GENERAL ASPECTS OF BOVINE WORMS AND THEIR OCCURRENCE IN THE STATE OF GOIÁS, BRAZIL

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ABSTRACT
Bovine worm is an infection of great importance for Brazilian and world livestock. The damage caused by parasitosis sometimes escapes reality and when it is noticed, it brings incalculable inconvenience. The control of parasites, whether gastrointestinal or pulmonary, must be part of a routine to be followed with great discretion and rigor by the rural property. Several studies demonstrate the economic impact and damage caused by worms. Financial figures are impressive about the size of the losses caused by parasites in cattle. In the state of Goiás, studies referring to *Hepatic Fasciola* are demonstrated in very significant data, as well as studies on Bovine Cysticercosis. Being careful and judicious in the use of anthelmintics is one of the main points to be observed in the established chemical management, in order to avoid resistance by parasites. It is important to know how to define the specific anthelmintic for the problem and target population. Biological management is used on a smaller scale in Brazil. To be successful in treatments, it is important to know the epidemiology and correctly apply the forms of control. There are several laboratory techniques available that can help in the correct diagnosis of parasitosis; Considering that most of them, because they are subclinical, are hardly perceived in everyday life in a visual way. Adequate sanitary management, adoption of efficient prophylactic measures with short-term results, bring numerous positive increases to the development of production animals. Establishing prophylactic calendars and instituting specific control programs for each situation or region converge to the consolidation of better gains at a lower cost.

Keywords: Endoparasites. Helminths. Parasitosis. Losses.

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INTRODUCTION

Cattle raising in Brazil represents one of the main sources of income for the farmer, cattle are known for their wide variety of products such as milk and meat, as well as numerous by-products, such as leather. Cattle ranching has been playing a role of great economic relevance within the national agribusiness. Brazil has the largest commercial herd in the world and the second largest effective herd in the world (LUNA et al., 2020; HEIDMANN et al., 2021).

The damage caused by worms is related to weight loss, decreased milk and/or meat production, predisposition to other diseases, low use of the food offered, among others. Animals of all age groups are generally infected, however, worms are more frequent in young animals (EMBRAPA, 2006a).

It is assumed that parasitism had its origin soon after the existence of life on earth. In the same sense, it is admitted that ectoparasites had their evolution prior to that of endoparasites. As well as the adaptability of gastrointestinal parasites, which used to be free-living and, over time, possibly ingested accidentally, resisted the new habitat and adapted to the internal environment (FORTES, 2004).

Bowman (2010) defines the parasite as a smaller living being that lives on or inside another larger organism (host), at the expense of the latter.

In Brazil, specifically in the Pantanal of Mato Grosso, Bianchin and Melo (1985) cite in their work that the authors Travassos and Muniz in 1927, had already described several species of helminths of both domestic and wild animals, already at the beginning of that twentieth century.

Lopes and Costa (2017), cite in their book that, according to Pinheiro et al., (1987), Paiva et al., (2001) and Rangel et al., (2005), it is believed that 100% of animals raised in the field harbor one or more species of helminths.

It is estimated that there are between 75,000 and 300,000 species of helminths. Nematodes and flatworms are the most important and the helminths of the phylum *Acanthocephala* are less important (TAYLOR et al., 2017).

There are several types of parasite classification, among which two stand out: regarding the time of permanence in the host (whether it is temporary, permanent or periodic) and regarding the type of this host (definitive, intermediate, paratenic/transport, reservoir or vector) (MONTEIRO, 2017).

The most widely used laboratory method for diagnosing helminths is counting eggs per gram of stool (OPG). It is a qualitative and quantitative method, since we are talking about the elimination of eggs by females, of the main strongylids (LOPES and COSTA, 2017).

According to data released in 2014 by Sindan – National Union of the Animal Health Products Industry – in Brazil, it is estimated that the expenditure was approximately 220 million dollars per year with the use of anthelmintics. If resistance is present in a certain helminth population, these values may be higher (LOPES and COSTA, 2017).

In the United States, it is estimated that the damage caused by worms is around 330 million dollars/year. In Germany, 50 million marks/year, and in Italy it was close to 30 million lira/year (PEREIRA et al., 2005).

The objective of this study is to describe the general aspects of bovine worms in Brazil, with emphasis on the state of Goiás, from the etiology to control and prevention measures.

LITERATURE REVIEW

BRAZILIAN AND GOIÁS CATTLE FARMING IN STATISTICAL NUMBERS

Brazil has the second largest cattle herd in the world, with 244 million animals, behind only India, which has more than 300 million cattle. The perspective is that the world herd will pass the mark of 1 billion head in 2021 (FARMNEWS/USDA, 2020).

According to Abiec – Brazilian Association of Meat Exporting Industries – Brazil has consolidated itself as the largest exporter of beef.

Goiás closed the year 2018 with exports of more than 230 thousand tons of beef, a record amount in the last 20 years, accounting for business that reached US$ 1 billion in this segment (Agrodefesa/SED, 2018).

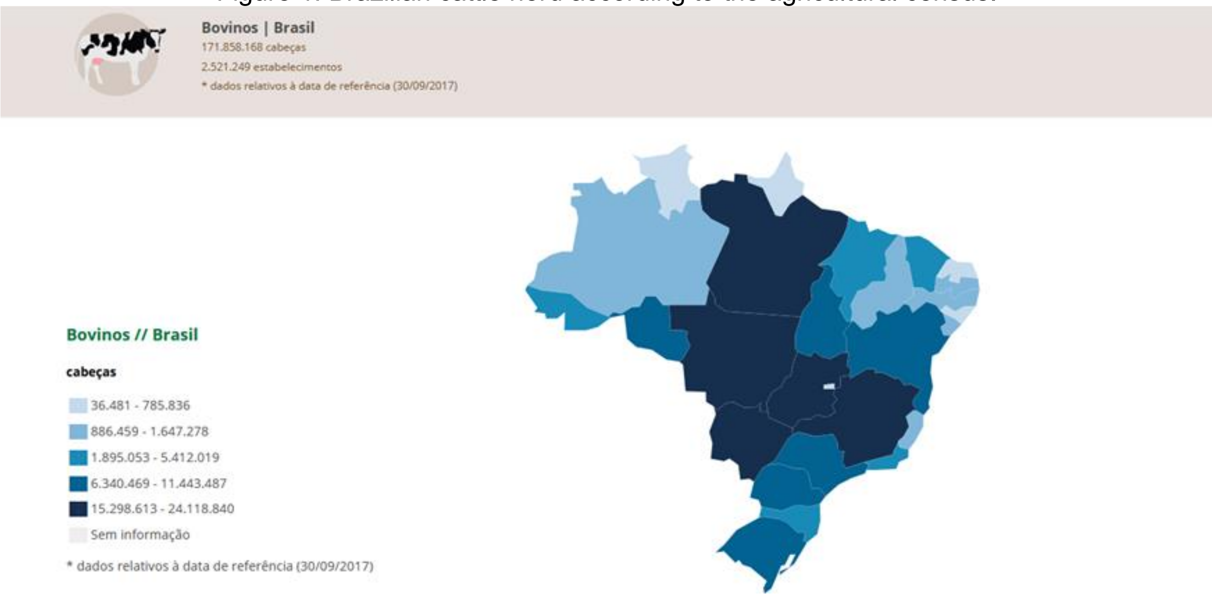
In the dairy farming segment, the state of Goiás stands out as the fourth largest milk producer in Brazil, representing 10.8% of the national production. In 2012, this sector moved around three billion reais (FAEG, 2019).

According to data released by Sindileite – Union of Dairy Industries in the State of Goiás, now in 2019, the state of Goiás produces nine million liters of milk per day, where small manufacturers are the majority (about 80%), but accounting for only 20% of total production. The state of Goiás exports 80% of its production; 64% of this amount is for the state of São Paulo alone.

According to MAPA – Ministry of Agriculture, Livestock and Supply – Brazil closed the year 2018 with a cattle population of 216,596,462 animals. Analyzing data from the IBGE – Brazilian Institute of Geography and Statistics – the institute accounts for a cattle herd of

171,858,168, according to the last agricultural census, represented in figure one (IBGE, 2017).

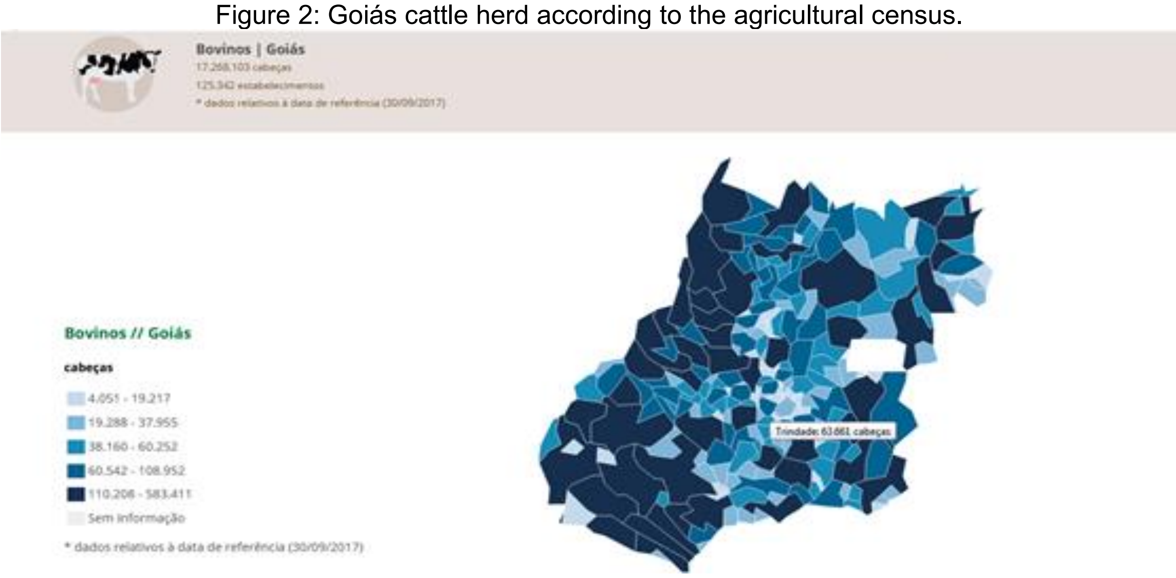
Figure 1: Brazilian cattle herd according to the agricultural census.



Source: IBGE, 2017.

For MAPA, there is a cattle herd of 22,412,687 head in the state of Goiás (MAPA, 2018). This number is practically identical to that released by the state health defense agency, Agrodefesa – Goiás Agency for Agricultural Defense – In the survey obtained by the IBGE, Goiás has a cattle herd of 17,268,103, distributed in just over 125 thousand breeding establishments, as shown in figure two (IBGE, 2017).

Figure 2: Goiás cattle herd according to the agricultural census.



Source: IBGE, 2017.

In Brazil, the GDP – Gross Domestic Product – of 2018, calculated by the Center for Advanced Studies in Applied Economics – Cepea of Esalq (Luiz de Queiroz College of Agriculture), a unit of USP (University of São Paulo), in partnership with the Confederation of Agriculture and Livestock of Brazil – CNA –, closed with a practically stable result compared to 2017 (CEPEA, 2018).

In the state of Goiás, the gross value of livestock production in Goiás in 2018 was 37.38%, with a highlight to the production of cattle, which was 17.72%; registering a positive change of 2.01% in relation to 2017. Beef exports alone accounted for 12.8% of the total (IFAG, 2018).

GENERAL ASPECTS OF WORMS IN CATTLE FARMING

Worms are a general name for parasitic diseases that affect animals. It is estimated that of 100% of the parasites, 95% are in the pasture and 5% in the gastrointestinal tract of the animals (BENAVIDES et al., 2020).

When the producer does not notice the parasite infections, the animals spend several months losing weight and delaying their development (20 to 30% drop in milk and meat production), low fertility, unnecessary expenses with dewormers due to the application at inappropriate times and the need to apply other medications to recover the animal. It is also worth noting the higher expenses with labor (EMBRAPA, 2006b).

Heckler (2015) cited in his work that the deleterious consequences of gastrointestinal worms in beef cattle, evaluated by Pinheiro et al. (2000), show that the weight gain of calves submitted to the treatment of gastrointestinal worms, compared to animals without treatment, can reach 50 kg/head. Borges et al. (2013), in Brazil and Miller et al. (1992), in the United States, also report that the use of antiparasitic drugs in beef cattle can result in an increase of 11.85 and 29.5 kg in weight gain, depending on the commercial formulation, product concentration and parasite load of the animals. Similar data were also observed by Bianchin et al. (2007) and Cleale et al. (2004), who observed an increase of 33 kg in body weight and 0.59 kg/day (23%) in weight gain, respectively, when treated correctly.

Rodrigues and Leite (2014) reported that when it comes to parasitic diseases, it is believed that there are no Brazilian commercial herds free of the problem; And these herds are responsible for the second largest meat production and the fifth largest milk production in the world.

Table one records numbers from a study carried out in 2013, on economic losses from parasitism in cattle, in only six main parasitosis. Untreated cattle (control) were considered; not representing the real impact of worms in Brazil, but rather the possible losses to not be treated.

Table 1 – Economic losses caused by cattle parasites in Brazil.

Parasite	Millions of US$
- Nematodes gastrintestinal	7,107.97
Carrapato bovino: *Rhipicephalus (Boophilus) microplus*	3.236,35
Mosca-dos-chifres: *Haematobia irritans*	2.558,32
Berne: *Dermatobia hominis*	362,45
Worm fly: *Cochliomyia hominivorax*	336.62
- Mosca-dos-estábulos: *Stomoxys calcitrans*	335.46
Total	13,937.62

Source: GRISI *et al.,* (2013)

In Rio Grande do Sul, it is estimated that calves will be in the order of 10 to 30% due to worms. The most worrying thing is when thinking about subclinical worms, because, in addition to the losses, there is also the factor of difficult perception, to be judged and estimated (LOPES and COSTA, 2017).

MAIN HELMINTHS OF CATTLE IN BRAZIL

The phylum *Nemathelminthes* is composed of 6 classes, but only the nematode class has paraister significance for cattle. Nematodes are commonly known as "cylindrical worms". This class is subdivided into two subclasses: *the Secernentea* and the *Adenophorea* , the first, in turn, being subdivided into 16 superfamilies with the highest representations in veterinary medicine. In this phylum there are six orders of worms with greater importance in animal parasitology (RODRIGUES, 2016; TAYLOR et al., 2017; MONTEIRO, 2017 and URQUHART, 1996 et al., 1996).

Pneumogastroenteric nematodes are one of the main causes of decreased productivity in ruminant farming; whether it is large or small animals (LOPES and COSTA, 2017).

Other classes that can also internally parasitize cattle are Trematodes and Cestodes, belonging to the phylum *Platyhelminthes* (MONTEIRO, 2017).

Dentre os nematódeos pulmonares, tem-se: *Dictyocaulus viviparus* e *Dictyocaulus filaria*. No grupo dos nematódeos gastrintestinais, destacam-se: *Haemonchus, Cooperia, Trichostrongylus, Oesophagostomum, Bunostomum, Nematodirus* e *Ostertagia* (LOPES e COSTA, 2017).

Some species of nematodes have reduced pathogenic potential, while others can cause animal death even before the first clinical signs are observed. In general, the main species that parasitize cattle in Brazil, more prevalent and with the highest intensity of infection, belong to the genera *Haemonchus* and *Cooperia* (SANTOS et al., 2010).

Taylor et al., (2017), cite Acanthocephala as a phylum of minor importance in veterinary medicine, which has a close relationship with the phylum *Nematoda*.

The class *Cestoidea*, or simply *Cestoda*, is divided into two subclasses: the *Cestodaria*, which is composed of parasitic helminths of annelids and primitive fishes, the latter of which are of no importance to human medicine and even less to veterinary medicine; and another subclass, which is the *Eucestodo* (tapeworms). *Cyclophyllidea* and *Pseudophyllidea* correspond to the two orders with the greatest significance for human and veterinary medicine (SANTOS, 2017).

As principais espécies de cestódeos mais estudados são: *Taenia solium, T. saginata, T. multiceps, T. hidatigena, T. ovis, T. taeniformis, T. serialis, Davainea proglotin, Echinococcus granulosus, E. multilocularis, E. vogeli, E. oligarthrus, Hymenolepis nana, H. fraterna H. diminuta, Dipylidium caninum, Raillietina tetrágona, R. cisticillus, R. echinobothrida, Amoebotaenia sphenoides, Anoplocephala perfoliata, Paranoplocephala mamillana, Moniezia expansa, Thysanosoma actinioide, Diphyllobothrium latum e D. pacificum* (SANTOS, 2017).

The parasites belonging to the third class of greatest importance, within the phylum of Nematodes, are the Trematodes. In this class, the species belonging to the subclass *Digenea* are the ones that present the greatest morphological diversity among the flatworms. They are oviparous endoparasites found in all vertebrate groups and in all organ systems (ALEJOS, 2017).

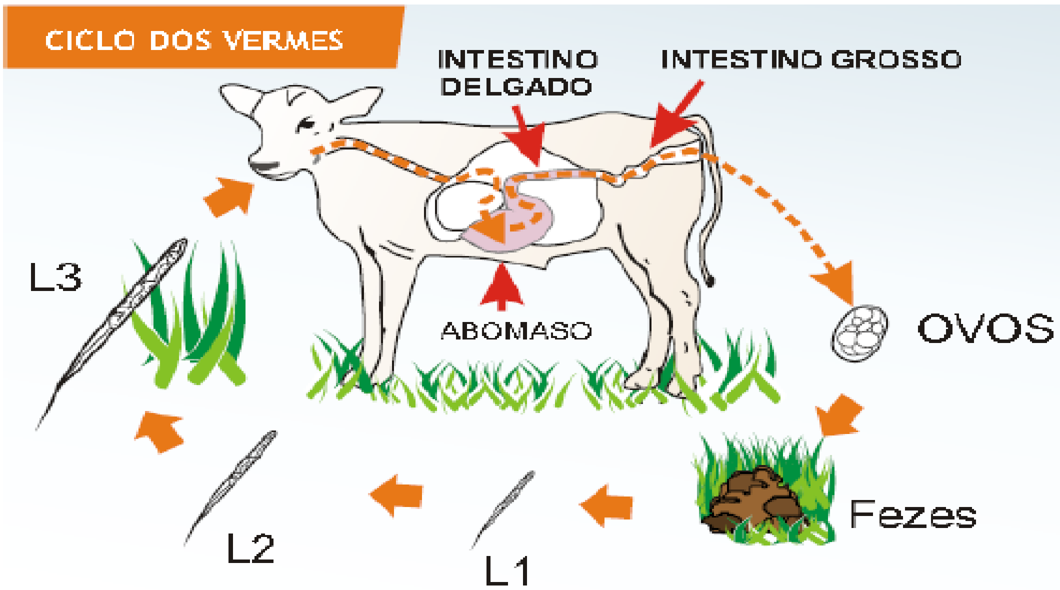
When it comes to public and animal health (with economic impact), the following species of Trematodes are the ones with the most prominence: *Fasciola hepatic*, *Echinostoma revolutum, Typhlocoelium cucumerinum, Brachylaemus mazzantii, Eurytrema coelomaticum, Platynosomum illiciens, Paramphistomum cervi, Schistosoma mansonie, Paratanaisia bragai* (ALEJOS, 2017).

EPIDEMIOLOGY OF WORMS IN CATTLE

Although the reasons for the occurrence of parasitic diseases are multiple and often interactive, the vast majority occur due to one of these four basic reasons: increase in the number of infective stages, change in host susceptibility, introduction of susceptible animals, or the introduction of infection (TAYLOR et al., 2017).

Worms can reach animals through different routes of infection. Most species are acquired orally, by ingesting larvae (L3), as shown in figure three, present in pastures, and some of them by ingesting larval eggs. The larvae of some species can also penetrate through the skin of animals or even pass from the cow to the calf through colostrum. In the vast majority of the Brazilian territory, the extensive production system is adopted, exposing the animals to continuous grazing, so that they remain constantly exposed to infection by parasites (PEREIRA et al., 2005).

Figure 3: Schematic representation of the generalized bovine worm cycle.



Source: Google Images, 2019.

In the evolutionary cycle, several environmental factors influence the pre-parasitic stages, among them: temperature, rainfall, evaporation, incidence of luminosity (sunlight), oxygen, humidity, soil and pasture type. In general, the development of free-living stages becomes faster with increasing temperature, on the other hand, survival time decreases. For optimal growth, the temperature range is 20 to 30ºC. Temperatures above 35 to 40ºC, as well as those below 8ºC, are not favorable to free-living and egg stages (LOPES and COSTA, 2017).

Among the endoparasites of cattle that do not use only the oral route to cause infection, *Strongyloides papillosus* and *Bunostomun sp* stand out. who also use the cutaneous route (PEREIRA et al., 2005).

In a study carried out in the municipality of Dracena-SP, where the degree of helminths in calves born to cows previously classified in different levels of parasite load were evaluated, it was found that: calves daughters of susceptible cows may be influenced by their mothers in relation to parasite load and consequent reduction in their productive performance. However, male calves born to resistant cows, capable of adapting and susceptible, are not influenced by their mothers in the degree of worming and performance (YAMADA, 2016).

Evolutionary cycle of nematode larvae (L3) in ruminants

Ovipositions are made daily by adult females. If there are favorable conditions, such as temperature and humidity, a larva still inside the egg develops, called (L1). Then it begins to feed on bacteria present in the feces; then the first molt (L2) occurs, which continue to feed according to those of the first stage. A second molt originates the third stage (L3), which is the infective form. The latter does not feed (and can survive for months) due to the cuticle envelope of the (L2). The migration of (L3) occurs to the pastures and a smaller portion settles in the soil. This evolutionary cycle: L1 → L3, happens around 7 to 10 days. As soon as the larvae of the third stage are ingested, they evolve and through successive molts: L3 → L4 and L4 → L5, sexual maturity is reached and a new cycle is completed (LOPES and COSTA, 2017).

The larvae (L3) when ingested are preferentially lodged in the abomasum and intestines. Egg elimination usually begins between 18-30 days (pre-patent period) after ingestion of the infective form (PEREIRA et al., 2005).

Studies show that the longevity of the larvae (L3) of *Cooperia spp*., in pasture for example, was up to 15 weeks. On average, it is possible to find larvae of *Haemonchus spp*., *Trichostrongylus spp*. and *Oesophagostomum spp.* in fecal masses of cattle, goats and sheep, for up to 150, 100 and 70 days, respectively (LOPES and COSTA, 2017).

Clinical symptomatology in infected cattle

In general, worms can be gastrointestinal and pulmonary, the latter being more common in calves up to one year of age and more frequent in the colder months. The symptoms are generally associated with loss of appetite, weight loss, frizzy and dull hair, pale mucous membranes, more visible especially in the eyelids and vagina, bulging dewlap, arching of the spine, enlarged belly, coughing, accelerated breathing, mucopurulent nasal discharge, dehydration and death of the affected animals (EMBRAPA, 2006a).

Clinical manifestations due to the action of nematodes can be observed, such as: dyspepsia (↓HCL and ↑HCO^3: increasing the PH from 2.5 to ± 7.0), gastritis, and diarrhea (LOPES and COSTA, 2017).

Another very important effect in worms is the interference with protein metabolism, responsible for the formation and maintenance of muscle mass. This metabolism is impaired by decreased digestibility and nitrogen retention and also by the loss of endogenous proteins (mucosal lesions, exaggerated production of mucus and mucous cells, and large loss of epithelial cells). Worms can also compromise bone growth due to the loss of minerals, such as calcium, phosphorus and magnesium, in fecal matter and urine (PEREIRA et al., 2005).

Clinical manifestations and non-clinical or subclinical manifestations are basically the two types that are observed at the field level. The first corresponds to 5% of the diagnosed cases and the second, which, theoretically would be the most worrying, comprises 95% of the data obtained. Only those animals that are more susceptible manifest clinical symptoms. There are four types of actions/alterations caused by nematodes in animals: mechanical and traumatic action, alteration of metabolism, spoliative action and toxic action. In view of this, it is correct to state that the evolution of helminths caused by nematodes in ruminants is slow and chronic (LOPES and COSTA, 2017).

Predisposing factors to parasite infection

Due to the enormous ecosystem diversity and favorable climate for livestock production presented in Brazil, they favor the maintenance and multiplication of helminths in the free life phase, throughout the year (HECKLER, 2015).

Some factors or conditions predispose cattle to certain parasitic diseases. Age, for example, is one of the main ones; Young animals are more sensitive to worms than adult animals. Animals aged between weaning and 24 to 30 months are the most affected by the effects of worms. While adult animals (fattening oxen, cows and bulls) suffer less from the effects of worms due to the degree of protection acquired over the time of exposure to these parasites (PEREIRA et al., 2005).

Curiously, with the infection of cattle by *Babesia* and *Anaplasma*, an inverse age resistance is generally supposed, due to the fact that young animals are more resistant than adult animals, raised free of infection (URQUHART et al., 1996).

The racial factor is another important issue to be observed. There is increasing evidence that the susceptibility of many animal breeds to parasites varies and is genetically determined. When comparing the breeds of *cattle Bos indicus*, it is observed that they are more resistant to ticks and other hematophagous insects than the breeds of *Bos taurus*. Another example is the trypanotolerance observed in West African N'dama cattle (TAYLOR et al., 2017).

For a number of reasons, many parasites do not develop in hosts other than their natural hosts; as an example of this, this is what is seen in the species of *Eimeria sp*. In other cases, a limit is cited in the degree of development of the parasite, although usually without it causing a clinical symptomatology of the disease. An example of this is what happens with the larvae of *Ostertagia ostertagi*, common to cattle, when they occasionally parasitize sheep, but few of them reach the adult stage in this phase (URQUHART et al., 1996).

Gender can also be a predisposing factor; there is evidence that whole male animals are more susceptible than females to some helminth infections (TAYLOR et al., 2017).

Pereira et al., (2005) and Taylor et al., (2017), comment that other factors, such as: nutritional, immunological and physiological status, type of diet, stages of lactation and/or gestation and steroid therapy, can predispose cattle to parasitosis.

In the environmental aspect and as to the type of parasite in question, factors such as: the type of management adopted, intensity of parasite load, species of parasite involved, biotic potential, hypobiosis/diapause phase, micro-habitat and seasonal development, type of vegetation, climatic conditions and type of exploitation system; are cited in the literature (PEREIRA, 2005 and TAYLOR et al., 2017).

Pathogenesis and laboratory findings

Due to our climatic conditions, most cattle are parasitized throughout the year by gastrointestinal and/or pulmonary helminths. The eradication of these parasites is impossible, mainly due to their ability to multiply and adapt to the environment. They are undesirable and permanent "partners" of the producer and because they do not cause a large number of mortalities or acute diseases, they gradually undermine the cattle breeder's economy (LOLLATO, 2020).

Most helminth species are well adapted to their natural hosts and the occurrence of death as a consequence of parasitism is a rare phenomenon. Pathological alterations can be classified as: mechanical, traumatic, direct or indirect despoiling and toxic. The pathogenesis begins with the migration of L4 in the abomasal epithelium, causing mucosal hyperemia, progressing to a catarrhal inflammatory process with necrosis, erosion and even ulceration of the epithelium (FONSECA, 2006).

Nascimento et al., (2016), mentioned that in the blood count performed on a bovine infected by *Strongyloide papillosus,* anemia, leukocytosis, and hypoproteinemia were evidenced.

Intense parasitism produces a process of gastroenteropathy, thickening of the lamina, edema, and infiltration of inflammatory cells, increasing the permeability of the capillaries. The mucosa of the duodenum is swollen, sometimes slightly hemorrhagic and villous atrophy due to hypoalbuminemia (FONSECA, 2006).

The blood count has great diagnostic value, since severe anemias, leukocytosis, and eosinophilia can occur in worms (**MIYASAKA, 2018).**

Severe loss of blood and plasma proteins occurs in parasitism by *Haemonchus* and *Bunostomum* resulting in edema in the submandibular region. The intense parasitism by *Haemonchus* in calves promotes a decrease in the number of erythrocytes, considerably reducing the organic resistance of the animals. In the initial phase of infection by *Dictyocaulus*, atelectasis may occur; in the adult phase, these parasites may cause pulmonary emphysema (FONSECA, 2006).

LABORATORY DIAGNOSIS

The most used laboratory technique is parasitological analysis of feces. Feces must be collected and preserved correctly. After collection, if it is not possible to send the sample quickly to the laboratory, keep it in the refrigerator or on ice until the time of the exam, which must be carried out within 48 hours of obtaining the material. Never freeze the feces and if there is no possibility of refrigeration, the feces can be stored in 10% formaldehyde or MIF (merthiolate/mercurochrome, iodine and formaldehyde solution) (MONTEIRO, 2017).

While the OPG test is used to count nematode eggs, stool culture is the technique that makes it possible to identify, after seven days of incubation, which genera of nematodes are present (EMBRAPA, 2008).

Each bovine fecal sample must have at least 4g that during the collection procedure, can be stored in an isothermal box with ice. After collection, these samples, which cannot go directly to the laboratory, can be kept in the refrigerator at 8ºC. In the case of stool culture, fecal samples can remain at room temperature (MINHO et al., 2015).

The direct test, which is done by homogenizing a small amount of fecal sample in a drop of 0.9% physiological saline solution, is a very quick and simple method. It is performed by placing this sample, immediately after this mixture, on a microscopic coverslip (BOWMAN, 2010).

Fecal samples from large animals should preferably be collected from the rectum and examined while still fresh. If there is difficulty in collecting samples from the rectum, then fresh feces can be collected from the field or the ground, ideally the collection should be carried out only if the time when the animal defecated was observed. Individual samples are required and, for ruminants, a minimum of 10 samples per herd should be collected (TAYLOR et al., 2017).

Minho et al., (2015), describe that a sample of 10% of the animals divided by categories and age groups within the property is recommended. For herds with quantities of less than 100 head, also divided into categories/ages, they recommend a minimum collection of 10 animals from that herd.

Numerous other techniques are cited in the literature as aids in parasitological diagnosis. Bowman (2010) lists some techniques such as: detection of parasite antigens in feces, concentration by flotation of eggs and cysts, culture of nematode larvae, fecal sedimentation technique, micrometry, culture for oocyst sporulation, egg count by dilution/concentration and also diagnosis by histopathology in heminths.

Taylor et al., (2017), cite the FLOTAC system as a diagnostic method, treating it as a simpler method for performing flotation in a centrifuge; This technique allows the quantification, in up to 1g of feces, of nematode and trematode eggs, as well as protozoan cysts and oocysts.

The Willis-Mollay technique, Faust *et al*. technique, modified Sheather technique, double centrifugation technique, modified McMaster technique, modified Baermann-Moraes method, among others; are cited by Monteiro (2017).

In view of the impossibility of calculating the population of worms existing in the host, based on the count of eggs in the feces, there is a parameter for the correct interpretation of the results. In the case of ruminants, for mixed parasite infections, egg counts above 1000 OPG, in general, are considered indicative of intense infection and those above 500 are considered moderate infections and up to 100 are mild. However, a low OPG is not necessarily indicative of very low or even non-existent infections (TAYLOR et al., 2017).

Helminths of the genus *Cooperia*, where the heavy infection is above 3000 OPG, and the parasites of the genus *Bunostomom,* which, from 100 onwards, is already considered intense (FONSECA, 2021).

Other diagnostic tests can also be used, but with numerous limitations, such as the EMZYME-Linked Immunosorbent Assay (ELISA) and PCR (TAYLOR et al., 2017).

Necropsy can also be a very important tool in the diagnosis of parasitosis in domestic animals; such as hookworm and strongylosis in small ruminants (BOWMAN, 2010).

PREVALENCE STUDIES IN SOME REGIONS OF BRAZIL AND IN THE STATE OF GOIÁS

Several studies on the prevalence of bovine worms in numerous areas of the national territory are available for consultation in the literature.

In a study carried out in the municipality of Realeza-PR, fecal samples were collected from 417 lactating cows and 169 calves, from 51 farms, analyzed by the methods of Willis and Gordon and Whitlock. Eggs of helminths of the superfamily *Strongyloidea* (94.1%), oocysts of *Eimeria* sp. (71.5%), eggs of *Eurytrema coelomaticum*, eggs of *Strongyloides papillosus*, eggs of *Toxocara vitulorum*, eggs of *Moniezia* sp. and eggs of *Trichuris bovis*. The frequency of eimeriosis and parasites of the superfamily *Strongyloidea* was higher in calves when compared to lactating cows. The parasites *E. coelomaticum*, *S. papillosus*, *T. vitulorum*, *Moniezia* sp. and *T. bovis* showed low prevalence and individual frequency, but were found in 24.5% of the farms and represented 2.7% and 5.0% of the infections found in cows and calves, respectively (PETRY et al., 2017).

In the study on the prevalence of *Fasciola hepatica* (bovine fasciolosis) that was published in 2018, referring to data on slaughters carried out between the years 2007 and 2014, the risk areas were evaluated, as well as the losses resulting from this parasitosis. Of the 23,255,979 cattle slaughtered, the average prevalence of *F. hepaticum* during the evaluated period was 0.0026% with a confidence index of 95%. In the State of Goiás, in approximately 10 years (since this parasite was first found by other researchers in 2007), *F. liverwort* has been diagnosed in 168 new municipalities. The estimated loss in this 10-year period, due to the condemnation of livers with *Fascíola* in cattle in the State of Goiás, was R$ 15,072.75 (AQUINO et al., 2018).

Regarding the prevalence and distribution of bovine cysticercosis (*Cysticercus bovis*), in the survey presented by Aquino (2017), it revealed a prevalence of 0.53%, with 42.31% of cysticerci being viable and 57.69% non-viable. The central mesoregion of Goiás had higher chances of finding cattle with cysticercosis (4.44%), when compared to the north (1.00%) and northeast (1.02%) regions. The economic losses estimated by the condemnation of carcasses, referring to slaughters in the period from 2007 to 2014, were R$ 64,809,817.50.

In Rio Grande do Sul, in the study carried out with 300 Angus cattle divided into two large lots: 114 steers between 12 and 15 months of age (super precocious confined group) and 186 steers aged between 36 and 40 months, under the pasture finishing regime, slaughtered in slaughterhouses in the southern region of the state; the general prevalence of animals with abomasum parasitized by *Haemonchus* SPP. was 14.04% in the super early and 4.84% in the traditional category. In addition, it was observed that the finishing system significantly influenced the prevalence of *Haemonchus* spp. and the count of helminth eggs per gram of feces in the super precocious group was significantly higher when compared to that of cattle in the traditional group. Highlighting the importance of detecting parasitism by inspection at slaughter and laboratory examination of feces, for subsequent evaluations of sanitary programs. In addition to detecting possible failures or management risks, which cause economic losses (MARMITT et al., 2020).

Also for *Fasciola hepatic*, Araújo et al. (2007) found a prevalence ranging from 0.95 to 20%, referring to the slaughter of cattle, under federal inspection, coming from six municipalities in the state of Goiás. Based on epidemiological investigations, the authors identified that the animals positive for parasitosis were born and raised on their properties of origin, demonstrating the autochthonous character of the cases of bovine fasciolosis.

ANTHELMINTIC TREATMENTS AND THERAPIES AVAILABLE

The use of anthelmintic compounds to combat the most diverse worms in ruminants began with the discovery of the vermicidal activity of copper sulfate, in 1881, in sheep. Then came carbon tetrachloride (*Haemonchus contortus* in sheep). In 1939, the efficacy of phenothiazine was described with *Haemonchus contortus* and *Oesophagostomum radiatum*, also in sheep. After the 60s, with the discovery of thiabendazole, new concepts for anthelmintic drugs were obtained. In the 80s, the group of macrocyclic lactones (avermectins and milbectins) was discovered; causing a great repercussion because they can be used in various species and because they have great safety. In 2010, the mone-pantel was launched; derquantel in 2011: aminoacetonitrile and spiroindole derivatives, respectively. Other drugs not yet available are being studied, such as aurixazole (based on levamisole disofenate), for oral use for sheep and cattle (LOPES AND COSTA, 2017).

Evaluating the weight gain of 137 cattle aged close to 20 months, divided into five lots, one of which was the control/control, the other four lots received ivermectin dosages in the following concentrations: 4%, 3.15%, 3.5% + 1.25g abamectin and 3.5% of ivermectin associated with a vitamin compound ADE. No statistically significant differences were observed between the control group and all the other treatments, demonstrating that the different formulations did not interfere with the mean weight from 20 to 25 months. This result may have been explained by the residual effect of deworming, carried out 150 days before the beginning of the experiment. Animals in the control group of the experiment, despite suffering from parasitosis during the dry season, in the subsequent rainy season start to have a compensatory weight gain even when not dewormed during the rearing phase. Thus, the author suggested the use of the most economical formulation in this age group in order to reduce the high production costs on beef cattle farms (HERDY et al., 2020).

It is important to emphasize that the rotation of drugs consciously used for anthelmintic treatment in cattle farming can delay the resistance of parasites to these more commonly used drugs (GASBARRE et al., 2009).

In order to synthesize and facilitate understanding, it can be said that antiparasitics are grouped into: anthelmintics, antiprotozoa and ectoparasiticides. Table one contains the main groups of anthelmintics currently used in the treatment of infections caused by nematodes, trematodes and cestodes (TAYLOR et al., 2017).

Table 1 – Groups of anthelmintics.

Chemical group	Cód. group	Nematodeans	Trematodeans	Cestodeans	Ectoparasites
Wide spectrum					
Benzimidazóis and pró-benzimidazóis	1-BZ	+	±	±	-
Imidazotiazóis/ Tetraidropirimidinas	2-LV	+ +	- -	- -	- -
Avermectinas/Mil-bectinas	3-ML	+	-	-	+
Derivatives of aminoacetil	4-AD	+	-	-	-
Espiroindóis	5-SI	+	-	-	-
Curto spectrum					
Salicilanilidas and Phenols substit.		±	+	±	±
Pepirazinas		±	-	-	-
Organofosforados		+	-	-	+
Arsenicais		+	-	-	-
Others		+	-	+	-

Source: TAYLOR et al., (2017)

As seen in chart one, this "other drugs" line are, for example: phenothiazine, epsiprantel, praziquantel, nitroscanate, emodepside, and chlorsulon (TAYLOR et al., 2017).

In a recent study published by SBTE – *Brazilian Society of Embryo Technology*) in 2020, treatment with levamisole phosphate at the beginning of the FTAI – Fixed Time Artificial Insemination protocol, improved the reproductive and productive performance of Nellore females. The use of a dose of the dewormer on the day of progesterone implantation improved the cumulative pregnancy rate (FTAI + bull) as well as the body weight of Nellore females: cows and heifers (LOLLATO, 2020).

Rodrigues et al., (2020), analyzing the efficacy of two veterinary drugs from the avermectin group, tested 81 Nellore cattle in three groups, one of which was the control group; in the others, 3.5% ivermectin and 1% abamectin were applied. The collection was carried out directly in the rectal ampoule of the cattle, packed in thermal boxes and sent to the laboratory. A considerable reduction in the parasite load was observed on each day of post-treatment collection, however, the efficiency of the active ingredients was classified as inefficient, with a rate of 70.27% and 73.80% for ivermectin and abamectin, respectively. It was concluded that the drugs tested were not efficient in controlling the parasite load, and there was a need for immediate change of the active ingredients.

On the other hand, in the experiment using 40 Angus calves, 45 to 100 days old and with an average weight of 112.9 ± 19 kg, divided into two groups: control (20) and treatment with 1% (20) dual oil doramectin (20); where 2 weighings were carried out to evaluate the average daily gain and four feces were collected for a cropoparasitological examination. The OPG result did not show a statistical difference between the groups, however, the mean weight gain of the treatment group was higher than that of the control group: 884g and 446g, respectively (BARBOSA et al., 2021).

According to the different formulations on the market, the main routes of administration of anthelmintics can be defined. Among the main and most common are the oral, parenteral, transcutaneous (pour-on or spot-on) and intraruminal routes (LOPES and COSTA, 2017).

MAIN TYPES OF CONTROL AND PROPHYLAXIS USED IN BRAZIL

To be successful in parasite control programs, one must have knowledge of the epidemiology of the organisms present and the forms of control, both for the free and parasitic life phases. The goal is to keep all animals in full welfare conditions. Sanitary control methods cannot depend only on control with chemical products; in addition to providing a better health condition, they have to improve the benefit-cost ratio for the owner and make them reduce their expenses with the excessive administration of these products (MOLENTO, 2017).

For the most part, the most used method for controlling parasitic infections in production animals is the chemical method; due to its high efficacy, easy administration and good safety margin. On the other hand, its indiscriminate use has brought numerous problems of resistance. The first reports of the appearance of resistance date back to the 1960s (MOLENTO, 2017).

Studies have shown minimal reversion to susceptibility in highly selected homozygous isolates, after discontinuation of the use of the selected drug and, consequently, once present in livestock farms, resistant worms can be considered permanent (TAYLOR et al., 2017).

By means of the technique of Global Genomic DNA Methylation – Deoxyribonucleic Acid –, in a work carried out in a herd of 72 half-blood Angus/Nellore heifers, with the objective of identifying resistant, resilient and susceptible animals to endo and ectoparasites; it was observed that 36.11% of animals were resistant, 52.78% resilient and 11.11% susceptible to infection by gastrointestinal helminths, with counts of 86, 392 and 1087 OPG, and 0.238, 0.225 and 0.197 of methylated DNA, respectively (GONÇALVES, 2020).

Some management strategies can be used to avoid parasite resistance, namely: treating the herd at intervals longer than the pre-patent period of the parasites; alternating different chemical compounds at intervals of more than three years (cattle); using both short- and long-acting products (according to demand/need); performing partial/selective treatments, allowing the survival of parasites in *refugee* (egg-larvae-adults: the larger the refugee population, the greater the possibility of dilution of the genes that encode resistant organisms) and treat newly acquired and/or introduced animals (MOLENTO, 2017).

There are non-chemical methods, which can be used for the treatment and control of worms. Mating between resistant animals, aiming at the procreation of animals genetically more tolerant to worms; periodic grazing on pastures with anthelmintic properties; administration of copper oxide metal particles, among others (TAYLOR et al., 2017).

Biological control is a natural phenomenon, based on the interactions that occur between living beings, especially those of a disharmonious nature (predation, parasitism and competition), which are of fundamental importance in the balance of ecosystems. Basically, this control is instituted in two ways: natural biological control and applied or artificial biological control. Entomopathogenic fungi such as *Metarhizium anisopliae* can be used to control the tick *Rhipicephalus (Boophilus) microplus;* as well as the distribution of nematofogo fungi in pastures, such as the genera *Arthrobotrys* and *Dactyella.* Bacteria of the genus *Bacillus* can also be used as biological control (GARCIA, 2008; GIROTTO et al.; 2008; BITTENCOURT and ARAÚJO, 2017).

Another method of biological control that is already widespread and known to many is the coprophagous beetle *Digitonthofagus gazella*. This arthropod has demonstrated its efficiency and functionality in reducing the incidence of horn fly larvae: *Haematobia irritans* (MOLENTO, 2017).

Molento (2017) mentioned that several plants have demonstrated their antiparasitic effect, proving the phytotherapeutic potential of their extracts or oils.

In a study carried out by EMBRAPA Beef Cattle in Campo Grande-MS, Catto et al., (2014) tested the Asian plant: *Aza-dirachta indica*, more commonly known as "neem" or "nest". This plant, whether as the ground dried leaf, seed oil or the cake resulting from its pressing, is marketed for use in the control of worms, horn flies and also ticks.

The rotation of pastures or the temporary fencing of pastures, provides the death of numerous larvae during the period in which the areas are free of animals, making them less contaminated. In this process, the death of the larvae occurs due to the exhaustion of their energy reserves and the effects of desiccation, and 80% of them can die in about 30 to 45 days. It is worth mentioning that, during the period of occupation of the paddocks, the stocking rate is much higher than that of continuous occupation; it can provide greater contamination by eggs eliminated in animal feces. These, in turn, can result in infective larvae in just five to seven days (PEREIRA et al., 2005).

The fact of not directly incorporating newly acquired animals into the existing herd on the property, allowing them to comply with a quarantine period (being properly dewormed at purchase), contributes greatly to the reduction of environmental contamination, of infectious larvae in the pastures. The reduction in the number of head per hectare is also a factor in the increase in this drop. Another good alternative for this purpose is to alternate the grazing of young sheep with that of adult cattle and vice versa. Adult cattle are not infected with the same species of parasites that infect young sheep. In addition, cattle reduce environmental contamination of infective larvae in the field through grazing, favoring the cleaning of pastures (BENAVIDES et al., 2020).

The use of the agriculture-livestock system and/or ICLFS – Crop-Livestock-Forest Integration – is cited as an effective way, even temporarily, to reduce the number of infective larvae in the pasture (MOLENTO, 2017).

According to EMBRAPA (2006a), basically as a form of control and prevention, some care and criteria must be carefully observed. Important points should be considered in a bovine worm control program, as an example of these criteria to be followed, some main ones are: prevent the accumulation of larvae in the pastures, as the initial amount of contamination determines the severity of the infection. Animals must be exposed to a degree of contamination sufficient to produce resistance without negative interference with their productivity.

EMBRAPA (2006a) also mentions that the dewormer, when applied without the aid of complementary control measures, provides temporary relief. However, if the herd remains on contaminated pasture, it will be reinfested, as adult worms develop within 21 to 28 days after ingestion of larvae. The fertilization of beef grass production fields with cattle manure should be considered a risk factor for the appearance of infestations; Reducing the amount of worms in the animal reduces the number of eggs available for pasture contamination.

The use of vaccines could, without a doubt, be one of the main tools for the control of worms in ruminants, however, there is still no commercial presentation available. Studies already advanced with the use of molecular biology have managed to discover several antigens. Obstacles such as the preparation of stable recombinants, appropriate adjuvants, associated with a reasonable cost, prolonged and efficient action, make the launch of an immunizer for this purpose remote (BASSETO et al., 2014).

Much has been written about the prevention and control of bovine worms, each scheme has its pros and cons. Parasitism should be considered as an annual battle between the herd, the helminths and the breeder. The final criterion for the success of any prophylaxis effort is the overall benefit obtained, not the number of parasites that are destroyed (BOWMAN, 2010).

The development of eggs and larvae and the survival, persistence and migration of larvae in the pasture are limited by the dry season with a lot of sunshine and heat and often even by the excessive amount of rainfall. The most favorable combination for the development of worms is the one characterized by the presence of rainfall interspersed with periods of sunshine, which keeps the heat and humidity in the correct measure for its dissemination. With such knowledge, and especially knowledge about the transmission of larvae, it is possible to establish a preventive strategic control scheme in which climatic and management conditions must also be considered (EMBRAPA, 2006a).

PROPOSED ANTIPARASITIC TREATMENT REGIMENS

It is not new that there is concern with the correct use and application of antiparasitics in cattle. In a study carried out more than 30 years ago, the authors already warned about this issue, when in that year, HONER and BIANCHIN (1987) were already concerned with the revolution in the development of antiparasitic drugs. The authors mentioned the awareness of the importance given to gastrointestinal helminths, but with discouraging results obtained by the incorrect use of the products. That same year, it was already cited as having a "revolution/expansion", of the previous 20 years, when a greater quantity of anthelmintics began to be available on the market.

According to Honer and Bianchin (1987), the theory on the use of these anthelmintics, which had been developed specifically in Australia, identified eight different types of treatment possibilities, but four of them would be the most important: extensive preventive treatment, curative treatment, tactical treatment and strategic treatment.

Pereira et al., (2005) cited as a way of better understanding, four types of control used as tools for the implementation of parasitological control programs, namely: curative, suppressive, tactical and strategic.

More recently, Lopes and Costa (2017) describe that we must be very careful about the grace period of formulations available on the market, an aspect that is much forgotten by users. In addition to being a public health issue, it can cause damage to the environment (ecological imbalance) and trade embargoes on beef exports. The author mentions four types of treatment schemes:

The first is curative treatment, as it treats only animals that have clinical symptoms of worms. The second (tactical) treatment is the one that is used only in specific or even critical periods, such as: when acquiring new animals, climatic variations (↑outbreaks of worms), pre-calving period. Selective treatment, on the other hand, is when more specific techniques are used, such as OPG, for example; thus selecting those animals that really have worms. Although it is still a very little used treatment.

Finally, the strategic treatment is described. This treatment is basically based on the epidemiology of the nematodes and the climatic seasonality or rainfall index of the region. In general, the recommendation is that applications be carried out in periods when the parasite load is higher in the host, than in the environment (pasture); that is, in the driest periods of the year, respecting an interval between 60 and 90 days, according to the recommendations of each product (LOPES and COSTA, 2017).

According to Pereira et al., (2005), about 80% of the doses of anthelmintics used in Brazil are given erroneously and, therefore, without economic return. The erroneous use of anthelmintics and the non-adoption of other measures to control worms, make them one of the factors responsible for the low enjoyment of the national cattle herd. The same authors mention that, according to BIANCHIN (2000), the dosage of these animals has been done in the wrong way: both by wrong deworming at different times of the year and also by the lack of criteria in the inappropriate animal categories.

In studies carried out in 2016, it was shown that the treatment in the months of May-August-November provided a better benefit-cost ratio than those used in the months of May-July-September (LOPES and COSTA, 2017).

According to Molacco (2020), for dairy calves, worm control can be started from 2 to 3 months of age and treatments every 90 days should be repeated until they reach 12 months of age; when concentrated products are used that provide high efficacy and a longer control period. For heifers from 12 months of age, strategic control of worms is employed, with a treatment carried out at the beginning of winter (May/June), another near the end of winter (August/September) and another just after the beginning of spring (October/November). Treatment in mid-summer (February/March) is also recommended, as these animals are in broad body development and suffer a high negative impact from the main worms. For dairy cows, the author recommends that it be done when "at the entrance of the milking line" and in the dry period.

Identifying and separating ruminants from sources of infection is a strategy to be adopted in outbreaks of worms; It is recommended not to exercise animals affected by strongylosis. The use of anthelmintics should be based on knowledge of the biology of the parasites, as well as the climate of the region. When the contamination in the pastures is very intense, it is suggested to use strategic treatments: before calving and when returning to pasture, in mid-summer and autumn; sometimes complementing with tactical treatments (BOWMAN, 2010).

According to Lopes and Costa (2017), beef cattle can be divided into four categories, according to susceptibility to worms and the need for treatments: before weaning, from weaning to 24 months of age, adult males and adult females.

FINAL CONSIDERATIONS

In view of the above, it is verified the importance of controlling worms in cattle; regardless of the type of livestock exploitation that is being practiced. In the most diverse studies carried out, the increase in weight gain, milk production and fertility index, and even in the drop in mortality, among other positive benefits observed, has been proven.

Based on the studies of this literature review, we also observed that there are no evaluations of the economic impact of bovine parasitosis carried out in Brazil. There are several studies that consider economic and financial aspects, but not specifically economic impact itself.

It is estimated that the financial losses in Brazil were more than 15 billion dollars in one year, due to the action of the main endo and ecto parasites, due to the absence of adequate parasite control measures. Representing approximately more than 10% of the GDP of all livestock activity.

In view of the numbers and data exposed, a negative performance of livestock, especially in the case of cattle farming, can have disastrous consequences for the financial markets.

In order to optimize the results, which are, for the most part, the most expected and desired part of the cattle breeder, it is necessary to use sanitary tools available in the agricultural segment. Among these tools, health is undoubtedly one of the great pillars of cattle farming; whether it is beef or dairy.

The fight against worms, as recommended in a complete cycle production system, must be carried out from those younger to the oldest animals; making use of the numerous information available and its efficiencies being duly proven.

REFERENCES

1. Agência Goiana de Defesa Agropecuária (AGRODEFESA). (2019). Exportações goianas de carnes bovinas geram negócios de US$ 1 bilhão. Disponível em: http://www.goias.gov.br/noticias/51-economia/63312-exporta%C3%A7%C3%B5es-goianas-de-carnes-bovina-geram-neg%C3%B3cios-de-us$-1-bilh%C3%A3o.html. Acesso em 28 abr. 2019.

2. Alejos, J. L. F. L. (2017). Classe Trematoda. In S. G. Monteiro (Ed.), *Parasitologia na Medicina Veterinária* (2. ed., pp. 319–337). Rio de Janeiro: Roca.

3. Aquino, F. M. de. (2017). *Prevalência e distribuição espacial da cisticercose e fasciolose bovina no estado de Goiás* (Dissertação de Mestrado). Universidade Federal de Goiás, Goiânia.

4. Aquino, F. M. de, Soares, V. E., Rossi, G. A. M., Nicaretta, J. E., Bastos, T. de S. A., Cruvinel, L. B., ... Gomes, L. V. C. (2018). Prevalence of bovine fascioliasis, areas at risk and ensuing losses in the state of Goiás, Brazil. *Brazilian Journal of Veterinary Parasitology*, 27(2), 123–130.

5. Araújo, J. L. de B., Linhares, G. F. C., Oliveira, A. P. M. de, Amoril, J. G., Freitas, M. R. de, Costa, I. C., ... Silvania, A. R. (2007). Infecções autóctones de bovinos por Fasciola hepatica Linnaeus, 1758 (Trematoda, Fasciolidae) no estado de Goiás, Brasil. *Revista de Patologia Tropical/Journal of Tropical Pathology*, 36(1), 96–100.

6. Associação Brasileira das Indústrias Exportadoras de Carnes (Abiec). (2019). Brasil se consolida como maior exportador mundial de carne bovina, diz Abiec. Disponível em: https://istoe.com.br/brasil-se-consolida-como-maior-exportador-mundial-de-carne-bovina-diz-abiec-2/. Acesso em 28 abr. 2019.

7. Barbosa, R. R. (2014). Tempos e movimentos: uma breve digressão cultural dos carros de bois no território goiano. *Ciência Geográfica - Bauru*, 18(1), janeiro/dezembro.

8. Bassetto, C. C., Silva, M. R. L., Newlands, G. F. J., Smith, W. D., Ratti Júnior, J., Martins, C. L., ... Amarante, A. F. T. (2014). Vaccination of grazing calves with antigens from the intestinal membranes of *Haemonchus contortus*: Effects against natural challenge with *Haemonchus placei* and *Haemonchus similis*. *International Journal for Parasitology*, 44(5), 697–702.

9. Benavides, M. V., & Souza, C. J. H. de. (2020). Verminose ovina. *EMBRAPA Pecuária Sul, Comunicado Técnico* (105). Bajé-RS.

10. Bianchin, I., & Melo, H. J. H. de. (1985). *Epidemiologia e controle de helmintos gastrintestinais em bovinos de corte nos cerrados* (2. ed.). Campo Grande-MS: EMBRAPA-CNPGC. (Circular Técnica, 16).

11. Bittencourt, V. R. E. P., & de Araújo, J. V. (2017). Controle biológico de parasitos. In S. G. Monteiro (Ed.), *Parasitologia na Medicina Veterinária* (2. ed., pp. 482–492). Rio de Janeiro: Roca.

12. Bowman, D. D. (2010). *Georgis – Parasitologia Veterinária* (9. ed.). Rio de Janeiro: Elsevier.

13. CATTO, J. B.; BIANCHIN, I.; DA SILVA, M. A.; DA SILVA, R. L. Avaliação Bioeconômica de Antiparasitários Fitoterápicos e Homeopáticos em Bovinos de Corte. (1. ed.). Campo Grande-MS, EMBRAPA-CNPGC, 2014. (EMBRAPA-CNPGC. Circular Técnica, 129), 7 p.

14. CENTRO DE ESTUDOS AVANÇADOS EM ECONOMIA APLICADA (CEPEA). PIB do Agronegócio Brasileiro. Disponível em: <https://www.cepea.esalq.usp.br/br/pib-do-agronegocio-brasileiro.aspx>. Acesso em: 20 mar. de 2019.

15. EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA (EMBRAPA). Comunicado Técnico 64: Instruções para coleta e envio de material para exame parasitológico das fezes – OPG e coprocultura para ruminantes. Isabella Cabral Hassum. Bagé, RS: EMBRAPA, 2008, (1. ed.), 2 p.

16. EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA (EMBRAPA). Folder Técnico: VERMINOSE EM BOVINOS. Amaury Apolônio de Oliveira. Aracajú, SE: EMBRAPA, 2006. 2 p.

17. EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA (EMBRAPA). Folder Técnico: VERMINOSE BOVINA. Francelino Goulart da Silva Netto. Porto Velho, RO: EMBRAPA, 2006, tiragem: 100 exemplares, 2 p.

18. FARMNEWS. Maiores rebanhos e produtores de carne bovina previstos para 2021. São Paulo, 09 de novembro de 2020. Disponível em: <https://www.farmnews.com.br/mercado/maiores-rebanhos-e-produtores-de-carne-bovina-2/>. Acesso em: 05 abr. 2021.

19. FEDERAÇÃO DA AGRICULTURA E PECUÁRIA DO ESTADO DE GOIÁS (FAEG). Goiás representa 10% da produção nacional de leite. Disponível em: <http://sistemafaeg.com.br/faeg/noticias/noticias/goias-representa-10-da-producao-nacional-de-leite>. Acesso em: 01 de mai. de 2019.

20. FONSECA, A. H. Disciplina de Doenças Parasitárias. Material Didático (Cálculo da Carga Patogênica/L3 de Helmintos de Ruminantes/Técnica de MacMaster e Coprocultura). MEC UFRRJ, 2021. Site do autor. Disponível em: <http://r1.ufrrj.br/adivaldofonseca/wp-content/uploads/2014/06/2_Tecnica_de_McMaster_e_Coprocultura.pdf#new_tab>. Acesso em: 01 mai. 2021.

21. FONSECA, A. H. Helmintoses gastrointestinais dos ruminantes. Disciplina de Doenças Parasitárias. Material Didático. UFRRJ, RJ: 2006, 12 p.

22. FORTES, E. Parasitologia Veterinária. 4. ed. São Paulo: Ícone, 2004. 607 p.

23. GARCIA, M. V. Aplicação do Fungo Metarhizium anisopliae em Pastagem Visando o Controle do Carrapato Boophilus microplus em Bovinos. 2008. 58 f. Tese (Doutorado em Microbiologia Agropecuária) - UNESP, Jaboticabal, SP, 2008.

24. GASBARRE, L. C. The identification of cattle nematode parasites resistant to multiple classes of anthelmintics in a commercial cattle population in the US. *Faculty

Publications from the Harold W. Manter Laboratory of Parasitology*, Nebraska, n. 625, 2009.

25. GIROTTO, M. J.; AQUINO, L. F. B.; PEREZ, R. B.; NEVES, M. F.; SACCO, S. R. O uso de fungos nematófagos no controle biológico de nematóides parasitas: revisão de literatura, São Paulo, Brasil. *Revista Científica Eletrônica de Medicina Veterinária*, São Paulo, 2008, ano VI, n. 10, 7 p.

26. GONÇALVES, J. A. Metilação global genômica relacionada à resistência parasitária em bovinos. 2020. 76 f. Dissertação (Mestrado em Ciência e Tecnologia Animal) - Unesp/SP, Dracena, 2020.

27. GRISI, L.; LEITE, R. C.; MARTINS, J. R. de S.; BARROS, A. T. M. de; CANCADO, P. H. D.; VILLELA, H. S. Perdas econômicas potenciais devido ao parasitismo em bovinos no Brasil. In *40º CONBRAVET, palestra magna proferida em 18 a 21 de novembro de 2013*. Salvador, BA. Disponível em: <https://www.milkpoint.com.br/noticias-e-mercado/giro-noticias/impacto-economico-das-parasitoses-de-bovinos-89321n.aspx>. Acesso em: 10 abr. de 2019.

28. HECKLER, R. P. Epidemiologia e controle estratégico da verminose em bovinos de corte. 2015. 126 f. Tese (Doutorado em Ciência Animal) - UFMS, Campo Grande, 2015.

29. HEIDMANN, M. J.; NASCIMENTO, C. G. do; CASTRO, B. C. de. Complexo respiratório bovino no contexto da sanidade animal. *Scientific Electronic Archives*, v. 13 (4), april., 2021.

30. HERDY, M. A.; PEREIRA, Y. G.; MATTA, M. V. R. da; SILVA, R. C. M. da; SILVEIRA, R. L.; KNACKFUSS, F. B. Avaliação do peso de bovinos da raça Nelore tratados com quatro anti-helmínticos à base de ivermectina. *PUBVET*, v. 14, n. 9, a642, p. 1-5, set., 2020.

31. HONER, M. R.; BIANCHIN, L. Considerações básicas para um programa de controle estratégico da verminose bovina em gado de corte no Brasil. Campo Grande-MS, EMBRAPA-CNPGC, 1987. (EMBRAPA-CNPGC. Circular Técnica, 20), 53 p.

32. INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). *Censo agro 2017: resultados preliminares*. Disponível em: <https://censoagro2017.ibge.gov.br/templates/censo_agro/resultadosagro/pecuaria.html>. Acesso em: 23 mar. de 2019.

33. INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). *Censo agro 2017: resultados preliminares*. Disponível em: <https://censoagro2017.ibge.gov.br/templates/censo_agro/resultadosagro/pecuaria.html?localidade=52&tema=75652>. Acesso em: 23 mar. de 2019.

34. INSTITUTO PARA O FORTALECIMENTO DA AGROPECUÁRIA DE GOIÁS (IFAG). *Conjuntura econômica*. Disponível em: <http://ifag.org.br/conjuntura-economica?start=0>. Acesso em: 20 mar. de 2019.

35. LOLLATO, J. P. Controle das verminoses em bovinos exige um calendário sanitário, estratégico, eficiente e racional. *Portal do Agronegócio*. Biogénesis Bagó, 19 nov. 2020.

36. **LOPES, W. D. Z.; DA COSTA, A. J.** Endoparasitoses de ruminantes. Goiânia: Editora UFG, 2017. 242 p.

37. **LUNA, H. S.; DAMASCENO, V. L. S.; SOUSA, I. M.; SILVA, W. L.; BLINI, R. C. B.** Diagnóstico das condições do manejo sanitário e da saúde de bovinos criados no assentamento vinte de março localizado no município de Três Lagoas-MS. *Revista Saúde e Meio Ambiente – RESMA*, Três Lagoas, v. 10, n. 1, p. 32-42, janeiro/julho, 2020.

38. **MARMITT, I. V. P.; SEDREZ, S. F.; FÉLIX, S. R.; NIEDERMEYER, F.; CHAGAS, B. C.; NIZOLI, L. Q.; SILVA, S. S. da.; SILVA, E. F. da.** Estudo transversal da ocorrência de *Haemonchus* spp. em bovinos de corte submetidos a diferentes sistemas de terminação. *Brazilian Journal of Development*, Curitiba, v. 6, n. 8, p. 58624-58633, ago. 2020.

39. **MINHO, A. P.; GASPAR, E. B.; YOSHIHARA, E.** Manual de Técnicas Laboratoriais e de Campo para a Realização de Ensaios Experimentais em Parasitologia Veterinária: Foco em Helmintos Gastrintestinais de Ruminantes. Bajé-RS, EMBRAPA, 2015. (1. ed.). (EMBRAPA PECUÁRIA SUL. Documento 148), 33 p.

40. **MINISTÉRIO DA AGRICULTURA PECUÁRIA E ABASTECIMENTO (MAPA).** Sanidade Animal. Programa Nacional de Erradicação da Febre Aftosa – PNEFA. Rebanho Nacional - Bovinos Bubalinos. Disponível em: <http://www.agricultura.gov.br/assuntos/sanidade-animal-e-vegetal/saude-animal/programas-de-saude-animal/febre-aftosa/vacinacao/copy3_of_Populaobovinaebubalina_2_etapaimpresso.pdf>. Acesso em: 20 mar. 2019.

41. **MOLACCO, M.** Controle parasitário no gado de leite. *Revista Safra*. Goiânia-GO, 17 jun. 2020. Disponível em: <http://revistasafra.com.br/controle-parasitario-no-gado-de-leite/>. Acesso em: 5 abr. 2021.

42. **MOLENTO, M. B.** Métodos de Controle e Resistência Parasitária. In: **MONTEIRO, S. G.** (Ed.). *Parasitologia na Medicina Veterinária.* 2. ed. Rio de Janeiro: Roca, 2017. cap. 30, p. 507-516.

43. **MONTEIRO, S. G.** *Parasitologia na Medicina Veterinária.* 2. ed. Rio de Janeiro: Roca, 2017. 594 p.

44. **MIYASAKA, D.** Parasitas provocam falha na atividade reprodutiva bovina. Disponível em: <https://noxon.com.br/parasitas-provocam-falhas-na-atividade-reprodutiva-bovina/>. Acesso em: 12 mai. 2019.

45. **NASCIMENTO, M. R.; ALEXANDRE, N. A.; MELO, I. H. de S.; BORGES, L. P. B.; REZENDE, S. R.; QUARESEMIN, L. V.; DIAS, F. G. G.; CASAS, V. F.; PEREIRA, L. de F.** Infestação por *Strongyloides* spp: Relato em Bovino. Hospital Veterinário da Universidade de Franca. São Paulo, 2016.

46. **PEREIRA, A. B.; LEITE, R. C.; BIANCHIN, I.** Verminoses dos bovinos: parte I: epidemiologia e efeitos sobre os animais; parte II: controle. In: **SIMPÓSIO PFIZER SOBRE VERMINOSE BOVINA**, 2, 2005. Evento ocorrido em cerca de 61 cidades. *Anais...* Campo Grande, MS: EMBRAPA/CNPGC, 2005. 14 p.

47. **PEREIRA, J. R.** Práticas para controle de verminose de bovinos leiteiros em Pindamonhangaba, São Paulo, Brasil. *Pesquisa & Tecnologia – APTA Regional*, São Paulo, 2014, v. 11, n. 1, 4 p.

48. PETRY, A. L.; DA SILVA, J. P.; GHISLERI, R. F.; FRITZ, M. F.; KOZERSKI, D.; TREVISAN, L. V.; HORN, V. A.; DE ANDRADE, G. L.; RIBEIRO, D. G.; FREITAS, F. L. C. Prevalência de verminose bovina em propriedades de agricultura familiar no município de Realeza, estado do Paraná, Brasil. In: XII Congresso Brasileiro de Buiatria, 2017. Anais... Foz do Iguaçu, PR. 2017.

49. RODRIGUES, D. S.; LEITE, R. C. Impacto econômico das parasitoses de bovinos. Giro de notícias. São Paulo, 2014. Disponível em <https://www.milkpoint.com.br/noticias-e-mercado/giro-noticias/impacto-economico-das-parasitoses-de-bovinos-89321n.aspx>. Acesso em 10 abr. de 2019.

50. RODRIGUES, M. de L. A. Classificação e Morfologia de Nematóides em Medicina Veterinária (IV/DPA). Departamento Parasitologia Animal, UFRRJ, Rio de Janeiro: SEROPÉDICA, 2016, 57 p.

51. RODRIGUES, V. de S.; RODRIGUES, M. H. D.; FIORAVANTE, F. C. R. C.; SOUZA, A. B. B.; OLIVEIRA, R. O. R. G. de.; REIS, T. S.; GARCIA, J. A. S.; FERREIRA, J. L. Eficiência de avermectinas no controle de parasitas gastrintestinais em rebanho comercial na região de Grajaú, Maranhão. *Brazilian Journal of Development*, Curitiba, v. 6, n. 10, p. 75936-75948, oct. 2020.

52. SANTOS, T., dos. Classe Cestoda. In: MONTEIRO, S. G. (2. ed.). *Parasitologia na Medicina Veterinária*. Rio de Janeiro: Roca, 2017. cap. 19, p. 338-375.

53. SANTOS, T. R.; LOPES, W. D. Z.; BUZULINI, C.; BORGES, F. A.; SAKAMOTO, C. A. M.; LIMA, R. C. A.; OLIVEIRA, G. P.; COSTA, A. J. Helminth fauna of bovines from Central-Western region, Minas Gerais State, Brazil. *Ciência Rural*, v. 40, p. 934-938, 2010.

54. SINDICATO DAS INDÚSTRIAS DE LATICÍNIO NO ESTADO DE GOIÁS (SINDILEITE). Goiás deixou de ser grande produtor nacional de leite por falta de profissionalismo, diz Sindileite. Disponível em: <https://www.jornalopcao.com.br/reportagens/goias-deixou-de-ser-grande-produtor-nacional-de-leite-por-falta-de-profissionalismo-diz-sindileite-164855/>. Acesso em 01 de mai. 2019.

55. TAYLOR, M. A.; COOP, R. L.; WALL, R. L. *Parasitologia Veterinária*. 4. ed. Rio de Janeiro: Guanabara Koogan SA., 2017. 3789 p.

56. URQUHART, G. M.; ARMOUR, J.; DUNCAN, J. L.; DUNN, A. M.; JENNINGS, F. W. *Parasitologia Veterinária*. 2. ed. Rio de Janeiro: Guanabara Koogan SA., 1996. 273 p.

57. YAMADA, P. H. Desempenho, Parâmetros Hematológicos e Grau de Helmintose em Bezerros Filhos de Vacas Previamente Classificados por Diferentes Níveis de Infecção Parasitária. 2016. 61 f. Dissertação (Mestrado em Ciência e Tecnologia Animal) - USP/SP, Dracena, 2016.