Economic impact of the use of anthelmintics in beef cattle in the rearing phase

Impacto econômico da utilização de anti-helmínticos em bovinos de corte na fase de recria

Impacto económico del uso de antihelmínticos en ganado vacuno en fase de recria

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ABSTRACT
The objective of the present study was to evaluate the effectiveness of anthelmintics and their influence on the performance of beef cattle supplemented during the rearing period, carrying out a cost analysis of the different treatments. 120 Nelore animals were used, with an average of 9 months of age, 60 males and 60 females. The animals were distributed into 6 groups of males and 6 of females, five treated with anthelmintics and a control group, G1: Moxidectin 1%, G2: Levamisole Phosphate 18.8%, G3: Ivermectin 0.8% + Albendazole Sulfoxide 10%, G4: Albendazole 10%, G5: Fenbendazole 10%, G6: Control (saline solution). Individual weighing was carried out using an electronic scale, at the beginning of the experiment (D0), fourteen days later (D14) and at the end of the experiment (D90), with performance assessed through weight gain (GP). Fecal collections were carried out on the same days as weighing, with individual egg counts per grams of feces (OPG) and stool culture to identify helminth genders. Economic viability was calculated based on the price of the calf and total production cost. The data obtained was subjected to the 5% Tukey test and the effectiveness of the anthelmintics was evaluated using the RESO program. It is concluded that the anthelmintics evaluated were effective, with the exception of Ivermectin 0.8% + Albendazole Sulfoxide 10%, which showed anthelmintic resistance. The anthelmintic treatment provided the animals with better performance, with the greatest weight gain observed in animals treated with Moxidectin 1%, demonstrating better economic indices.
Keywords: Weight gain, Helminth, Steer, Resistance.

RESUMO
Objetivo do presente estudo foi avaliar a eficácia de anti-helmínticos e sua influência no desempenho de bovinos de corte suplementados no período de recria, realizando uma análise de custo dos diferentes tratamentos. Utilizou-se 120 animais da raça Nelore, com média de 9 meses de idade, sendo 60 machos e 60 fêmeas. Os animais foram distribuídos em 6 grupos de machos e 6 de fêmeas, sendo cinco tratados com anti-helmínticos e um grupo controle, G1: Moxidectina 1%, G2: Fosfato de Levamisol 18,8%, G3: Ivermectina 0,8% + Sulfóxido de Albendazole 10%, G4: Albendazole 10%, G5: Fenbendazole 10%, G6: Controle (solução salina). Foi realizada a pesagem individual por meio de balança eletrônica, no início do experimento (D0), posteriormente quatorze dias (D14) e no final do experimento (D90), sendo o desempenho avaliado através do ganho de peso (GP). Coletas de fezes foram realizadas nos mesmos dias das pesagens, realizando-se individualmente contagens de ovos por gramas de fezes (OPG) e coprocultura para identificação de gêneros dos helmintos. A viabilidade econômica foi calculada em função do preço do bezerro e custo total de produção. Os dados obtidos foram submetidos ao teste de Tukey 5% e a eficácia dos anti-helmínticos avaliada por meio do programa RESO. Conclui-se que os anti-helmínticos avaliados foram eficazes, com exceção da Ivermectina 0,8% + Sulfóxido de Albendazole 10%, que apresentou resistência anti-helmíntica. O tratamento anti-helmíntico proporcionou aos animais um melhor desempenho, sendo o maior ganho de peso observado nos animais tratados com Moxidectina 1%, demonstrando melhores índices econômicos.

Palavras-chave: Ganho de peso, Helminto, Novilho, Resistência.

RESUMEN
El objetivo del presente estudio fue evaluar la efectividad de los antihelmínticos y su influencia en el rendimiento del ganado vacuno suplementado durante el período de recria, realizando un análisis de costos de los diferentes tratamientos. Se utilizaron 120 animales Nelore, con un promedio de 9 meses de edad, 60 machos y 60 hembras. Los animales se distribuyeron en 6 grupos de machos y 6 de hembras, cinco tratados con antihelmínticos y un grupo control, G1: Moxidectina 1%, G2: Fosfato de Levamisol 18,8%, G3: Ivermectina 0,8% + Sulfóxido de Albendazol 10%, G4: Albendazol 10%, G5: Fenbendazol 10%, G6: Control (solución salina). El pesaje individual se realizó mediante balanza electrónica, al inicio del experimento (D0), catorce días después (D14) y al final del experimento (D90), evaluándose el rendimiento mediante la ganancia de peso (GP). Las recolecciones fecales se llevaron a cabo los mismos días del pesaje, con recuentos individuales de huevos por gramos de heces (OPG) y cultivo de heces para identificar el género de los helmintos. La viabilidad económica se calculó con base en el precio del ternero y el costo total de producción. Los datos obtenidos se sometieron a la prueba de Tukey al 5% y se evaluó la efectividad de los antihelmínticos mediante el programa RESO. Se concluye que los antihelmínticos evaluados fueron efectivos, a excepción de Ivermectina 0,8% + Sulfóxido de Albendazol 10%, que presentó resistencia antihelmíntica. El tratamiento antihelmíntico proporcionó un mejor rendimiento a los
animales, observándose la mayor ganancia de peso en los animales tratados con Moxidectina al 1%, demostrando mejores índices económicos.

**Palabras clave:** Ganancia de peso, Helmíntos, Buey, Resistencia.

## 1 INTRODUCTION

La ganadería en Brasil es una actividad económica de gran importancia para el país, siendo uno de los sectores más representativos del agribusiness nacional y uno de los pilares de su economía (Imac, 2023). El ganado bovino brasileño tiene aproximadamente 234 millones de cabezas, lo que representa 20.6% de la ganadería mundial, lo que corresponde a la mayor ganadería comercial del mundo, después de la India, en número de cabezas (Ibge, 2022).

La actividad agropecuaria brasileña contribuye directamente al crecimiento del producto interno bruto, donde la ganadería de carne destaca en este escenario. Brasil es el principal exportador de carne de res del mundo, con 27.7% de las exportaciones mundiales, reafirmando así la importancia de las exportaciones de carne de res para la economía brasileña (Abiec, 2023). Contribuyendo significativamente al desarrollo socioeconómico del país (Imac, 2023).

Una gran parte de la producción de carne de res en Brasil se basa en pastizales, que juegan un papel esencial en la ganadería brasileña, aseguran costos de producción más bajos, y se considera la manera más económica y práctica de proveer y ofrecer alimentos para el ganado (Dias-Filho, 2014). Con la intensa expansión de la ganadería de res, hay un aumento en la carga de pastizales, junto con el método de pastoreo continuo, lo que conlleva un aumento en los problemas de salud (Venturini; Menezes, 2016).

Algunos factores son capaces de causar una reducción en la productividad en la ganadería de res, especialmente: alta y baja disponibilidad y calidad de pastizales durante las estaciones, manejo incorrecto, aparición de parásitos, enfermedades y deficiencias minerales (Bianchin, 1987). Por lo tanto, existe una necesidad de identificar los factores que negativamente influyen el proceso productivo y buscar formas de remediarlos, que sean económicamente factibles y traigan resultados positivos (Fachiolli et al., 2017).
The predominance of tropical and subtropical climates in Brazil favors the occurrence of internal and external parasites in cattle (Grisi et al., 2014). Therefore, the control of these pathogens is crucial for livestock farming, as they result in significant economic losses due to reduction in weight gain and carcass yield, costs associated with antiparasitics and labor, disease transmission, reduction in productivity and even mortality (Hepburn; Belanger; Mattheis, 1987).

Among parasites, infections by gastrointestinal nematodes in farm animals determine important economic losses due to direct and indirect effects resulting from parasitism (West et al., 2009; Sutherland; Scott, 2010). Ineffective control of gastrointestinal nematodes is capable of causing losses of US$7.11 billion per year (Grisi et al., 2014).

The use of anthelmintics is the most used way to control these infections in cattle (Brito et al., 2019). As a result, the intense use of these drugs, underdosing, erroneous diagnoses and the lack of rotation of pharmaceutical bases have caused an important health problem, which is the resistance of nematodes to the drugs. This phenomenon occurs due to the hereditary capacity of a parasitic population to reduce its sensitivity to the action of one or more drugs (Fiel et al., 2003; Soutello; Seno; Amarante, 2007), thus reducing their effectiveness (Bullen et al., 2016).

It was estimated that in Brazil around 80% of the dosages used by producers are given inappropriately (Bianchin, 1991). In 2017, Brazil invested around 76 million dollars in bovine antiparasitic products, according to the National Union of the Animal Health Products Industry (Sindan, 2018). Thus causing an increase in production costs, not achieving the desired objectives (Almeida et al., 2020).

The objective of the present study was to evaluate the effectiveness of anthelmintics from different classes and their influence on the performance of beef cattle supplemented during the rearing period, through weight gain, together with a cost analysis, in order to observe the economic viability of different treatments.
2 MATERIAL AND METHODS

2.1 LOCATION

THE experiment was developed from October 2020 to January 2021 (90 days) on a farm located in the municipality of Castilho - SP, belonging to the northwest region of the State of São Paulo (latitude 20°52'09.0'' south, longitude 51°29'22.9'' oeste), in partnership with the Faculty of Agricultural and Technological Sciences (FCAT), UNESP - Dracena-SP Campus.

2.2 ANIMALS AND FOOD

120 contemporary Nelore animals were used, coming from the same breeding herd, with an average of 9 months of age, 60 males and 60 females, naturally infected by gastrointestinal nematodes.

The animals were kept in two different paddocks, formed by Urochloa Brizantha with natural waters, the females received low-consumption protein supplementation (0.1% of body weight) and the males received medium-consumption protein-energy supplementation (0.3% of body weight), alive.

2.3 EXPERIMENTAL DESIGN

The animals were randomly distributed using a completely randomized design (DIC), into 6 groups of males and 6 groups of females with 10 animals each group, with five animals being treated with anthelmintics and a control group without anthelmintic treatment. After forming the groups and fasting for eight hours, the products were administered at doses recommended by the manufacturers, applied by injection (subcutaneous) or orally depending on the animal’s weight.

The animals received the following treatments: G1- Moxidectin 1% (Cydectin ®, 1ml/50 kg, injectable); G2- Levamisole Phosphate 18.8% ( Ripercol ®, 1ml/40kg,
injectable); G3- Ivermectin 0.8% + Albendazole Sulfoxide 10% (Evol, 1 ml/40kg, injectable); G4- Albendazole 10% (Valbazen®, 1ml/20kg, oral); G5- Fenbendazole (Panacur®, 1ml/20kg, oral); G6- No anthelmintic treatment (Sodium Chloride 0.9, 1ml/50 kg, injectable).

2.5 WEIGHING

The animals were individually weighed using an electronic scale at the beginning of the experiment (D0), 14 days after treatment (D14) and at the end of the experiment (D90). Weight gain (WG) was obtained by the difference between the final and initial weighing, and daily weight gain (DWG) according to the number of days of the experiment (90 days).

2.6 COPROPARASITOLOGICAL EXAMINATIONS

Fecal collections were carried out on the day of application of anthelmintics (D0), fourteen days after (D14) and at the end (D90), in which fecal samples were collected directly from the rectal ampoule, identified according to the number of each animal and stored in a thermal box with recyclable ice until processed.

At the Parasitology and Animal Health Laboratory at Unesp, tests were carried out to count eggs per gram of feces (OPG), using the McMaster camera (Gordon; Whitlock, 1939) to carry out quantification. Subsequently, feces were cultivated and third stage larvae were extracted using the method of Roberts and O'Sullivan (1950) for identification using Keith's key (1953).

2.7 DATA ANALYSIS

The data obtained were analyzed using the General Linear Model (PROC GLM) procedure and the means were compared using the Tukey test at a significance level of 5% using the SAS University Edition program (Version 9.4). Data distribution was
evaluated using the Shapiro-Wilk test, and when it did not meet the assumption of normality, the data were transformed into Log+10. The following variables were evaluated: OPG, weight gain (WG) and daily weight gain (GPD). The efficacy of the drugs was evaluated using the values of OPG counts, comparing the OPG on the day of treatment (D0) with the OPG after anthelmintic treatment (D14), using the Reso FECRT Analysis program. Program, version 2.0 (Wursthorn; Martin, 1989), with the reduction in OPG (R-OPG) of drugs calculated according to Coles et al. (1992), using the formula:

$$R\text{-}OPG = 1 - \frac{T}{C} \times 100$$ (1)

Where:

- $T =$ mean OPG 14 days after application of the anthelmintic (D14);
- $C =$ mean OPG on the day of anthelmintic treatment (D0).

2.8 ECONOMIC ANALYSIS

The cost/benefit analysis was calculated based on all expenses incurred during the experimental period. Based on fixed costs: vaccines, pasture, supplementation, labor and price of the calf; and variable costs: treatment with different anthelmintics. The intermediate cost (sum of all costs mentioned above) and the final cost (intermediate cost + financial charges) were also evaluated in the economic analysis. Based on the weight gain and the price per kilo of live weight of the calf (according to the Anualpec 2021 price), the monthly profitability, the gain in Real (R$) per head during the experimental period and the cost per kilo of live weight were calculated. produced (Soutello, 2001; Fachiolli et al., 2017). The economic analysis was evaluated differently for males and females, as the commercial parameters are different (Furlong 1993; Gomide, 2006).
3 RESULTS AND DISCUSSIONS

The steers began the study with an overall average weight of 180.9 kg, showing no significant difference between the groups (Table 1).

Table 1 – Mean weight D0, D14 and D90, weight gain, daily weight gain, ± standard error of the mean of steers treated with Moxidectin, Levamisole Phosphate, Ivermectin + Albendazole Sulfoxide, Albendazole, Fenbendazole and without anti-helminthic (control).

<table>
<thead>
<tr>
<th>Groups</th>
<th>Weight D0</th>
<th>Weight D14</th>
<th>Weight D90</th>
<th>GP</th>
<th>GPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moxidectin</td>
<td>181.0 (±3.65)</td>
<td>175.3 (±3.61)</td>
<td>275.7 (±4.07)</td>
<td>94.7 a</td>
<td>1.05 to</td>
</tr>
<tr>
<td>Levamisole Phosphate</td>
<td>182.4 (±2.40)</td>
<td>176.8 (±2.32)</td>
<td>272.4 (±2.61)</td>
<td>90.0 ab</td>
<td>1.00 ab</td>
</tr>
<tr>
<td>Ivermectin + Albendazole Sulfoxide</td>
<td>172.7 (±1.74)</td>
<td>169.5 (±1.63)</td>
<td>257.8 (±2.50)</td>
<td>85.1 ab</td>
<td>0.95 ab</td>
</tr>
<tr>
<td>Albendazole</td>
<td>178.6 (±2.36)</td>
<td>172.1 (±2.17)</td>
<td>269.1 (±2.68)</td>
<td>90.5ab</td>
<td>1.01 ab</td>
</tr>
<tr>
<td>Fenbendazole</td>
<td>173.4 (±2.08)</td>
<td>169.9 (±1.98)</td>
<td>263.0 (±2.55)</td>
<td>89.6 ab</td>
<td>0.99 ab</td>
</tr>
<tr>
<td>Control</td>
<td>197.2 (±2.76)</td>
<td>193.0 (±2.63)</td>
<td>279.9 (±3.66)</td>
<td>82.7b</td>
<td>0.92b</td>
</tr>
</tbody>
</table>

Arithmetic means with different letters in the same column differ significantly using the Tukey test (P<0.05).

Source: Prepared by the authors.

During the experimental period, animals treated with Moxidectin 1% demonstrated greater weight gain compared to the other groups, where treatment with this anthelmintic resulted in a significant difference (p<0.05) in weight gain (12.0 kg more) in relation to the group that did not receive anthelmintic treatment (control). A difference in weight gain was also observed compared to the control group of 7.3 kg for the group treated with Levamisole Phosphate 18.8%, 2.4 kg for the group treated with Ivermectin 0.8% + Albendazole Sulfoxide 10 %, 7.8 kg for the group treated with Albendazole 10% and 6.9 kg for the group treated with Fenbendazole 10%. And in relation to the other anthelmintics, the weight gain of the group that received treatment with Moxidectin 1% was 4.7 kg more than the animals treated with Levamisole Phosphate 10.8%, and 9.6 kg, 4.2 kg and 5.1 kg more in treatments with Ivermectin 0.8% + Albendazole Sulfoxide 10%, Albendazole 10% and Fenbendazole 10% respectively. Therefore, it was observed that the steers treated with anthelmintics did not present a significant difference (p>0.05) between them, (Table 1), and that in turn, they also did not present a statistical difference to the control group, except the group Moxidectin 1%.
At the beginning of the study, the overall average egg count per gram of feces of the steers was 262.3 OPG, with no significant difference between the groups.

### Table 2 - Means and reduction of OPG (R-OPG) at baseline (D0), 14 (D14), 90 (D90) days after treatment in steers treated with Moxidectin, Levamisole Phosphate, Ivermectin + Albendazole Sulfoxide, Albendazole, Fenbendazole and without anthelmintic treatment (control).

<table>
<thead>
<tr>
<th>Groups</th>
<th>D0</th>
<th>D14</th>
<th>R-OPG</th>
<th>D90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moxidectin</td>
<td>235.2</td>
<td>0 to</td>
<td>100%</td>
<td>20.6</td>
</tr>
<tr>
<td>Levamisole Phosphate</td>
<td>290.7</td>
<td>9.3 (0-50) a</td>
<td>96.8%</td>
<td>40.6</td>
</tr>
<tr>
<td>Ivermectin + Albendazole Sulfoxide</td>
<td>273.9</td>
<td>17.7 (0-100) a</td>
<td>93.5%</td>
<td>14.7</td>
</tr>
<tr>
<td>Albendazole</td>
<td>235.4</td>
<td>0 to</td>
<td>100%</td>
<td>38.2</td>
</tr>
<tr>
<td>Fenbendazole</td>
<td>316.6</td>
<td>5.6 (0-50) a</td>
<td>98.2%</td>
<td>47.2</td>
</tr>
<tr>
<td>Control</td>
<td>222.0</td>
<td>166.5 (0-300)b</td>
<td>-</td>
<td>27.8</td>
</tr>
</tbody>
</table>

Arithmetic means with different letters in the same column differ significantly using the Tukey test (P<0.05).

Source: Prepared by the authors.

Table 2 presents the average, minimum and maximum OPG in addition to the percentage of reduction after anthelmintic treatment for each group. Where it can be observed that animals treated with Moxidectin 1% and Albendazole 10% obtained a maximum reduction in OPG, demonstrating R-OPG of 100% on D14, with treatments with Levamisole Phosphate 18.8% and Fenbendazole 10% also showed anthelmintic efficacy, with R-OPG greater than 95%. However, the only group that presented R-OPG below 95% was Ivermectin 0.8% + Albendazole Sulfoxide 10%, with a reduction of 93.5%, showing anthelmintic resistance.

It can also be observed that 14 days after administration of anthelmintics (D14), the OPG of animals treated with Moxidectin 1%, Levamisole Phosphate 18.8%, Ivermectin 0.8% + Albendazole Sulfoxide 10%, Albendazole 10 % and Fenbendazole10% showed a significant difference (p<0.05) when compared to the OPG of animals in the control group, without anthelmintic treatment. At the end of the experimental period (D90), all groups presented low OPG averages, where no statistically significant difference was observed (p<0.05), including the group without anthelmintic treatment (control), presenting similar averages.

The heifers began the study with an overall average weight of 165.3 kg, showing no significant difference between the groups (Table 4).
Table 3– Mean weight D0, D14 and D90, weight gain, daily weight gain, ± standard error of the mean of heifers treated with Moxidectin, Levamisole Phosphate, Ivermectin + Albendazole Sulfoxide, Albendazole, Fenbendazole and without anti-helminthic (control).

<table>
<thead>
<tr>
<th>Groups</th>
<th>Weight D0</th>
<th>Weight D14</th>
<th>Weight D90</th>
<th>GP</th>
<th>GPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moxidectin</td>
<td>165.4 (±2.25)</td>
<td>158.7 (±2.14)</td>
<td>230.6 (±2.48)</td>
<td>65.2 a</td>
<td>0.72</td>
</tr>
<tr>
<td>Levamisole Phosphate</td>
<td>171.3 (±2.38)</td>
<td>166.2 (±2.32)</td>
<td>229.7 (±2.63)</td>
<td>58.4 ab</td>
<td>0.65</td>
</tr>
<tr>
<td>Ivermectin + Albendazole Sulfoxide</td>
<td>166.2 (±2.07)</td>
<td>160.4 (±1.98)</td>
<td>227.5 (±2.57)</td>
<td>61.3 ab</td>
<td>0.68</td>
</tr>
<tr>
<td>Albendazole</td>
<td>165.0 (±2.73)</td>
<td>160.9 (±2.80)</td>
<td>224.5 (±3.45)</td>
<td>59.5 ab</td>
<td>0.66</td>
</tr>
<tr>
<td>Fenbendazole</td>
<td>171.0 (±2.51)</td>
<td>165.0 (±2.44)</td>
<td>229.8 (±3.06)</td>
<td>58.8ab</td>
<td>0.65</td>
</tr>
<tr>
<td>Control</td>
<td>152.8 (±3.12)</td>
<td>146.8 (±2.83)</td>
<td>198.7 (±2.96)</td>
<td>45.9b</td>
<td>0.51</td>
</tr>
</tbody>
</table>

Arithmetic means with different letters in the same column differ significantly using the Tukey test (P<0.05).

During the experimental period, heifers treated with 1% Moxidectin demonstrated greater weight gain compared to the other groups, resulting in a difference in weight gain of 19.3 kg more than the group that did not receive anthelmintic treatment, differing statistically. A weight gain of 12.5 kg was also observed for the group treated with Levamisole Phosphate 18.8%, 15.4 kg for the group treated with Ivermectin 0.8% + Albendazole Sulfoxide 10%, 13.6 kg for the group treated with Albendazole 10% and 12.9 kg for the group treated with Fenbendazole 10%, more than the control group. In relation to other anthelmintics, the weight gain of the group that received treatment with Moxidectin 1% was 6.8 kg more than the animals treated with Levamisole Phosphate 18.8% and 6.4 kg, 5.7 kg and 3.9 kg with Fenbendazole 10%, Albendazole 10% and Ivermectin 0.8% + Albendazole Sulfoxide 10% respectively, showing no statistical difference between all groups treated with anthelmintics.

The overall average egg count per gram of feces in heifers was 258.4 OPG, with no significant difference between groups (Table 4).
A marked reduction in OPG was observed on D14 in animals treated with Moxidectin 1%, Levamisoiol Phosphate 18.8%, Albendazole 10% and Fenbendazole 10% on D14, demonstrating R-OPG greater than 95%. However, the only group that presented R-OPG below 95% was Ivermectina 0.8% + Albendazole Sulfoxide 10%, showing anthelmintic resistance (Table 4).

It could also be observed that 14 days after administration of anthelmintics (D14), the OPG of treated animals showed a significant difference (p<0.05) when compared to the OPG of animals in the control group, without anthelmintic treatment. At the end of the experimental period (D90), all groups showed low OPG averages, where no statistically significant difference was observed (p<0.05), including the group without anthelmintic treatment (control), showing similar averages.

The genera of helminths found in steers and heifers, through coprocultures at the beginning of the experiment, were predominant Cooperia ssp. and Haemonchus ssp. and to a lesser extent Trichostrongylus ssp. and Oesophagostomum ssp.

Fourteen days after the beginning of the study, the control groups of both males and females maintained the prevalence of helminths similar to the beginning of the experiment. While among the groups treated with anthelmintics, in both sexes, only Ivermectin 0.8% + Albendazole Sulfoxide 10% showed anthelmintic resistance mainly to Cooperia ssp and to a lesser extent to Haemonchus spp. (D14). At the end of the study (D90), a 100% prevalence of Cooperia ssp could be observed in all groups.

### Table 4 - Means and reduction of OPG (R-OPG) at baseline (D0), 14 (D14), 90 (D90) days after treatment in heifers treated with Moxidectin, Levamisole Phosphate, Ivermectin + Albendazole Sulfoxide, Albendazole, Fenbendazole and without anthelmintic treatment (control).

<table>
<thead>
<tr>
<th>Groups</th>
<th>D0</th>
<th>D14</th>
<th>R-OPG</th>
<th>D90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moxidectin</td>
<td>200 (50-400)</td>
<td>4 (0-50) to</td>
<td>98.0%</td>
<td>66.6 (0-300) a</td>
</tr>
<tr>
<td>Levamisole Phosphate</td>
<td>370.8 (0-600)</td>
<td>8.3 (0-100) a</td>
<td>97.8%</td>
<td>79.1 (0-400) a</td>
</tr>
<tr>
<td>Ivermectin + Alben-</td>
<td>273 (50-750)</td>
<td>20 (0-250) to</td>
<td>92.7%</td>
<td>67 (0-350) a</td>
</tr>
<tr>
<td>dazole Sulfoxide</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Albendazole</td>
<td>287.5 (0-950)</td>
<td>1.3 (0-50) a</td>
<td>99.5%</td>
<td>12.5 (0-400) a</td>
</tr>
<tr>
<td>Fenbendazole</td>
<td>286.3 (0-900)</td>
<td>3.8 (0-50) a</td>
<td>98.7%</td>
<td>13.8 (0-100) a</td>
</tr>
<tr>
<td>Control</td>
<td>141.7 (0-500)</td>
<td>108.3 (0-600) b</td>
<td></td>
<td>25.0 (0-100) b</td>
</tr>
</tbody>
</table>

Arithmetic means with different letters in the same column differ significantly using the Tukey test (P<0.05).

Source: Prepared by the authors.
The table of total operating costs and profitability indicators for the six groups is represented in tables 5 (males) and 6 (females). Where the economic viability of using the evaluated anthelmintics was observed.

Table 5. Steer production costs and financial analysis related to the use of different anthelmintics.

<table>
<thead>
<tr>
<th></th>
<th>Moxidectin</th>
<th>Levamisole Phosphate</th>
<th>Ivermectin + Albendazole Sulfoxide</th>
<th>Albendazole</th>
<th>Fenbendazole</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase price (R$12.26)</td>
<td>R$ 2,219.06</td>
<td>R$ 2,236.22</td>
<td>R$ 2,117.30</td>
<td>R$ 2,189.64</td>
<td>R$ 2,125.88</td>
<td>BRL 2,417.67</td>
</tr>
<tr>
<td>Pasture</td>
<td>R$ 118.41</td>
<td>R$ 118.41</td>
<td>R$ 118.41</td>
<td>R$ 118.41</td>
<td>R$ 118.41</td>
<td>R$ 118.41</td>
</tr>
<tr>
<td>Labor</td>
<td>R$ 9.00</td>
<td>R$ 9.00</td>
<td>R$ 9.00</td>
<td>R$ 9.00</td>
<td>R$ 9.00</td>
<td>R$ 9.00</td>
</tr>
<tr>
<td>Vaccine</td>
<td>R$ 3.15</td>
<td>R$ 3.15</td>
<td>R$ 3.15</td>
<td>R$ 3.15</td>
<td>R$ 3.15</td>
<td>R$ 3.15</td>
</tr>
<tr>
<td>Supplement Cost</td>
<td>R$ 92.48</td>
<td>R$ 92.10</td>
<td>R$ 87.18</td>
<td>R$ 90.66</td>
<td>BRL 88.37</td>
<td>BRL 96.61</td>
</tr>
<tr>
<td>Antihelmintic</td>
<td>R$ 2.40</td>
<td>R$ 1.00</td>
<td>R$ 2.50</td>
<td>R$ 1.26</td>
<td>R$ 1.64</td>
<td>R$ 0.00</td>
</tr>
<tr>
<td>Intermediate Cost</td>
<td>R$ 2,444.50</td>
<td>BRL 2,459.88</td>
<td>R$ 2,337.54</td>
<td>BRL 2,412.12</td>
<td>BRL 2,346.46</td>
<td>R$ 2,346.46</td>
</tr>
<tr>
<td>Final cost (0.5% month)</td>
<td>BRL 2,481.17</td>
<td>BRL 2,496.78</td>
<td>R$ 2,372.60</td>
<td>BRL 2,448.30</td>
<td>BRL 2,381.65</td>
<td>BRL 2,684.52</td>
</tr>
<tr>
<td>Sale price (R$13.52)</td>
<td>R$ 3,727.46</td>
<td>R$ 3,682.85</td>
<td>R$ 3,485.46</td>
<td>BRL 3,638.23</td>
<td>BRL 3,555.76</td>
<td>BRL 3,784.25</td>
</tr>
<tr>
<td>Monthly profitability</td>
<td>16.74%</td>
<td>15.83%</td>
<td>15.63%</td>
<td>16.20%</td>
<td>16.43%</td>
<td>13.66%</td>
</tr>
<tr>
<td>Earnings in R$ in the period/cab.</td>
<td>R$ 1,246.29</td>
<td>R$ 1,186.07</td>
<td>R$ 1,112.85</td>
<td>R$ 1,189.93</td>
<td>R$ 1,174.11</td>
<td>R$ 1,099.73</td>
</tr>
<tr>
<td>Cost kg produced</td>
<td>R$ 2.38</td>
<td>R$ 2.49</td>
<td>R$ 2.59</td>
<td>R$ 2.46</td>
<td>R$ 2.46</td>
<td>R$ 2.75</td>
</tr>
<tr>
<td>Real gain from the use of anthelmintics</td>
<td>R$ 146.56</td>
<td>BRL 86.34</td>
<td>R$ 13.12</td>
<td>R$ 90.20</td>
<td>BRL 74.38</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Prepared by the authors.

A higher monthly profitability can be observed for steers (Table 5) treated with Moxidectin 1%, followed by the groups treated with Fenbendazole 10%, Albendazole 10%, Levamisole Phosphate 18.8%, Ivermectin 0.8% + Sulfoxide Albendazole 10%, with the group of animals that did not receive anthelmintic treatment (control group) showing lower profitability.

In relation to heifers (Table 6), the group that received treatment with Moxidectin 1% also showed higher monthly profitability, followed by the groups treated with Ivermectin 0.8% + Albendazole Sulfoxide 10%, Albendazole 10%, Fenbendazole 10%, Levamisole Phosphate 18.8% and the control group showed the lowest profitability.
Table 6. Heifer production costs and financial analysis related to the use of different anthelmintics.

<table>
<thead>
<tr>
<th>Purchase price (R$ 11.78/kg)</th>
<th>Moxidectin</th>
<th>Levamisole Phosphate</th>
<th>Ivermectin + Albendazole Sulfoxide</th>
<th>Albendazole</th>
<th>Fenbendazole</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture</td>
<td>R$ 1,948.41</td>
<td>R$ 2,017.91</td>
<td>R$ 1,957.84</td>
<td>R$ 1,943.70</td>
<td>R$ 2,014.38</td>
<td>R$ 1,799.98</td>
</tr>
<tr>
<td>Labor</td>
<td>R$ 118.41</td>
<td>R$ 118.41</td>
<td>R$ 118.41</td>
<td>R$ 118.41</td>
<td>R$ 118.41</td>
<td>R$ 118.41</td>
</tr>
<tr>
<td>Vaccine</td>
<td>R$ 3.15</td>
<td>R$ 3.15</td>
<td>R$ 3.15</td>
<td>R$ 3.15</td>
<td>R$ 3.15</td>
<td>R$ 3.15</td>
</tr>
<tr>
<td>Supplement Cost</td>
<td>R$ 29.58</td>
<td>R$ 29.95</td>
<td>R$ 29.41</td>
<td>R$ 29.10</td>
<td>R$ 29.94</td>
<td>R$ 26.26</td>
</tr>
</tbody>
</table>

| Intermediate Cost | R$ 2,110.96 | R$ 2,179.43 | R$ 2,120.31 | R$ 2,104.62 | R$ 2,176.52 | R$ 1,956.80 |
| Final cost (0.5% month) | R$ 2,142.62 | R$ 2,212.12 | R$ 2,152.11 | BRL 2,136.19 | BRL 2,209.17 | R$ 1,986.16 |
| Sale price (R$ 12.35/kg)  | R$ 2,847.91 | R$ 2,836.80 | R$ 2,809.63 | BRL 2,772.58 | BRL 2,838.03 | BRL 2,453.95 |
| Monthly profitability | 10.97%      | 9.41%        | 10.18%     | 9.93%       | 9.49%       | 7.85%     |
| Earnings in R$ in the period/cab. | BRL 705.29 | BRL 624.67 | BRL 657.51 | BRL 636.39 | BRL 628.06 | BRL 467.79 |
| Cost kg produced          | R$ 2.49     | R$ 2.77      | R$ 2.65    | R$ 2.70     | R$ 2.76     | R$ 3.42    |
| Real gain from the use of anthelmintics | R$ 237.50  | R$ 156.88   | R$ 189.72  | R$ 168.60   | R$ 161.07   | -         |

Source: Prepared by the authors.

When analyzing the real gain per unit of capital invested in relation to the use of anthelmintics (Tables 5 and 6), the group treated with Moxidectin 1% presented a greater financial return for both males and females, compared to the other treated groups with other anthelmintics.

Just like the males and females treated with Moxidectin 1%, they had a lower cost per kilo of live weight (LW) produced due to the greater weight gain obtained, compensating for the investment with anthelmintic and energy protein supplementation of medium consumption for the animals, males and low-consumption protein supplementation for females (Tables 5 and 6).

The fact that male and female Nelore steers treated with anthelmintics achieved greater weight gain than the control group corroborates a study by Catto et al. (2009), who over three years observed that animals treated with anthelmintics gained approximately 23 kg more than animals in the control group. In a study carried out by Borges et al. (2022) Moxidectin 1% was the only treatment that resulted in a significant
increase in the animals’ weight gain in relation to the placebo group after 118 days of treatment, with a difference of 7.6 kg. This was also observed in the present study, with animals raised on pasture, showing a significant difference for both steers and heifers using Moxidectin 1% compared to the group that did not receive anthelmintic treatment (control). A greater weight gain in animals treated with 1% Moxidectin was also observed by Fazzio et al. (2016), where the animals gained around 160g/day more than the group treated with Ivermectin.

The similarity of the OPG means of the other treated groups in relation to the control group at the end of the study (D90) may be related to nutritional factors. Fachiolli et al. (2017) explains that in a study with post-weaning animals in a grazing system, they reported that supplementation with concentrate provides greater nutritional support to calves, preventing the implantation of gastrointestinal helminths and increasing performance. Soutello et al. (2002), with animals receiving protein supplementation and anthelmintic treatment, found a significant difference in weight gain compared to animals that were only dewormed and only supplemented, however, it should be noted that the animals used were on pasture with more challenging conditions, with age considered more susceptible to helminth infections and receiving only low-consumption protein supplements, different from the conditions of the present study.

Research dating back to the 1980s indicates that a high parasitic load promotes lower performance in animals kept on pasture, approximately 30-70 kg less per year, in relation to animals that received anthelmintics, for non-supplemented animals (Pinheiro, 1985; Zocoller; The same was observed by Soutello et al. (2001), with supplemented animals raised on pasture, as in the present study.

At the beginning of the present study, the animals presented a parasitic challenge, evidenced by the level of helminths in the animals, with average values between 200-1000 OPG, which for Ueno and Gonçalvez (1998), represent moderate to severe infection, and the use of anthelmintics is recommended.

According to the analysis of egg count reduction per gram of feces (R-OPG), resistance to the drug used was found in both steers and heifers treated with Ivermectin 0.8% + Albendazole Sulfoxide 10%. Coles et al. (2006) states that a drug can be
considered to have anthelmintic resistance when it presents a reduction in OPG of less than 95%. According to Barnes; Dobson; Barger (1995) the associated use of drugs becomes an alternative to increase the useful life of the anthelmintic. This fact does not corroborate the results found in the present study, as the steers treated with Ivermectin 0.8% + Albendazole Sulfoxide 10%, the only compound drug used in this study, showed a slight degree of resistance.

In their study Paiva et al. (2001) concluded that *Haemonchus placei* and *Cooperia punctata* have shown anthelmintic resistance to Ivermectin, one of the active ingredients in group 3, for decades, which could explain the lower efficacy when compared to other anthelmintics. The data obtained also corroborates the results found by Soutello; Sine; Amarante (2007), in which they report the presence of resistance to the use of anthelmintics with the active ingredient Ivermectin in 25 properties in the region where the present study was carried out. For Ivermectin, inefficiencies in treatments were also reported in other regions of Brazil (Cezar et al., 2010; Borges et al., 2013). Analyzing other studies carried out previously, it was also observed that the species most frequently found in the southeast and central-west regions of Brazil are *Cooperia punctata* and *Haemonchus placei* (Felippelli et al., 2014).

Soutello et al. (2002) found that animals not treated with anthelmintics had a higher percentage of larvae of the genus *Haemonchus spp.*, in relation to the genus *Cooperia spp.*. This was not observed in any of the treatments, as in the present study the larvae cultures at the end of the experiment indicated a predominance of larvae of the genus *Cooperia spp.*, a result similar to the study carried out by Araújo and Lima (2005) and Stromberg et al. (2012), which in addition to the prevalence of the genus, the data obtained suggest that *C. punctata* has a deleterious effect on both appetite and the absorption or use of nutrients, which compromises the animals' weight gain.

Regarding the resistance of the genus *Cooperia spp.* found in the group treated with Ivermectin 0.8% + Albendazole Sulfoxide 10%, may be related to its characteristic of being dose-limiting for macrocyclic lactones (LMs) (Shoop; Mrozik; Fisher; 1995), that is, of being naturally more tolerant to these drugs compared to most other nematode genera. As for the genus *Haemonchus spp.*, this fact appears to be related to genetic
dominance, which makes the transmission of resistance to LMs more efficient (Dobson; Lejambre; Gill, 1996).

The animals' weight loss after the start of the study was possibly a consequence of weaning stress, which, according to Quadros (2005), generally results in delayed development and weight loss, in addition to making the animal more susceptible to diseases and parasites.

Analyzing the economic viability of males and females in the present study, it is possible to state that all groups in which the animals received anthelmintic treatment were economically profitable, these results corroborate Soutello et al. (2001), where it was observed that animals supplemented and treated with anthelmintics had greater profitability than animals that received only supplements without anthelmintic treatment. Also Fachiolli et. al (2017), after carrying out an economic analysis, observed that the use of anthelmintics is quite viable in this post-weaning period, having shown greater profitability in males than in females. Male cattle respond better to investments when compared to females, due to their higher market value and greater performance potential.

4 CONCLUSION

The anthelmintics evaluated in the present study using steers and heifers demonstrated to be effective in controlling helminthiasis, with the exception of Ivermectin 0.8% + Albendazole 10%, which showed anthelmintic resistance. Also, it can be stated that the use of anthelmintics provided animals of both sexes with better performance during the experimental period. The greatest weight gain was observed in animals treated with Moxidectin 1%, and the use of anthelmintics was profitable in all groups, where animals treated with Moxidectin 1% demonstrated better economic indices.
THANKS

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