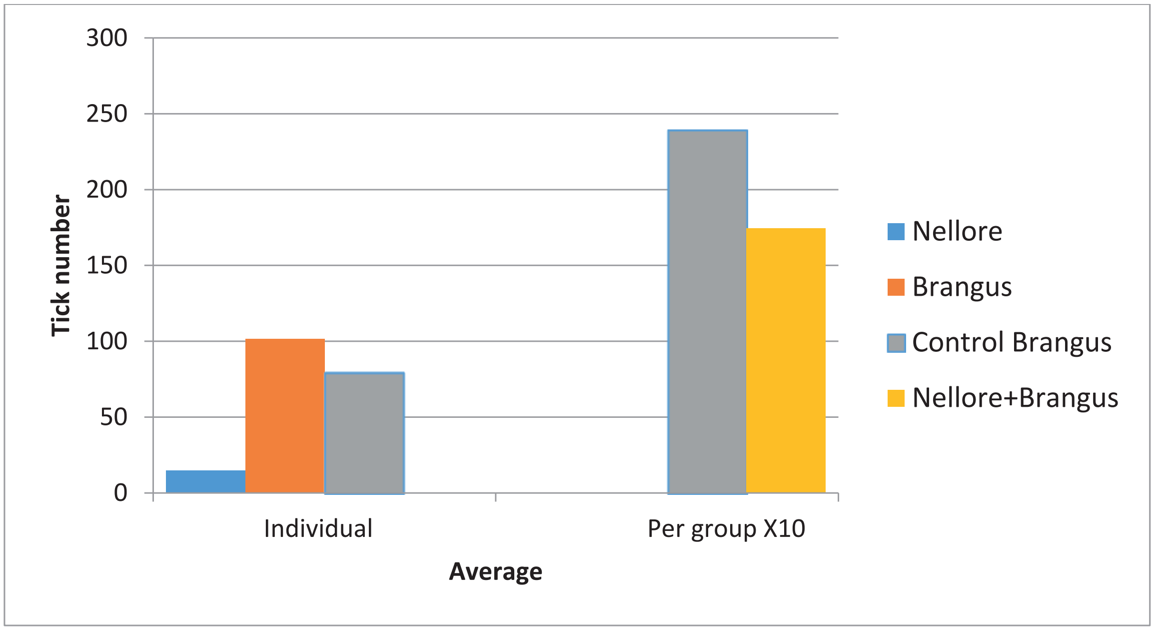
The number of ticks on the Nellore animals is significantly different from that of Brangus animals in both groups (group 1, $p < 0.001$; group 2, $p < 0.001$). No significant difference was observed between the numbers of ticks on the Brangus animals in either group in the evaluated period (6 months).

The Nellore animals produced a daily mean of 15 ticks per animal, which corresponds to 14.7% of the production of the Brangus animals (102) under the same pastures and conditions. That is, naturally infested Brangus produced 6.8 times more ticks than naturally infested Nellore when both breeds were raised under the same pasture conditions, tick infestation pressure, and weather conditions. The mean daily tick production per animal and the mean daily total tick production per group are shown in Table 2. Group 1 produced 27% fewer ticks than group 2 ($p < 0.001$); that is, the paddock that held the Nellore animals, which are more resistant to ticks than are Brangus, produced fewer ticks than the paddock that held only crossbreed animals (Figure 3).

Table 2. Mean daily tick production per animal compared to the mean tick production per group.

	Animal mean	Group mean
Nellore	15	222
Brangus	102	1,524
Control Brangus	80	2,394

Figure 3. Mean tick production per animal and per group.



The mean tick production per group was divided by 10 to fit the scale in the graph.

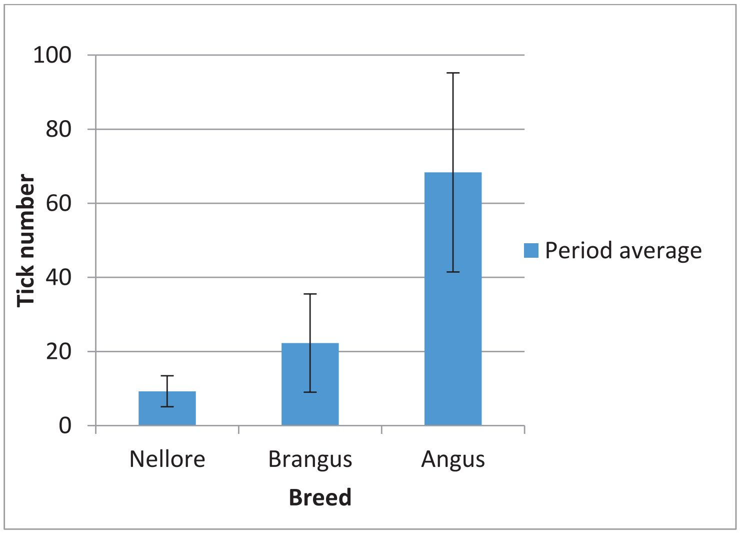
Presence of myiasis in pasture-raised animals

Five of the Brangus animals of the control group that had high tick infestation also had myiasis, however, these animals were treated and remained in the experiment.

Recovery of engorged females in stanchioned animals

The mean daily production of engorged females and the respective standard deviation in the Nellore, Brangus, and Angus animals artificially infested with 10,000 cattle tick larvae are shown in Figure 4.

Figure 4. Mean production of engorged females per animal in the 3 breeds.



Bar represents the standard deviation of the mean.

The Brangus and Angus animals produced 2.44 and 7.55 times more ticks, respectively, than the Nellore animals. The artificial infestation with 10,000 larvae per animal generated a recovery rate of engorged females of 0.83% for Nellore, 2.01% for Brangus, and 6.15% for Angus animals (Table 3).

Table 3. Tick production in artificially infested animals.

Groups	Daily Mean	Total Production	Standard Deviation	Recovery Rate
Nellore	9	83	4	0.83
Brangus	22	201	13	2.01
Angus	68	615	27	6.15

Under these conditions, we can estimate the minimum number of larvae necessary for a daily infestation to produce the mean amount of ticks in pasture-raised animals (Table 4). Because each female tick produces an average of 3,000 eggs that will develop to larvae, estimations of the number of larvae that each animal released to the pasture are possible (Table 4).

Table 4. Number of larvae required for field infestation and daily larval production.

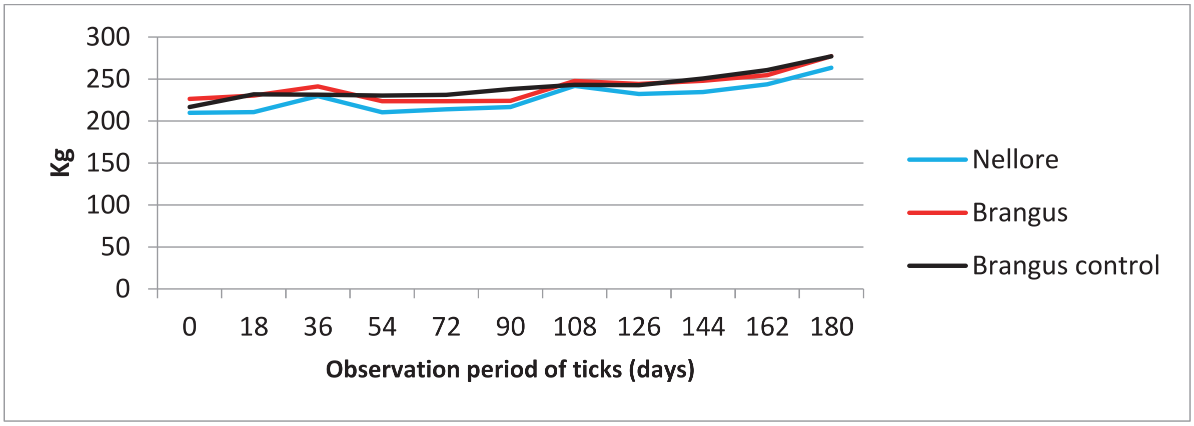
Breed	Individual		Group 1		
	Number of Larvae Required	Larvae Production	Number of Larvae Required	Larvae Production	Infestation Pattern*
Nellore	1,807	45,000	27,108	675,000	1,204
Brangus	5,074	306,000	76,119	4,590,000	497
Total larvae			103,227	5,265,000	

Group 1 included 15 animals of each breed.
*Infestation pattern is the number of larvae/day required for the infestation to produce 10 ticks/day/animal, considering the recovery rate of engorged females per breed.

Weight gain of pasture-raised animals

The weight gain profile of the post-weaning animals during the experimental period (June to December) is shown in Figure 5. No difference was observed in the weight gain between the Nellore and Brangus animals regardless of the group ($p > 0.05$).

Figure 5. Mean weight gain of pasture-raised animals.



Brangus and Nellore animals in the post-weaning phase were raised in the same paddock. Brangus animals (control group) were raised in an adjacent paddock. Both groups were raised in the same pasture and at the same stocking rate. Kg (Kilogram)

A comparison of the mean initial and final weights showed that the Nellore, group 1 Brangus, and group 2 Brangus (control) gained 54 kg, 51 kg, and 61 kg, respectively (Table 5).

Table 5. Daily weight gain per animal.

	Mean weight (kg)												
Group	**0**	**18**	**36**	**54**	**72**	**90**	**108**	**126**	**144**	**162**	**180**	Weight Gain	%
Nellore	210	211	230	210	214	217	242	232	234	244	263	54	26
Brangus	226	230	241	224	224	224	248	244	248	255	277	51	22
Brangus control	217	232	231	230	231	238	243	243	251	261	277	61	28

Correlation between number of ticks and weight gain

In the 6-month evaluation period, no correlation was observed between the total number of ticks and the weight gain for any of the groups, regardless of the breed: Nellore ($r = -0.12$), Brangus (group 1, $r = 0.1$), and Brangus (group 2, $r = 0.05$).

PCR results for tick fever pathogens

The PCR results show that the pathogens circulating among all the animals were *Anaplasma marginale* and *Babesia bigemina*. None of the animals was positive for *B. bovis*.

Hematocrit

In the present study, no correlation was observed between the parasitic load and below-normal hematocrit values. All animals, regardless of the parasitic load, had normal hematocrit values.

Discussion

Observations from the field data of breeding Nellore cattle associated with Brangus in the central Brazil savannah were made to provide the necessary estimates to support the management of tick control.

Introductions of European crossbreeds in the Brazilian savannah, which attempted to improve live weight gains, have been evaluated since the 1980s. The impact of these crosses on the cattle tick (*R. microplus*) populations in the area is a source of concern because Nellore herds presently do not receive regular treatments with acaricides and facilities for the control of ticks have not been developed (GOMES et al., 1989).

Weather profile of the farm

The experiment was performed when the animals were beginning the post-weaning phase, which corresponds to the dry season in central Brazil. As expected, in the first months of the study, low rainfall occurred until the end of the dry season, and then, the rainfall increased gradually until December, when the rainy season was reached. The mean temperature during the study period ranged from 22 to 28°C, which is normal for the region.

The weather conditions affected the pasture production. In the beginning of the experiment, which coincides with the beginning of the post-weaning phase, low availability existed for dry plant matter with low nutritional value, which contributed to the animal's adaptation stress. The start of the rainy season led to better pastures, and consequently, the animals showed better development.

This same pattern was observed in the tick population, which was low in the beginning of the experiment due to low humidity but increased later due to better temperature and humidity conditions. Therefore, both the cattle and the ticks passed through an unfavorable period first and then through more favorable conditions.

Furlong et al. (2003) observed that in the spring, increased temperature and humidity contributed to the development of ticks by stimulating egg metabolism and promoting larval hatching, leading to an increase in the number of larvae in the pastures.

Tick count in pasture-raised animals

Brangus animals had the same number of ticks regardless of whether they were raised with Nellore animals or by themselves. Likewise, Nellore animals raised with the Brangus animals experienced linear tick production following the breed pattern, suggesting that the genetic profile of the animals is not affected by the tick infestation level of animals raised in the same pasture.

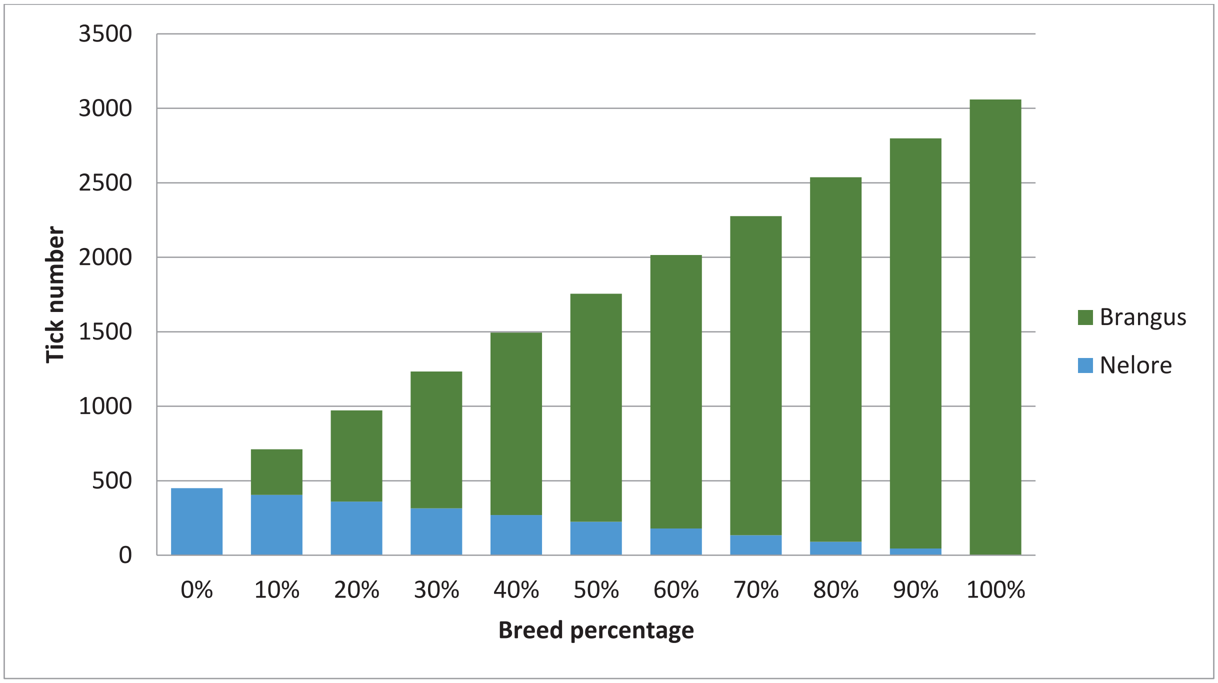
The infestation levels observed in the Brangus animals in the present study were higher than those observed by Gomes et al. (1989) in Ibagé animals (5/8 Angus x 3/8 Nellore) at the same post-weaning phase raised in separate paddocks with *U.*(*B.*) *decumbens* pasture. Gomes et al. (1989) reported that Ibagé had an infestation level of 59.7 ticks/day, which is 58.5% lower than the infestation level observed in the Brangus (1\2 Angus) in the present study (102 ticks). These conflicting results may be attributed to the sample number and observation period, although the results of both studies are characteristic of animals susceptible to ticks.

Nellore animals showed a low mean daily tick production; however, the authors observed many larvae and nymphs attached to the animals' skin, but these immature stages did not develop into adults in the following 18-day observation period. These observations suggest that when Nellore animals are infested by ticks, the immature instars try to develop, but the animal genetic profiles inhibit their development.

Considering the mean production of ticks in the pasture where the Nellore and Brangus cattle were raised, we can estimate the effect of the percentage of Brangus animals in the group (composed of 30 animals) on tick production (Figure 6) even though Jonsson (2006) reported that "average" tick numbers are difficult to relate to an actual tick burden due to the fluctuating sizes of the tick populations.

When considering this projection, we assume that in some environments, where tick survival shows low impact in a pure *Bos indicus* herd such as Nellore, the use of acaricides is not necessary; on the other hand, when *B. taurus* genotypes are replaced with crosses such as Brangus, tick populations grew to a level 6.8 times more in areas where tick control is mandatory, according to Gomes et al. (1989), whose studies showed that tick production in Brangus was 9.5 times that of Nellore cattle in the field.

Figure 6. Tick distribution in the herd where the Brangus breed associated with Nellore.



The analyses were performed on a group of 30 animals.

A difference exists in the resistance of ticks among animals of the same breed. In our study, when only Brangus were considered, 20% of the animals produced 30% of the ticks, whereas the more resistant animals (20%) produced 10% of the ticks. For the Nellore animals raised with the Brangus cattle, we observed that 20% of the Nellore animals produced 42% of the ticks, and the more resistant animals (20%) produced 6% of the ticks. Labruna and Veríssimo (2001), when studying crossbred animals (Holstein x Zebu) that received no acaricide treatment and were managed under a rotational grazing system, observed that 33.3% of the animals carried 63.2% of the total number of ticks counted throughout the experiment.

Several factors may affect the access of larvae to animals, such as the height and type of the pasture and environmental conditions. Gauss and Furlong (2002) suggested that the hierarchical position within a herd raised in the same paddock leads some animals to become infested before other animals and thus to a greater infestation level.

In the present study, we observed that the more widespread introduction of crossbreds is changing both the parasitological and economic aspects of extensive cattle raising.

Recovery of engorged females in stanchioned animals

Bos indicus cattle are known to carry fewer ticks than *B. taurus* cattle; purebred Brahmans generally carry one-tenth the number of ticks that Herefords would carry if exposed to the same infestations, with crossbred cattle having intermediate resistance (JONSSON, 2006).

Comparing the number of ticks in pasture-raised animals and stanchioned animals, the results suggest that Brangus and Nellore animals have more ticks when pasture-raised than when stanchioned.

We propose an Infestation Pattern Model to evaluate the larval infestation level in the field. Considering a recovery rate of engorged females of 0.83% and 2.01% for Nellore and Brangus animals, respectively, the establishment of an infestation pattern is possible for each breed (Table 4). The pattern provides an estimate of the minimum number of larvae required for an infestation to produce a known number of ticks/days/animal, according to the proposed model:

$$\text{Pinf} = \left(\frac{\text{F x 100}}{\text{Fx}}\right) \text{x n}$$

Pinf = Minimum number of infesting larvae

F = Number of engorged females/day/animal (mean)

Fx = Recovery rate of engorged females per breed

n = Number of animals

Minimum number of infesting larvae =

$$\left(\frac{\text{Number of engorged females/day/animal (mean) x 100}}{\text{Recovery rate of engorged females per breed}}\right)$$

x Number of animals

When the production of 10 engorged females/day/animal is taken into account, an infestation pattern of 1,204 and 497 larvae/day, respectively, was observed. That is, Brangus animals require fewer larvae to develop the same number of engorged females as the Nellore, confirming the susceptibility of the Brangus to the cattle tick.

In this study, the Nellore cattle were infested with 27,108 larvae/day to maintain a mean of 15 ticks/day/animal, whereas the Brangus animals were infested with at least 76,119 larvae/day to maintain a mean production of 102 ticks/day/animal, totaling 103,227 larvae/day in the paddock.

Because each engorged female produces 3,000 larvae, on average, the daily contribution of Nellore and Brangus to the pasture infestation was 675,000 larvae/day and 4,590,000 larvae/day, respectively, totaling an availability of 5,265,000 larvae/day in the paddock (group 1).

The larval production of the Nellore animals (675,000 larvae/day) and the estimated infestation of the Brangus animals (76,000 larvae/day) suggest that the pasture had an infestation level much higher than necessary to guarantee larvae numbers sufficient for maintaining the tick population at the level analyzed.

The Brangus, when introduced to a paddock with Nellore, required only 11.3% of the larvae already available in the pasture to maintain the infestation level observed in the present study. Therefore, the Nellore animals produce more larvae than necessary to maintain the pasture infestation level and to infest the Brangus animals.

Tick fever transmission

Madruga et al. (1987) found 100% positivity for *B. bigemina, B. bovis,* and *A. marginale* by serology in 130-day-old animals with a mean infestation rate of 4.5 engorged females/calf/day. In the present study, we found the DNA of *A. marginale* and *B. bigemina* in all animals evaluated, but none of the animals were positive for *B. bovis*. The suppression of immune function of the host has been suggested to facilitate the transmission of tick-borne diseases such as babesiosis and anaplasmosis (INOKUMA et al., 1993).

Ranchers regard the good resistance of zebu cattle to ticks as sufficient for maintaining the enzootic stability of tick fever (*Babesia* + *Anaplasma*) without incurring significant losses due to tick worry (MADRUGA et al., 1985).

The decisions regarding the management of the production systems of central Brazil are taken while considering a Nellore herd. In this experiment, the crossbreed group, Brangus, must be considered as being at risk for tick fever.

Kemp et al. (1982) assumed that anemia is an inevitable consequence of heavy infestation with the tick *R. (*B.*) microplus* and that cattle deaths were attributable to anemia from these infestations. Riek (1965) estimated that each engorging tick was responsible for the loss of 1 mL of blood.

None of the animals of the present study had below-normal hematocrit values, and all groups showed a similar weight gain, differently from that reported by Kemp et al. (1982). Definitions of normal hematocrit are dependent on the age and class of the animal and, to some degree, the environment (including nutritional) in which the animal lives.

Weight gain of pasture-raised animals

Battistelli et al. (2013) studied the development of Brangus cattle in the post-weaning phase and showed that this crossbreed is superior to Nellore cattle and other crosses in weight gain in the Brazilian savannah region. In the present study, we did not find any weight gain difference between the breeds over the 6 months of observation.

Sutherst et al. (1983) studied the effect of *R. microplus* on the live weight gain of crossbred steers and identified a mean loss of 0.6 grams of live weight per tick at an infestation level of 158 ticks/day.

In our study, the infestation level did not affect the animals' weight gain, which differs from that reported by Jonsson (2006), who estimated that tick infestations lead to a loss of 1.18 g/tick/day.

The weight gain observed in the present study corroborates the results of the study by Battistelli et al. (2013) that showed that Brangus animals in the post-weaning phase gained 0.190 kg live weight/day during the dry season and 0.665 kg live weight/day during the rainy season.

Conclusion

The results confirm that the Nellore breed is more resistant to ticks, and when these animals are raised with animals more susceptible to ticks, the tick infestation level and weight gain of the Nellore cattle are not affected.

The level of larval infestation in the pasture with Nellore cattle allows the production of engorged females by Brangus animals at the levels found in the present study, which were 6.8 times more than the level observed in the Nellore after its introduction.

The parasitic loads of the Brangus animals do not decrease when these animals are raised in the same pasture with Nellore cattle. The crossbred animals continue to suffer the effects of tick infestation, and the mean daily tick production places them at risk of developing tick fever.

Finally, the Nellore animals raised with the Brangus animals do not act as a cleaner because they do not contribute to a lower infestation level in Brangus animals.

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