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Risk factors related to resistance to *Rhipicephalus (Boophilus) microplus* and weight gain of heifers

Fatores de risco relacionados à resistência a *Rhipicephalus (Boophilus) microplus* e ganho de peso de bezerras

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Abstract

The aim of the present study was to evaluate the influence of age and genetics in dairy heifers on resistance to the cattle tick *Rhipicephalus (Boophilus) microplus* and correlate these parameters with weight gain. Twenty-two heifers were evaluated from birth up to two years of age. Resistance to the cattle tick was evaluated by counting the number of engorged female ticks and subjective qualification of the larvae and nymph infestation. The animals were weighted in the first 24 hours after birth and at six, 12, 18 and 24 months of age. The average tick count and weight gain were compared by Tukey's test at 5% significance. Subsequently, linear regression was performed to verify the strength of the association between the risk factors age and genetics and infestation by *R. (B.) microplus*. Age and genetics were both significant risk factors for *R. (B.) microplus* infestation in heifers. Between the third and sixth months of age, the animals showed a window of susceptibility to *R. (B.) microplus*. Regardless of age, *Bos taurus* heifers had higher infestations than *Bos indicus*, crossbred F1 ($\frac{1}{2}$ *B. taurus* x $\frac{1}{2}$ *B. indicus*) and crossbred Gir-Holstein (Girolando) ($\frac{5}{8}$ *B. taurus* x $\frac{3}{8}$ *B. indicus*) heifers. *B. taurus* heifers were heavier than *B. indicus* heifers at birth and had significantly greater weight gain ($p < 0.01$).

Key words: *Bos indicus*, *Bos taurus*, weight gain, resistance, *Rhipicephalus microplus*

Resumo

O objetivo do estudo foi conhecer a influência da idade e da genética sobre a resistência ao carrapato *Rhipicephalus (Boophilus) microplus* e correlacionar estes parâmetros com ganho de peso de bezerras de origem leiteira. Foram avaliadas 22 bezerras desde o nascimento até dois anos de idade. A avaliação da resistência foi realizada por meio da contagem de teleóginas ingurgitadas e qualificação subjetiva da infestação por larvas e ninfas. Os animais foram pesados nas primeiras 24 horas pós-nascimento, aos seis, 12, 18 e 24 meses de idade. A comparação das médias das contagens de carrapatos e ganho de peso foi realizada pelo teste Tukey a 5% de significância. Posteriormente foi realizada regressão linear para verificar a força da associação entre os fatores de risco idade e genética e a infestação por *R. (B.) microplus*. A idade e a genética constituíram importantes fatores de risco para infestação por *R. (B.) microplus* nas bezerras. Entre o terceiro e sexto mês de idade, os animais apresentaram uma janela de suscetibilidade ao carrapato *R. (B.) microplus*. Independente da idade, bezerras *Bos taurus* foram mais infestadas do que bezerras *Bos indicus*, mestiças F1 ($\frac{1}{2}$ *B. taurus* x $\frac{1}{2}$ *B. indicus*) e Girolandas ($\frac{5}{8}$ *B.*

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taurus x $\frac{3}{8}$ *B. indicus*). Além de nascerem mais pesadas, as bezerras *B. taurus* demonstraram ganho de peso significativamente maior ($p < 0.01$) do que as bezerras *B. indicus*.

Palavras-chave: *Bos indicus*, *Bos taurus*, ganho de peso, resistência, *Rhipicephalus microplus*

Cattle infestation by the *Rhipicephalus microplus* tick has caused significant losses to the livestock industry (JONSSON, 2006). It is estimated that the economic losses caused by *R. (B.) microplus* worldwide can reach 13 billion dollars annually, and in Brazil alone, this value can exceed 800 million dollars (MARTINEZ et al., 2006). These economic losses are mainly associated with the ingestion of host blood, toxin inoculation, decreased leather quality and the transmission of pathogenic agents, especially protozoans of the genera *Anaplasma* and *Babesia* (TURNER; SHORT, 1972; SUTHERST et al., 1983; SILVA et al., 2013, 2014).

Host susceptibility to parasites is a multifactorial phenomenon in which distinct characteristics can be recognized such as the host immune response, age and genetics (CONSTANTINOIU et al., 2010). The first immunity of newborns against parasitic agents is the immunity provided by colostral antibodies, which is an important factor for the establishment of the host-parasite balance. Maternal antibodies in calves usually disappear 9-12 weeks after birth; however, calves remain resistant for a longer period (POTGIETER; STOLTZ, 1994).

Zebu and taurine breeds are equally susceptible to primary infestation by *R. (B.) microplus* larvae (WAGLAND, 1975; SILVA et al., 2013). The greater resistance level in Zebu cattle becomes apparent after a period of susceptibility to primary infestation (HEWETSON, 1971). Studies have demonstrated greater resistance to cattle ticks in Zebu cattle compared with taurine animals (PIPER et al., 2009; CONSTANTINOIU et al., 2010). This difference has also been demonstrated in crossbred animals in which greater proportions of Zebu blood are associated with greater resistance to the cattle tick (JONSSON, 2006).

The economic damage caused by the cattle tick to cattle and the rational use of acaricides can be determined by counting the number of engorged females (SUTHERST et al., 1983). Jonsson (2006) estimated that the economic loss caused by each engorged female is 1.25 g of bodyweight for both *Bos taurus* and *Bos indicus*. Thus, especially in tropical regions where pure *B. taurus* cattle have largely been replaced by *B. indicus* and their crossbreeds, knowledge of the parasite load is very important to determine the genetic patterns of herds. In this context, the aim of the present study was to evaluate the influence of age and genetics as risk factors for resistance to *R. (B.) microplus* and weight gain in dairy heifers.

Field activities were performed from 2008 to 2010 in the Dairy Cattle Division (Setor de Bovinocultura de Leite) of the State Center for Research in Organic Agriculture (Centro Estadual de Pesquisa em Agricultura Orgânica) from the Agricultural Research Corporation of the State of Rio de Janeiro (Empresa de Pesquisa Agropecuária do Estado do Rio de Janeiro - Pesagro-Rio), located in the metropolitan microregion of the municipality of Rio de Janeiro (latitude 22°45'S, longitude 43°41'W and 33 meters altitude).

Twenty-two heifers were evaluated from birth up to two years of age. The evaluated animals remained in the same pasture and were maintained under the same husbandry management throughout the experimental period. The animals were randomly selected by stratified sampling. Of all the animals evaluated, six were *B. taurus* calves, six were crossbred F1 ($\frac{1}{2}$ *B. taurus* x $\frac{1}{2}$ *B. indicus*) calves, five were Gir-Holstein crossbred (Girolando) ($\frac{5}{8}$ *B. taurus* x $\frac{3}{8}$ *B. indicus*) calves and five were *B. indicus* calves.

After birth, the heifers remained in individual pens for the first 15 days of life, being fed with milk twice a day (4 kg of milk/day). After this period, the animals continued to be fed with milk and were moved to a 0.5 hectare (ha) paddock with *Brachiaria humidicola* pasture until they were four months old. From four to 12 months of age, the animals were kept in an area measuring three ha with *Brachiaria decumbens* and *Panicum maximum* pasture. When they were one year old, they were transferred to an agro-forestry-pastoral system measuring 5 ha, where they remained until they were two years old. *R. microplus* infestation was controlled with mineral salt containing DIFLY S3® (a chitin synthesis inhibitor), which was supplied daily in the feeding trough *ad libitum*. For helminth control, the animals received quarterly IVOMECA® (ivermectin, 1 mg/kg, Merial, Brazil). For hemoparasite control, animals with clinical signs of anaplasmosis or babesiosis were treated with TERRAMICINA® (oxytetracycline, 20 mg/kg, Ouro Fino, Brazil) and IMIZOL® (imidocarb dipropionate, 2.1 mg/kg, Bayer, Brazil).

Resistance to the cattle tick was evaluated by counting the number of ticks in naturally infested animals using the method described by Wharton and Utech (1970). All the fully or partially engorged females of *R. (B.) microplus* (between 4.5 and 8.0 mm in length) on one side of the animal's body were counted, and then, the number was multiplied by two.

The animals were separated into four categories according to their *R. (B.) microplus* infestation level: absence of adult ticks, nymphs and larvae; low infestation (between 1 to 10 engorged females and few larvae and nymphs); intermediate infestation (between 11 and 30 engorged females and an intermediate number of larvae and nymphs); and high infestation (more than 31 engorged females and several larvae and nymphs).

To monitor weight, the animals were weighed within the first 24 hours after birth and at six, 12, 18 and 24 months of age. The daily average weight

gain (DAWG) was calculated using the following formula: $\text{DAWG (kg/day)} = (\text{weaning weight} - \text{birth weight}) \div \text{number of days between weaning and birth}$.

Because the characteristics studied did not fit a normal probability distribution, they were transformed to $\log_{10}(n+1)$. The variable average number of *R. (B.) microplus* for each age group and genetic group was subjected to analysis of variance. Subsequently, the means were compared by Tukey's test at 5% significance. The data were subjected to linear regression analysis to quantify the strength of the association between variables. The statistical analyses were performed using the software R Foundation for Statistical Computing, version 2.12.2 (R DEVELOPMENT CORE TEAM, 2011).

Age was an important risk factor for *R. (B.) microplus* infestation level. One-day-old to two-month-old heifers had low levels of parasitism, with an average of 10 engorged females and a low larvae/nymphs infestation. A significant increase ($p < 0.05$) in the *R. (B.) microplus* infestation as a function of age was observed, and the three- to six-month-old animals showed the greatest parasitism, with an average of 31 engorged females and a high larvae/nymphs infestation. Among the seven- to 12-month-old animals, moderate infestation was observed, with 15 engorged females on average and an intermediate larvae/nymphs infestation. Animals older than one year of age had a low infestation, with an average of 12 engorged females and a low larvae/nymphs infestation (Figure 1).

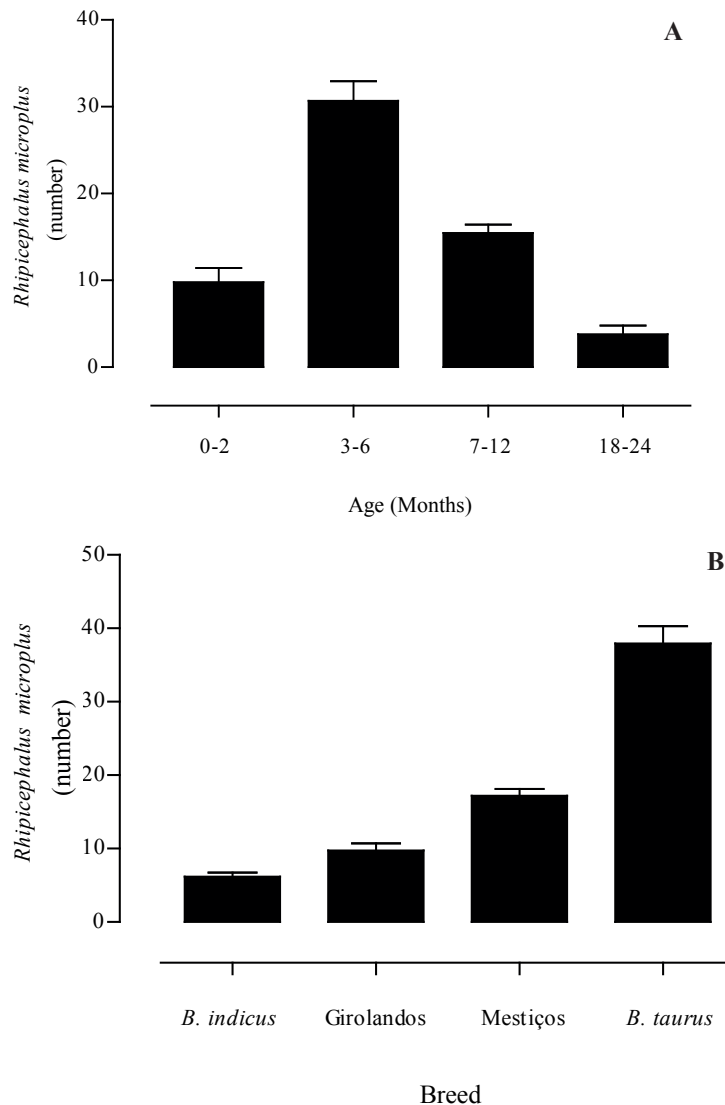
The blood proportion significantly ($p < 0.05$) influenced *R. (B.) microplus* infestation in the heifers (Figure 1). Throughout the study, the *B. taurus* heifers were more infested (38 engorged females and a high larvae/nymphs infestation) than *B. indicus* (six engorged females and a low larvae/nymphs infestation), Girolando (10 engorged females and an intermediate larvae/nymphs infestation) and crossbred F1 (17 engorged females and an intermediate larvae/nymphs infestation) heifers. A positive correlation (0.96) was observed

between the level of *R. (B.) microplus* infestation and a greater proportion of *B. taurus* blood.

The highest average infestation was observed in three- to six-month-old *B. taurus* heifers (90

engorged females and a high larvae/nymphs infestation), and the lowest average infestation was found in *B. indicus* heifers older than 12 months (one engorged female and a low larvae/nymphs infestation).

Figure 1. Average number of *Rhipicephalus microplus* ticks on 22 heifers, Pesagro-Rio, 2008-2010. **A** - Number of *R. (B.) microplus* according to age during the first two years of life. **B** - Number of *R. (B.) microplus* according to the breed of dairy cattle.



The heifers' weights at birth and at six, 12, 18 and 24 months by genetic group are shown in Table 1. Pure *B. taurus* animals showed significantly greater DAWG ($p < 0.05$) than *B. indicus* animals.

Although the *B. taurus* heifers were the heaviest at birth and had a higher DAWG throughout the study, there was no significant difference ($p > 0.05$) between the *B. taurus* heifers and the two

groups of crossbred animals.

At the end of the 24 months, the average weights (DAWG) of the *B. taurus*, F1, Girolando and *B. indicus* heifers were 208 kg (285 g/day), 190 kg (260 g/day), 187 kg (256 g/day) and 182 kg (249 g/day), respectively. At the end of the evaluation period, the *B. taurus* heifers had gained 32 kg more than *B. indicus* heifers on average.

The influence of age on cattle resistance to *R. (B.) microplus* ticks has been reported by other

authors (VERÍSSIMO et al., 1997; ANDRADE et al., 1998). The present study agrees with Veríssimo et al. (1997), who observed that lactating or very young heifers are more resistant to ticks due to the passive immunity transmitted by cows via colostrum. These authors also found that the animals became less resistant over the subsequent months, passing through a phase of high susceptibility during puberty before ultimately stabilizing their resistance once the active immune response was established.

Table 1. Average weight change in 22 animals according to age and breed, Pesagro-Rio, 2008-2010. The *Bos taurus* (Holstein), F1 crossbreed ($\frac{1}{2}$ *B. taurus* x $\frac{1}{2}$ *B. indicus*), Gir-Holstein crossbreed (Girolando) ($\frac{5}{8}$ *B. taurus* x $\frac{3}{8}$ *B. indicus*) and *B. indicus* (Gir) animals were weighed every six months for two years.

Breeds	Weight of heifers				
	Birth	6 months old	12 months old	18 months old	24 months old
<i>Bos taurus</i>	32±3.4 ^A	125±5.4 ^A	150±4.7 ^A	180±4.5 ^A	240±6.3 ^A
F1	30±3.8 ^A	120±3.5 ^{AB}	140±4.2 ^{AB}	170±4.8 ^{AB}	220±4.3 ^{AB}
Girolando	28±4.8 ^{AB}	115±3.9 ^{AB}	132±3.6 ^{AB}	165±3.8 ^{AB}	215±4.4 ^{AB}
<i>Bos indicus</i>	26±2.3 ^B	110±3.2 ^B	117±3.6 ^B	154±3.3 ^B	208±3.5 ^B

Different letters in the columns indicate a significant difference by the Kruskal-Wallis test at 5% probability.

All the animals were susceptible to *R. (B.) microplus* from one to 24 months of age; however, *B. taurus* animals remained vulnerable throughout the first year of life, whereas *B. indicus* animals became resistant after the first infestations. Several authors have demonstrated the higher resistance of Zebu cattle to *R. (B.) microplus* compared with taurine cattle (PIPER et al., 2009, 2010; CONSTANTINOIU et al., 2010) and their crossbreeds (JONSSON, 2006). Zebu and taurine cattle without previous contact with *R. (B.) microplus* are equally susceptible to primary infestation (WAGLAND, 1975). Therefore, the higher resistance level of Zebu animals becomes apparent after a period of susceptibility to initial *R. microplus* infestation (HEWETSON, 1971).

Acquired immunity combined with selection for resistant animals and management practices such as rotational grazing have been proposed as

viable methods for tick control because they reduce the use of acaricides (FRISCH, 1999). *B. indicus* breeds are more resistant to *R. (B.) microplus* than *B. taurus* breeds, although this resistance can vary between breeds and individuals (SEIFERT, 1971; WHARTON; UTECH, 1970; SILVA et al., 2014). An animal's resistance to tick infestation has high heritability, with estimated rates of 39% - 49% for *B. taurus* (WHARTON et al., 1970) and 82% for *B. indicus* (SEIFERT, 1971). Thus, selection of individual animals of *B. taurus* and *B. indicus* breeds can be an important tool in the sustainable control of ticks in the tropics.

B. taurus animals had higher weight gains, despite being significantly more parasitized. These results are likely explained by the genetic characteristics of *B. taurus* animals and the low parasitism shown by all the studied animals. According to Jonsson

(2006), each *R. (B.) microplus* engorged female is responsible for a 0.25 to 1.37 g reduction in the bodyweight of *B. taurus* cattle. In crossbred animals, this reduction ranges from 0.21 to 1.18 g of bodyweight per tick. According to Jonsson (2006), these values are not statistically significant, indicating that *B. taurus* animals and crossbreds are equally harmed by *R. (B.) microplus*.

Under the management conditions adopted in the present study, four- to six-month-old heifers and animals of the *B. taurus* breed were more susceptible to the *R. (B.) microplus* tick. Regardless of age, *B. taurus* calves had greater weight gain than *B. indicus* calves.

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