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Original article

Profile of cattle breed sensitivity to the tick *Rhipicephalus microplus*

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ABSTRACT

Among cattle, *Bos taurus* breeds and their crosses are more sensitive to tick infestations than *Bos indicus* breeds that are more resistant to infestation and more adaptable to tropical climates. The presence of susceptible individuals in herds and inadequate tick control lead to direct and indirect losses in the meat production chain, in addition to increased mortality due to cattle tick fever. The objective of this study was to describe, compare and rank the sensitivity of different breeds of stabled cattle to the tick *Rhipicephalus microplus* and to present, as an innovative result, a scale called the Tick Ruler. Secondary data on the number of retrieved engorged females, engorged female ticks' weight, egg mass weight and number of larvae were extracted from research reports of experiments conducted over 18 years with eight breeds to describe and report the sensitivity of the breeds to artificial infestation by *R. microplus* larvae. For analyses, the recovery rate of engorged female ticks and the percentile of dispersion of individuals in their respective races were calculated, and comparison of these percentiles between races was performed. The ranking of the percentiles resulted in the organization of the breeds by their susceptibility to *R. microplus*; we call this scale the "Tick Ruler." The ruler is a simple, easy-to-understand tool that can be used by technicians and producers to evaluate the tick sensitivity of a breed of interest and can assist producers in decision-making to find a balance between increased production gains and the risk of economic losses depending on the breed composition in a cattle herd.

1. Introduction

Rhipicephalus microplus is a tick species with a monoxenous cycle, and cattle are its main host (Garcia et al., 2014; Gonzales, 1975). In Brazil, where this species is known as the cattle tick, it was introduced in the early 18th century and is distributed between the 32° north and 32° south parallels (Nuñes et al., 1982).

Environmental factors such as temperature and humidity directly influence the metabolism and development of the free life stages of *R. microplus*. A temperature of 28 °C and relative humidity of 80 % are considered favorable for this species, and in Brazil, the number of generations can vary from 2.5 to 5 across the country in a year depending on the regional climate (Oshiro et al., 2021). The region where the study was conducted is in the transition zone between the humid subtropical (Cfa) and humid and dry tropical (Aw) climates according to the Köppen-Geiger classification. (Peel et al., 2007).

Rhipicephalus microplus has a predilection for attaching itself, in some regions, on the skin of cattle, for example, on the ventral region, between the legs, and on the udder, scrotum, dewlap and ear. Additionally, cattle find it difficult to clean themselves in body parts such as the axilla and neck (Wagland, 1978).

The losses caused by this tick species are a direct result of the infestation of cattle, causing inappetence, irritability, immunosuppression, anemia, weight decrease, leather lesions leading to commercial devaluation, decreases in meat and milk production, and the transmission of pathogens of cattle tick fever (CTF), leading to cattle mortality (Andreotti et al., 2019).

Indirect losses are related to the costs of labor, drugs to control CTF, acaricides, the acquisition of equipment and maintenance. These direct and indirect losses in Brazil are estimated to reach US$ 3.2 billion

Abbreviations: CTF, Cattle tick fever; RREF, Recovery rate of engorged female ticks; QT, Total quantity of engorged female ticks recovered per animal; QIL, Quantity of infested larvae per animal.

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annually (Grisi et al., 2014).

Bos taurus and its crosses have greater sensitivity to tick infestations than other breeds (Gomes et al., 1989). Furthermore, *B. taurus* cattle are more productive but less tolerant to heat in tropical climate regions and suffer more thermal stress than *Bos indicus* cattle (West, 2003). *Bos indicus* breeds have short coats, are more resistant to tick infestations and are more adaptable to the tropical climate of central Brazil (Hansen, 2004; Ribeiro et al., 2009).

The presence of susceptible individuals in herds and inadequate tick control lead to endemicity with fluctuations that can induce high levels of infestation in just one generation, allowing more intense outbreaks of CTF and increasing mortality in the herd (Martins et al., 2020, 2022).

The cattle production chain in Brazil has grown in recent decades with the genetic development of more productive and rapidly maturing European breeds, with the goal of meeting the demand for animal products as a source of protein and other derivatives and for greater added value in international markets (Wedekin, 2017).

Approximately 80 % of the effective cattle population in Brazil is composed of Zebu and Nellore crossbreeds. In 2018, Brazil was the second largest producer of beef worldwide, accounting for 15 % of beef production and ranking first in exports (ABIEC (Associação Brasileira das Indústrias Exportadoras de Carne), 2023).

The base of the beef herd in central Brazil is the Nellore breed, which is characterized by adaptability to the climate, rusticity, and resistance to ticks, leading to low levels of parasitic infestation and serving as a genetic basis for improvements (Andreotti et al., 2018).

Among the productive European breeds used in Brazil for beef cattle, the Angus breeds originated in Scotland; composite breeds such as Caracu originated from crosses of several breeds (Primo, 2000); and the Senepol breeds originated in the Caribbean, resulting from crosses between the NDama and Red Poll breeds, which were introduced in Brazil in 2000 (ABCB Senepol - Associação Brasileira de Criadores de Bovinos Senepol, 2023).

Among tropical areas, the Brangus breed was first developed in Brazil in 1940 and is genetically 3/8 Nellore and 5/8 Angus, with production characteristics associated with tropical climate adaptability and tick sensitivity (Salomoni and Del Duca, 2009). The genetic composition of the synthetic breed has led to 62.5 % greater sensitivity to the tick than that of resistant breeds, with a race-specific sensitivity observed.

In terms of milk production, the Friesian Holstein breed has high productivity but low adaptability to the tropical climate and is also bred with the Gir breed to form the Girolando breed (5/8 Holstein with 3/8 Gir). Both breeds require tick control in herds (McManus et al., 2008).

Thus, advancements in beef cattle production in Brazil include achieving increased productivity using genetic breeding as a tool, but tick control is an obstacle that must be overcome, especially due to the worsening of resistance and/or multidrug resistance in ticks. There are reports of populations resistant to more than eight chemical acaricides in Rio Grande do Sul (Higa et al., 2015; Junior et al., 2022).

Currently, in the Brazilian production system, there are several cattle breeds and crosses with different degrees of sensitivity to ticks, although these characteristics are not considered by producers during the selection of new animals. This reality makes the control of *R. microplus* difficult, and therefore, it is important to know the susceptibility of *R. microplus* breeds to ticks for the development of successful control strategies.

The objective of this cross-sectional study was to describe, compare and rank the sensitivity of different breeds of stabled cattle to the tick *R. microplus* and present, as an innovative result, a scale called the Tick Ruler.

2. Materials and methods

This was a cross-sectional observational study, as it investigated the statistical associations between a cause (breed) and effect (tick sensitivity) in a given period (Levin, 2006). The analysis and evaluation were performed using secondary data from research reports released in Embrapa Gado de Corte (S 20° 44 25 76′; W 54° 72 20 66′; 530.0 m) in Campo Grande MS, Brazil, from 2002 to 2020.

The secondary data, i.e., the biological parameters of the engorged female ticks, including the number of retrieved engorged females, the weights of the engorged female ticks and the egg mass weight, were recorded in Excel spreadsheets for each experiment.

These data were used to assess tick infestations in several breeds of stabled cattle without previous treatment with any type of acaricide. This study sought to describe and report the sensitivity of breeds to artificial infestation by *R. microplus* tick larvae.

2.1. Description of the experiments

2.1.1. Project design

Over 18 years, eight breeds, i.e., Holstein, Caracu, Senepol, Romosinuano, Belmont Red, Angus, Brangus, and Nellore, were used for each experiment, and some were used more than once. There were five different experiments with Holstein cattle, four with Angus, three with Caracu, two with Senepol, two with Brangus, and two with Nellore; the other breeds were used only once (Table 1).

All the procedures performed using animals were in accordance with the norms published by the National Council of Control of Animal Experimentation/CONCEA and were approved by the Ethics Commission of the Use of Animals/CEUA at Embrapa Gado de Corte, "(CEUA 008/2014 e 005/2018)".

2.1.2. Study area

All experiments used individual pens (2.8 × 2.0 m); each pen had a wooden platform with slots 20 cm from the ground to facilitate the flow of water when washing the stalls and to remove waste and engorged female ticks. There were a total of 32 pens.

The cattle in each experiment had been recently weaned (aged 8 to 12 months) and were of the same breed. All animals were individually identified using numbered ear tags. For each experiment, the cattle were placed in individual pens at different times of the year and infested with active larvae.

Throughout the study period, the feeding management system was the same for all the experiments. The feed, which included silage of forage, sorghum, and corn and was designed for a weight gain of 200 gs per day, was provided twice daily; water was provided ad libitum.

Table 1
Description of the variables studied in the evaluation of the sensitivity of breeds to artificial infestation by *Rhipicephalus microplus* tick larvae, Campo Grande, MS, Brazil.

Breed	Number of animals	Year/ month	Number of larvae used per animal
Angus	9	2016/Feb	10,000
	4	2016/Apr	15,000
	5	2018/Dec	15,000
	6	2020/Oct	15,000
Belmont Red	6	2002/Apr	20,000
Brangus	5	2013/Apr	15,000
	10	2016/Feb	10,000
Caracu	6	2002/Apr	20,000
	16	2018/Jul	15,000
	12	2018/Aug	15,000
Holstein	6	2010/Apr	15,000
	6	2010/Nov	15,000
	6	2011/Jun	15,000
	6	2012/Feb	15,000
	4	2014/Sep	15,000
Nellore	10	2016/Feb	10,000
	5	2016/Apr	15,000
Romosinuano	6	2002/Apr	20,000
Senepol	14	2018/Jul	15,000
	10	2018/Aug	15,000

2.1.3. Infestations and collections

In all experiments, for larval infestation in each animal unit, engorged female ticks of a regional tick strain (Campo Grande, MS, Brazil) were collected and incubated in a biochemical oxygen demand (BOD) oven at 27 °C with 80 % relative humidity to complete their off-host development. After the oviposition period of the engorged female ticks, the egg mass was separated and weighed based on the needs of each experiment, wherein 1 g of egg mass corresponded to 20,000 larvae (Labruna et al., 1997), and the egg mass was placed in tubes for incubation and subsequent hatching. After the maturation period, at approximately 12 to 15 days of life, the larvae were used to infest the cattle.

To artificially infest the cattle, tubes with unfed larvae were tied with string to the scapular dorsum of the animal for four hours, allowing the larvae to escape from the tubes and to attach to the animal skin. From the twenty-first day after infestation onwards, the detachment and recovery of engorged female ticks was carried out using the stall test following the procedure described by Brasil (1997). For 20 consecutive days, engorged female ticks were collected by means of separation in droppings, identified by stall and animal, and taken to the laboratory. According to Pereira and Labruna (2008), engorged females of *R. microplus* detach from cattle between 18 and 35 days after larval infestation, with the modal day of detachment being the 21st or the 22nd day. Thus, during our experiments we may have missed a small number of engorged females that detached before the 21st day after infestation. However, this gap was normalized in the study because it was applied to all experimental infestations.

Subsequently, the groups of ticks from the respective animals were washed, dried, counted and weighed. The engorged female ticks were then placed in Petri dishes and stored in a BOD oven, after which the egg mass was weighed at the end of oviposition.

3. Analysis of biological parameters

3.1. Recovery rate of engorged female ticks

Considering the number of infested larvae and female engorged ticks retrieved per animal in each experiment, it was possible to calculate the recovery rate of engorged female ticks (**RREF**) by breed (Piña et al., 2021):

RREF = QT/QIL × 100 where

RREF = recovery rate of engorged female ticks

QT = total quantity of engorged female ticks recovered per animal

QIL = quantity of infested larvae per animal.

Genetic variability by breed

To analyze the dispersion of animals in relation to sensitivity to *R. microplus* within the same breed, the percentile of the variable quantity of ticks recovered was calculated. A box plot was used to compare the dispersion among breeds. The analyses were performed using SAS OnDemand for Academics.

3.2. Ranking susceptibility to ticks

All individual data on the number of ticks recovered, regardless of breed, were grouped, and the percentile was calculated. The analyses were performed using SAS OnDemand for Academics. These percentiles were ordered on a horizontal line with a scale from 0 to 100 %, and the mean value of ticks recovered by breed was recorded in the respective percentile and highlighted.

This ranking was used to organize the breeds by their susceptibility to *R. microplus*, which we call the "Tick Ruler", which also provides the economic threshold percentile. For this tool, the closer the value is to 0, the more resistant the breed is, and the further away from the economic threshold the value is, the greater the susceptibility of the breed. This information can be used in decision-making by producers to invest in more productive breeds.

3.3. Statistical analysis

The data on engorged female ticks production, retrieval rate and mean weight of the engorged female ticks were compared using ANOVA with the least squares post hoc test, and p values < 0.05 were considered indicative of statistical significance. For the analysis of infestation levels, ANOVA was used (SAS OnDemand for Academics), with p values < 0.05 considered indicative of statistical significance.

4. Results

The number of infested larvae per animal varied among 10, 15 and 20 thousand, and despite this fluctuation, there was no significant difference among the infestations ($p = 0.33$). These results regarding the number of larvae applied in the infestations demonstrate that the data were sufficient and uniform and thus could be used to assess the sensitivity of breeds of cattle through their genetic susceptibility over the study period and to define a profile for each group to construct the Tick Ruler.

Fig. 1 shows the mean number of recovered ticks per animal during the entire experiment by breed. The results revealed the tick sensitivity profiles by breed; the Nellore breed showed the highest resistance to the parasite, and the Romosinuano breed was the most susceptible.

Comparing breeds with Zebu blood in their genetic composition with the other breeds revealed that there were differences in the profiles of sensitivity to *R. microplus* (Table 2). The Nellore and Brangus breeds did not differ significantly from each other in terms of the number of engorged female ticks; however, they differed significantly from the other breeds.

The retrieved ticks had statistically equal weights among the Brangus, Angus, and Holstein breeds (Table 2), varying from 0.237 to 0.310 g.

The mean weight of the ticks, which ranged from 0.243 g to 0.271 g for the Brangus, Angus, Holstein, Nellore and Senepol breeds, may reflect the normality and good individual conditions of the engorged female ticks. Although cattle with Zebu blood had fewer ticks, engorged female ticks that reached adulthood had weights and sizes within the expected range.

For the Caracu, Romosinuano and Belmont Red breeds, the engorged female tick weights were not significantly different. Variation between 42.9 % and 49.8 % was observed for the conversion rate into eggs.

The recovery rate of engorged female ticks (RREF), shown in Fig. 2, indicates the capacity of cattle to convert artificially infested larvae into engorged female ticks, given that the number of larvae used is known; that is, the RREF reflects the percentage of successful survival of the larvae that develop to the adult stage. The RREF is an indicator that assists in the evaluation of breed sensitivity.

The dispersion of the genetic variability of individuals in their respective breeds is shown in Table 3, which provides the distribution of individuals in breeds (%) by the number of ticks collected.

Fig. 3 provides a comparison of the trends of the dispersion of genetic variability among breeds and supports the construction of the Tick Ruler. Knowing the average number of ticks by breed and distribution allows us to rank the breeds by sensitivity profile (Fig. 4). The dotted line marks the economic threshold (P11).

5. Discussion

The recovery rates of the viable larvae of the engorged females in the experiments ranged from 0.04 % to 5 % (Table 2- 0.3 ± 0.26 and 2.7 ± 2.58), indicating that there was a large difference in infestation among the animals depending on their breed. The infestation conditions in the pastures represented 95 % of the tick population (Pereira and Labruna, 2008), providing the opportunity for daily infestation. Given that a female tick lays approximately 3000 eggs (Pereira and Labruna, 2008), in uncontrolled situations, a serious crisis can occur within a month of

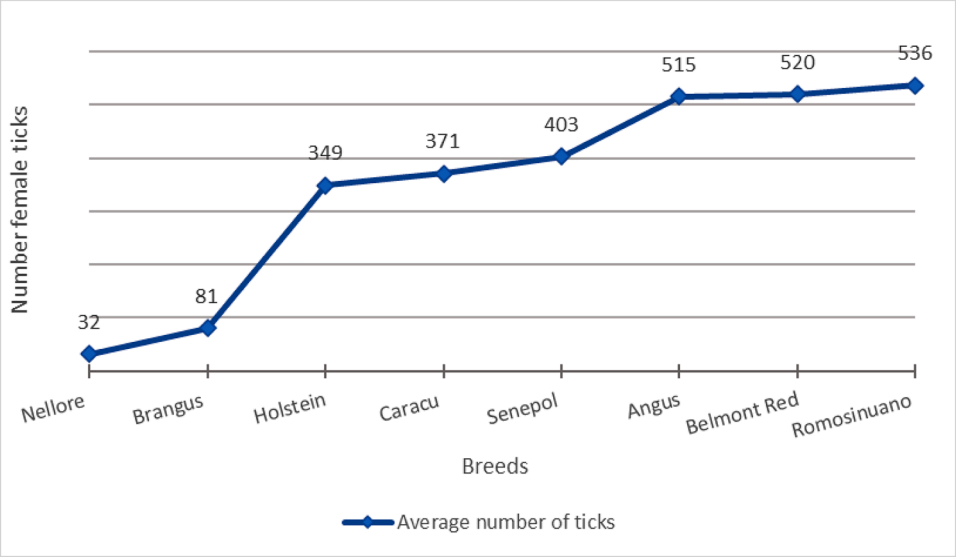

Fig. 1. Mean number of engorged females of *Rhipicephalus microplus* collected by breed throughout the experiments.
Note: The ANOVA results used to compare the differences are detailed in Table 2.

Table 2
Statistical analysis of the biological parameters of the engorged female *Rhipicephalus microplus* ticks collected by breed.

Cattle breeds	Mean number of engorged females collected	Mean weight (g)	Recovery rate of engorged females* (%)	Egg conversion rate ** (%)
Nellore	32.53 ± 25.17^{a}	0.249 ± 0.019^{bc}	0.3 ± 0.26^{a}	46.0 ± 0.64
Brangus	80.60 ± 54.05^{a}	0.271 ± 0.030^{a}	0.8 ± 0.57^{a}	45.4 ± 1.27
Holstein	349.14 ± 203.65^{b}	0.264 ± 0.017^{ab}	2.3 ± 1.36^{b}	49.8 ± 1.02
Caracu	371.29 ± 316.87^{b}	0.233 ± 0.025^{cd}	2.4 ± 2.09^{b}	-
Senepol	403.42 ± 238.99^{b}	0.243 ± 0.031^{cd}	2.7 ± 1.59^{bc}	-
Angus	515.50 ± 336.00^{b}	0.268 ± 0.036^{a}	3.8 ± 2.14^{c}	42.9 ± 1.50
Belmont Red	520.16 ± 782.45^{b}	0.219 ± 0.020^{d}	2.6 ± 3.89^{bc}	-
Romosinuano	535.83 ± 515.88^{b}	0.228 ± 0.020^{cd}	2.7 ± 2.58^{bc}	-

Different letters in the same column indicate significant differences ($p < 0.05$).
* RREF.
** Percentage of engorged female weight that was converted to eggs.

exposure, i.e., in a short timeframe, negatively affecting the health of the animals.

Compared with the genetically more susceptible breeds, the number of ticks recovered from the Angus breed was 1.3 times greater than that recovered from the Senepol breed, i.e., the number of ticks recovered from the Angus breed was 28 % higher than that recovered from the Senepol breed and 6.4 times higher than that retrieved from the Brangus breed.

When comparing the Brangus, Senepol and Angus breeds with the Nellore breed, 2.5 ×, 12.6 ×, and 16.1 × more ticks were retrieved from the Brangus, Senepol and Angus breeds than from the Nellore breed.

Andreotti et al. (2018) compared tick infestations in Nellore and Brangus animals raised together in the field and reported that the Brangus breed was more susceptible, with 6.8 × more ticks than that retrieved from the Nellore breed, suggesting that breed genetics interact with the environmental conditions in the field to affect tick sensitivity.

Thus, raising animals with different sensitivities leads to greater costs in tick control, considering that it is important to control larvae in pastures and that it is necessary to treat all animals in the paddock.

Tick infestation in Nellore animals produced large numbers of engorged larvae and nymphs, but few individuals developed to adulthood, demonstrating that this breed, despite receiving the same infestation load as the other breeds, has a greater ability to protect itself, suggesting that its immune system hinders the development of the tick to adulthood.

These observations were consistent with the results of studies of the transcriptome of tick saliva by Giachetto et al. (2020), who reported a rich variety of bioactive substances that enable blood feeding in sensitive Angus animals. Different transcripts were identified in ticks that had susceptible animals as hosts and in resistant animals, indicating that these traits are defined in the genomes of the breeds.

The weights of the engorged female ticks of the Caracu, Romosinuano and Belmont Red breeds were not significantly different but were below the average weight reported in the literature by Oliveira (1979). This suggests that due to the large number of nymphs that became viable, intraspecies competition put pressure on the development of the engorged female ticks, resulting in lower tick weights.

The percentage of engorged female weight that was converted to eggs was between 42.9 % and 49.8 %. Oliveira (1979) reported conversion rates between 47.8 % and 56.9 %; however, in that study, breed was not mentioned, and breed influences the oviposition process.

The higher the recovery rate is, the lower the effect of an animal's immune response to tick infestations and, consequently, the greater its susceptibility to *R. microplus*. Angus had the highest RREF (3.8 %). Animals in the field are subjected to daily infestation by thousands of larvae, meaning that the higher the RREF is, the greater the risk of cattle contracting CTF due to increased agent transmission.

In contrast, for the most resistant breed, Nellore, the RREF was 0.3 %. The profile of Brangus, with an RREF of 0.8 %, was not significantly different from that of the Nellore breed; importantly, Brangus is currently one of the breeds widely used to increase productivity in beef cattle production systems in the Cerrado region of central Brazil.

In general, animals with *B. taurus* blood were more susceptible to ticks, with RREF values that were significantly different from those for animals with Zebu blood (Table 2). Molento et al. (2013) performed tick counting for animals of different breeds and observed that animals with a greater proportion of *B. indicus* blood had lower tick counts than did

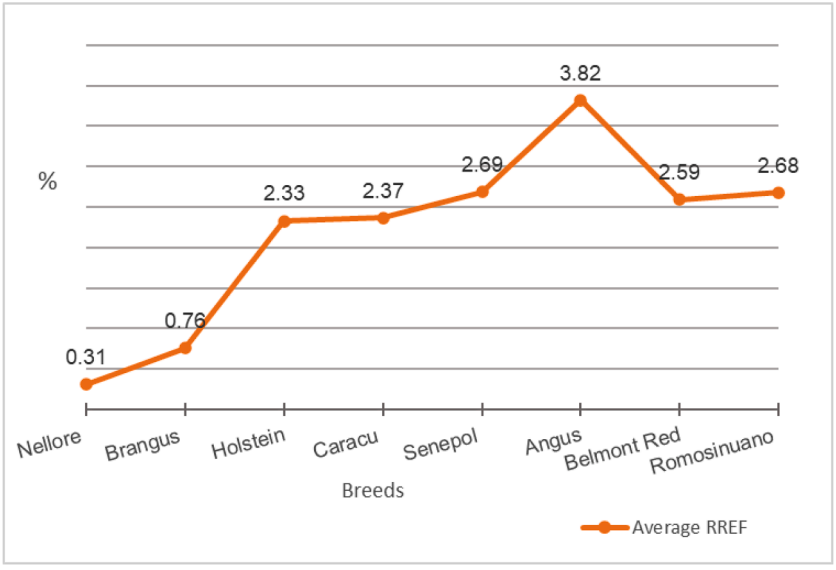

Fig. 2. Recovery rate of engorged females of *Rhipicephalus microplus* (RREF) by breed.

Table 3
Genetic variability of individuals within a breed (%) classified according to the number of *Rhipicephalus microplus* ticks collected.

	Number of ticks		
	<40	40–100	>100
Nellore	70.5	29.5	0
Brangus	31.3	39.7	29
Holstein	0	12.4	87.6
Caracu	4	14.1	81.9
Senepol	0	10.7	89.3
Angus	0	0	100
Belmont Red	0	5.7	94.3
Romosinuano	0	4.4	95.6

animals of European breeds, a finding that corroborates the results of this study.

Within the same breed, there were animals with different sensitivities to *R. microplus*; this finding is supported by different levels of infestation observed in individuals of the same herd after five months of counting ticks (Brasil, 2020).

Comparing the genetic variability of individuals within a breed and the dispersion among them, in the Nellore breed, 70.5 % of the animals had fewer than 40 ticks (Table 3), i.e., below the economic threshold of estimated loss of 8.8 kg/animal/year (Gonzales, 2003), with no measurable effect on animal performance.

Among the Nellore animals, 29.5 % had up to 91 ticks, i.e., at the extreme quartile 4 threshold (Fig. 3). Honer and Gomes (1990) calculated a weight loss per cattle of 0.22 kg/tick/year; based on this estimate, for animals that have between 41 and 80 ticks, there are direct losses due to infestation; for animals that have between 81 and 100 ticks,

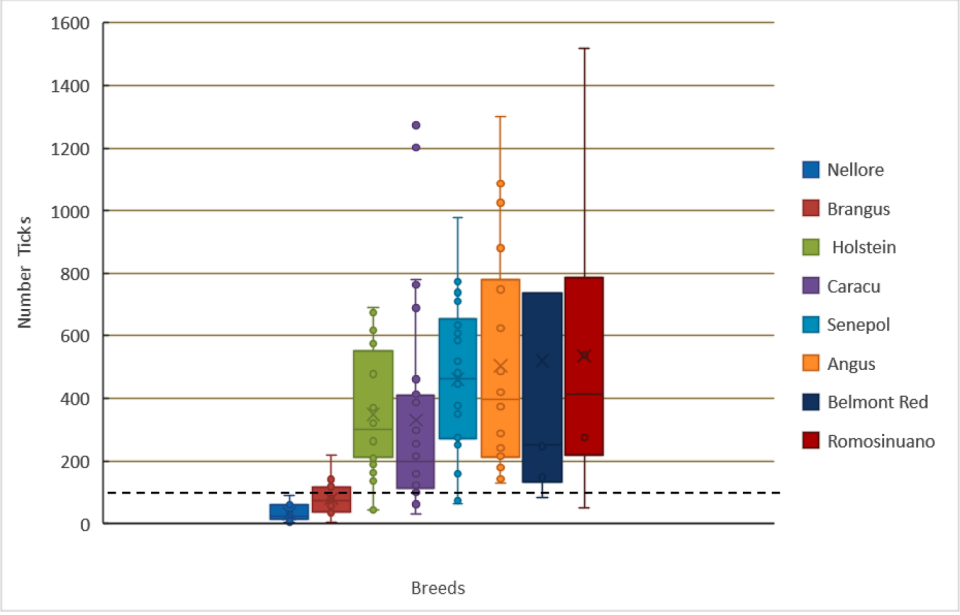

Fig. 3. Dispersion of animals in relation to the sensitivity to *R. microplus* within the same breed and between races.
Note: The dashed line indicates 100 ticks.

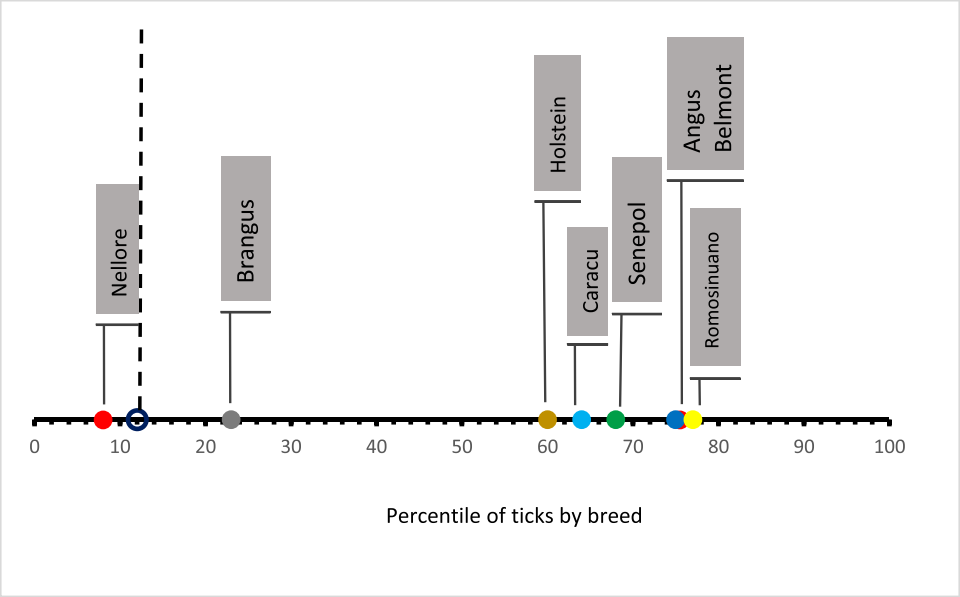

Fig. 4. Ranking the susceptibility to *Rhipicephalus microplus*: Tick Ruler.
Note: The percentile by breed was calculated based on the number of engorged female ticks recovered. The dashed line shows the economic threshold relative to 40 ticks.

there are negative impacts on weight gain.

For animals that have high sensitivity, with more than 100 ticks, the impact on weight gain is greater, and they are at greater risk of CTF. These observations corroborate the findings of Jonsson (2006), who reported that high levels of *R. microplus* infestation promote a suppressive effect on the immune response and that this suppression facilitates the transmission of diseases such as babesiosis and anaplasmosis; moreover, for those with more than 100 ticks/day, the application of acaricide is profitable because the cost of application per head offsets the loss of live weight per engorged female.

Among the Brangus animals, 31.3 % were more resistant, with fewer than 40 ticks, 39.7 % had up to 100 engorged female ticks, and 29 % had more than 100 ticks. As the Brangus breed originated from the Angus and Nellore breeds, the Nellore genetics provide a greater degree of resistance.

A small portion of the animals of the Holstein, Caracu, Senepol, Belmont Red and Romosinuano breeds (12.4 %, 14.1 %, 10.7 %, 5.7 % and 4.4 %, respectively) had between 41 and 100 engorged female ticks. The remaining individuals were more sensitive, and the risk of CTF increased as the number of ticks increased (Fig. 3).

All Angus individuals (100 %) had more than 100 ticks, peaking at 1300, which demonstrates the degree of susceptibility of this breed to *R. microplus*, requiring greater tick maintenance.

On the Tick Ruler, breeds to the left have fewer than 40 ticks on average and can be classified as resistant. In this study, only the Nellore animals fit that category. In general, the studied breeds require tick control to ensure their genetic productive potential.

The closer the number of ticks is to 100, the more susceptible a breed is, and the greater the risks of economic losses resulting from weight loss, acaricide costs, curative treatments, and risk of death due to infection by CTF agents.

Tick infestation analysis performed by Calvano et al. (2019) revealed economic losses in Brangus breeds and in other breeds evaluated based on animal performance (weight loss), showing the importance of tick control to mitigate these effects. Additionally, as technology advances, including expansion of the choice of breeds with more productive genetics and more tick sensitivity, the economic impact on the livestock production chain increases (Calvano et al., 2021).

The field production system puts pressure on herds through massive larval production in pastures over generations; 95 % of ticks are in the larval form in pastures. This high infestation in addition to the breed profile and other variables, such as pasture quality, nutritional status, effect of stress on the herd and time of year, influence the general condition of the animals and amplify tick sensitivity.

The Tick Ruler helps in identifying the extent of this problem and establishing methods to prevent recurrent attacks when the level of concern about ticks is inadequate. The Tick Ruler provides a practical guide that demonstrates the effects of the infestation level increasing from 30 ticks to 600 ticks for different breeds, for example. Furthermore, this tool demonstrates the impact of the infestation on the economic conditions in the field, corroborating the data of Calvano et al. (2021), who showed a greater loss of investment in technology in situations where ticks were not adequately controlled.

An evaluation of market projections revealed a positive projection for the cattle production chain, highlighting the need for investment in more productive genotypes, as reported by Barros et al. (2024); however, this transformation will depend on a commitment to tick control due to the sensitivity of productive breeds to tick infestation.

6. Conclusions

In times of precision livestock, when producers make decisions based on organized and accurate databases, knowledge of the particularities of breeds helps ranchers choose the most productive and profitable bovine lines to compose a herd.

In this study, herd composition was characterized by resistance or sensitivity to *R. microplus,* and resistance or sensitivity was compared among breeds using the Tick Ruler, allowing producers to better analyze the potential economic damage due to ticks when introduced to the most productive breeds.

The findings support the need for cattle ranchers to know the risks of acquiring more productive animals, such as Brangus, 29 % of which will exhibit tick sensitivity, leading to economic losses; comparatively, 100 %, 81.9 % and 89.3 % of Angus, Caracu and Senepol cattle will exhibit tick sensitivity leading to economic losses and will therefore require greater management.

The Tick Ruler is a simple, easy-to-understand tool. It can be used by technicians and producers to evaluate the tick sensitivity of a breed of

interest and can assist producers in decision-making to find a balance between increased production gains and the risk of economic losses depending on the breed composition in a cattle herd. In addition, in the future, the development of a Tick Ruler application will allow the continuous incorporation of breed information into the system over time and ensure its availability to producers.

Author statement

The authors declare that they do not have a conflict of interest, permit the use of figure and tables, have seen and approved the manuscript and have contributed significantly to the work.

CRediT authorship contribution statement

Jacqueline Cavalcante Barros: Writing – original draft, Investigation. **Marcos Valério Garcia:** Writing – review & editing. **Leandro de Oliveira Souza Higa:** Validation. **Alexandre da Silva Souza:** Investigation. **Renato Andreotti:** Writing – review & editing, Supervision.

Data availability

Data will be made available on request.

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