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REGULAR ARTICLES

Epidemiology and effect of gastrointestinal nematodes on beef cattle from tropical Argentina

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Abstract

The aim of this work was to study the epidemiology and the harmful effect of gastrointestinal nematodes (GINs) on beef cattle in the piedmont forest and grassland region of northwestern Argentina, between March 2015 and March 2016. Sixty weaned female calves were divided into three groups: STG—calves treated systematically with 200 mcg/kg moxidectin every 40–50 days; LTG—calves treated as usually locally implemented, with 200 mcg/kg ivermectin on May 4 and August 5; and UTG—calves not receiving treatment. Moreover, a group of 20 untreated first-calving cows was monitored. Eggs per gram of faeces (epg) and faeces cultures were performed. Live weight gain (LWG) was recorded. Differences among groups were compared using analysis of variance and Tukey test. At the start of the experiment, mean epg was from moderate to high (595 ± 480); therefore, this group was treated in May. Mean UTG epg peaked (907 ± 754) in mid-winter, decreasing toward spring. LTG epg only decreased partially after treatment, showing 54.2% of ivermectin efficacy. Epg values of STG were always negligible values (95.8% of moxidectin efficacy). The dominant nematode genus was *Cooperia* (81.9%), followed by *Haemonchus* (15.5%). The effect of treatments was evident from middle autumn, with STG showing a significantly ($p < 0.002$) higher LWG than the other groups. Toward the end of the trial, LWG of STG and LTG increased by 27.2 and 8.2%, respectively, to those of UTG. This preliminary study showed a winter epg peak and a negative effect of GINs on LWG, even in moderately infected calves.

Keywords Cattle · Gastrointestinal nematode · Epidemiology · Effect · Tropical Argentina

Introduction

Beef cattle production in northwestern Argentina (NOA) is increasingly important because of the potential contribution to livestock rearing, since some 24 million hectares is suitable only for this productive activity. Accordingly, between 2003 and 2010, stocks have increased from 562,252 to 1,049,782 heads in Salta province, from 1,157,779 to 1,397,580 in Santiago del Estero province, and from 1,403,243 to 1,748,920 in Formosa province (Milano 2011). This production growth in subtropical areas with almost no history of commercial intensive beef cattle raising has posed some limiting factors that are different from those in central Argentina. Among those limitations are issues affecting cattle health and productivity, such as infection with gastrointestinal nematodes (GINs).

Nematode infection may reduce productivity of grazing cattle (Suarez 1993; Borges et al. 2013; Charlier et al. 2014; Fazzio et al. 2014). Free-living forms of GINs exhibit a close relationship with climatic factors, the environment and animal management, affecting GIN development, survival, and final infestation rate of pastures (Suarez and Lorenzo 2000). Thus, there are marked differences in epidemiology and effect of GINs among regions and production systems. For this reason, knowledge about GINs from the temperate Pampas plains (Suarez et al. 2013; Fiel et al. 2013) cannot be extrapolated to subtropical cattle systems.

The NOA region is characterised by a subtropical climate with a dry winter season and summer rainfalls and the presence of mountain valleys, Chaco semiarid forests, and mountain tropical forests (yungas). Between the yungas and the semiarid Chaco region, there is a transition area of piedmont forests and grasslands. These agroecological areas have been

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largely modified by human activities and are used for cattle raising on natural or implanted pastures, as an alternative to other agricultural and forestry activities.

Knowledge about the internal parasites of beef cattle in the NOA is scarce, especially considering the diversity of environments present in the region (Le Riche et al. 1982; Kühne 1985; Kühne et al. 1986; Suarez et al. 2017). Particularly for this piedmont region in Argentina, which can be related to other similar regions in Bolivia, Brazil, Venezuela, and Colombia, there are no previous studies about epidemiology of GINs and their effects on beef cattle. Therefore, the aim of this work was to study the epidemiology of GINs and their effects on replacement beef heifers in a representative region of the piedmont forests and grasslands in Salta province.

Materials and methods

Study area and animals

The study was conducted in San José de Pocoy ranch, located in General San Martín department, Salta, province, at 500 m a.s.l. The area has a very irregular seasonal rainfall regime, with an annual mean of 900 mm (ranging between 650 and 1500 mm), and a dry period extending from May to October (Bianchi 1992).

The study group was composed of 4–5-month-old red Brangus cross calves, which were weaned early (at 3 months of age), in January–February. Management was based on grazing of implanted perennial pastures *Brachiaria brizantha* (Mulato or Toledo cultivar) and *Magathyrsus maximum* (Gatton Panic cultivar) supplemented with ground maize, at a rate of 3 to 7 calves per hectare.

Experimental design

Between March 18, 2015, and March 22, 2016, 60 calves naturally infected with GINs were monitored. Three groups of 20 weaned female calves were formed to compare their responses to anthelmintic treatment and the effect of parasites on weight gain: untreated group (UTG); group treated systematically on each sampling date (STG) with subcutaneous moxidectin (MXD 200 mcg/kg); and group under a locally implemented treatment according to the ranch health management (LTG). The latter group was treated with ivermectin (IVM 200 mcg/kg) on May 4, 2015, and August 5, 2015. STG was included in the study with the sole purpose of obtaining an optimal unparasitized group to compare the nematode effect and not to propose it as a control method. The groups grazed together along with the entire stock of 280 replacement heifers. In addition, in March, June, September, and December 2015 and March 2016, 20 pregnant cows whose first calving was in July–August 2015 were monitored.

Parasitological analyses

Faecal samples were taken every 42 days from the start of the study (March 2015) to September, then in December 2015 and March 2016. Individual faecal nematode egg counts were determined using the modified McMaster technique (Roberts and O'Sullivan 1949), where 1 egg represents 10 epg. Faecal cultures were performed in each group to assess the generic composition of nematode populations according to Suarez (1997), and nematode larvae were identified using the morphological characters described by Van Wyk et al. (2004). The presence of lungworm larvae and *Fasciola* eggs to discard out other parasites effect on LWG was recovered respectively according to Suarez (1997) and Viñabal et al. (2015). Two replacement calves that grazed together with the experimental groups died because clostridial disease during the trial and GIN were recovered and identified according to Suarez (1997).

Production assessment

Live weight gain (LWG) was assessed by monthly weighing female calves after 18 h of fasting.

Data analysis

Least squares means analysis of variance was conducted using InfoStat Statistical Software (Di Rienzo et al. 2008). Differences in LWG were compared via Tukey test. Faecal egg counts were tested with non-parametric Kruskal–Wallis test.

Results

Climatic data

Mean temperatures and monthly precipitations during the study period are shown in Fig. 1. Mean maximum and minimum temperatures for the warmest and coldest months were 36.6 and 23.9 °C (February) and 23.3 and 12.3 °C (July), respectively. Maximum monthly precipitations were recorded in January (219 mm) and no precipitations were recorded in September (0 mm).

Parasitological analyses

At the start of the study, mean epg (595 ± 480) values were moderate to high; therefore, LTG calves were treated with IVM in May (Fig. 1). For UTG, epg was high until the start of winter (907 ± 754), whereas LTG showed a partial decrease. From July to the end of observations, UTG exhibited a gradual decrease in epg, whereas LTG did not have a

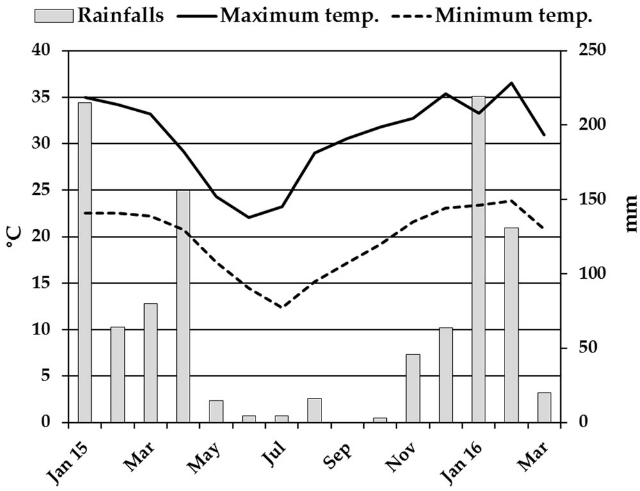

Fig. 1 Mean monthly temperatures and precipitations recorded during the study period

favourable response after treatment in August, showing a similar decrease to that of UTG (Fig. 2).

In STG, epg values were very low during the period when the interval between treatments was 42 days (until September), indicating a good MXD activity; after September, as shown in Fig. 2, epg increased until the December treatment, with lower values being recorded at the end of the study.

Since treatments with IVM in LTG exhibited low efficacy, a faecal egg count reduction test was performed, which showed a lower efficacy of IVM (54.2%) than that of MXD (95.8%).

In UTG, the prevailing GIN genera recovered from faecal cultures were *Cooperia* (81.9%), and, to a lesser degree, *Haemonchus* (15.5%); larvae of *Oesophagostomum* (2.3%) and *Trichostrongylus* (0.3%) were also recorded. The presence of the genera *Cooperia* and *Haemonchus* was observed early in autumn; in winter, only *Cooperia* remained until September, when *Haemonchus* was present again, always in a lower proportion (Fig. 3). In March, the presence of *Haemonchus* and *Oesophagostomum* increased in yearling heifers.

The proportion of genera recovered from LTG was similar to that described for UTG; however, after anthelmintic treatment, the only genus present was *Cooperia*. In the STG, *Cooperia* was the only genus recovered during the periods when treatments were performed at 42-day intervals. *Cooperia punctata*, *C. pectinata*, and *Haemonchus placei* were recovered from the two necropsied calves.

Neither *Fasciola hepatica* eggs nor *Dictyocaulus* larvae were recovered.

Regarding pregnant cows, egp values were always low, ranging on average between 5 (extreme values 0–30) in winter and 30 (extreme values 0–190) in spring-summer (lactating cows) and with prevalence of the GIN genera *Cooperia* in winter and *Haemonchus* when the highest epg values were recorded (spring-summer).

Production data

Calves did not show clinical signs of verminous gastroenteritis or any other sign of health problems in the herd. At the start of the experiment, the treated groups LTG and STG showed a significant difference ($p < 0.004$ and $p < 0.001$, respectively) in LWG after treatment with respect to UTG. Then, differences in LWG between groups continued to increase until December 1, when they showed significant differences ($p < 0.01$). Toward the end of the experiment, differences in LWG between December 2015 and March 2016 were also significantly ($p < 0.02$) higher than in the UTG. At the end of observations, there were significant differences ($p < 0.05$) between total LWG among groups, with STG and LTG showing an increase of 49.6 and 24.8%, respectively, with respect to UTG (Table 1).

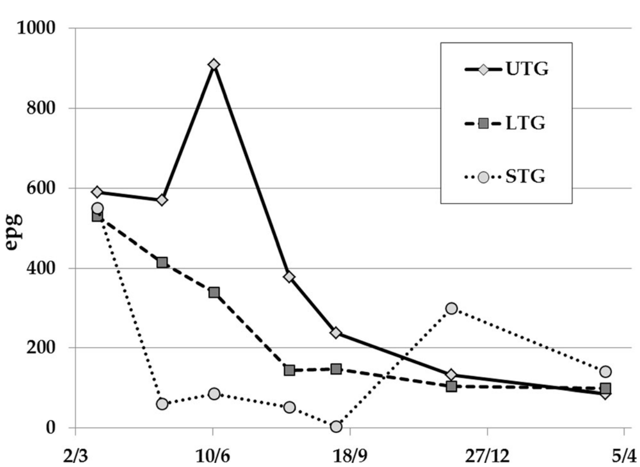

Fig. 2 Mean of eggs per gram (epg) of replacement heifer calves during the assay. STG—systematically treated group; LTG—locally treated group; UTG—untreated group

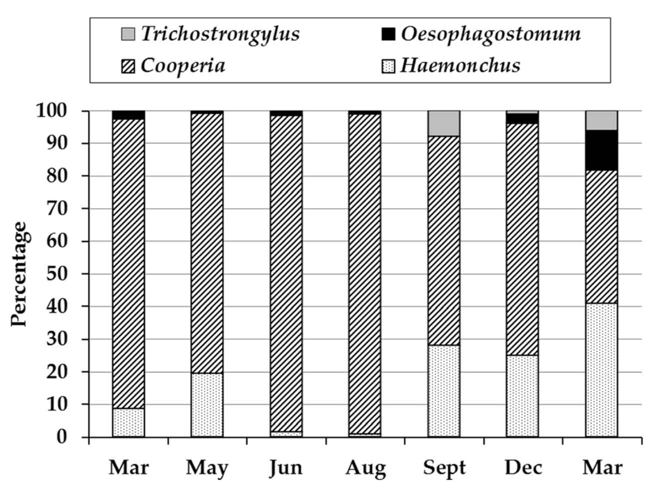

Fig. 3 Percentage of nematode genera of the untreated group (UTG) recovered from faeces culture during the study

Table 1 Initial weight and final weight recorded in December 2015 and live weight gain (LWG in kg) of calves between weight records. UTG—untreated group; STG—group treated systematically with moxidectin; LTG—group treated using local practices

Groups	18/3/15 Initial weight	18/3–4/05 LWG	4/5–11/06 LWG	11/6–5/08 LWG	5/8–8/09 LWG	8/9–1/12 LWG	18/3–1/12/15 Final LWG	1/12/15 Final weight
UTG	158 a	12.2 a	8.5 a	7.8 a	2.3 a	21.2 a	52 a	210.2 a
LTG	153 a	12.5 a	11.5 ab	12.8 b	4.2 a	23.9 ab	64.9 b	217.2 a
STG	158 a	18.4 b	13.4 b	14.9 b	4.6 a	26.5 b	77.8 c	235.1 b

Different letters indicate significant differences ($p < 0.05$)

Furthermore, despite the long interval (112 days) between the last treatment in December 2015 and weight record in March 2016, no compensatory LWG of UTG and LTG groups was observed with respect to STG, with total LWG at the start of autumn remaining significantly ($p < 0.0008$) higher in STG (131.9 kg) than in UTG (103.7 kg) and LTG (111.0 kg). Figure 4 illustrates LWG of groups and the lack of compensatory gains.

Discussion

Temperature values were similar to historical means, but total precipitations during the 12 months of the study (758 mm) were lower than the regional mean (983 mm), although showing the historical trend for the region. Accordingly, these values provide results with epidemiological validity due to the close relationship between GINs and climate.

The results of parasitological analyses show that at the end of the summer-start of autumn, epg values were already moderate to high (595 ± 480) in calves. These values depended on infection of early weaned calves in mid-summer and were favoured by the coincidence of weaning and stress due to ingestion of pastures in small paddocks and summer rains. Then, epg of UTG increased until the start of winter (907 ± 754), probably due to reinfestation of plots induced by the increase in animal stocking rate in pastures and by temperatures and rains fell in April, which favoured development, concentration, and migration of free-living stages of GINs. This increase in epg at the end of autumn is in agreement with observations reported by Suarez et al. (2013) for the Pampas semiarid region. In that region, the previous contamination of the pastures caused by cows or yearling cattle in late summer or early autumn is maintained due to the environment humidity or rains when these fall until mid-autumn (Suarez and Lorenzo 2000). However, in contrast to what was reported for the semiarid Pampas region, *Cooperia* was the prevalent genus (97%) recovered from the faecal samples during the overall trial (Fig. 3). Then, by mid-winter, the dry period and the scarce rains would minimise larva availability in plots, which is reflected in the decrease of epg toward spring (Suarez 2001). In addition, a strengthened immunity of 1-year-old calves would contribute to a reduction in GIN oviposition and in epg values (Fig. 2).

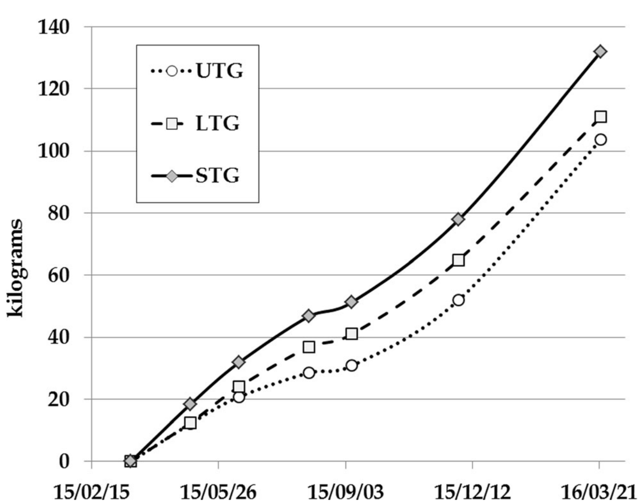

Fig. 4 Live weight gains (kg) of heifer calf groups. UTG—untreated group; STG—group systematically treated with moxidectin; LTG—group treated as usually done locally in the ranch

These results are partially similar to those obtained in 1979–1980 by Kühne et al. (1986), who observed two epg peaks, the first one from weaning to the end of winter and the second one in replacement females at the start of autumn, which was not observed in the present work, probably because we performed only one sampling in March. A peak in epg at the end of summer-start of winter was also recorded in the upland grassland region in NOA and in the central Pampas region (Suarez et al. 1999; Suarez et al. 2013. Suarez et al. 2017).

Values of epg of LTG after treatment showed only a partial decrease, with an IVM efficacy of 48%. This result compared to the efficacy of MXD (93%) suggests the existence of anthelmintic resistance (AR). Despite the lack of previous records of GIN in cattle for the NOA region, this result should be further studied, since AR of GIN treated with IVM or doramectin has been detected in three other cattle ranches (Suarez, unpublished data). The most probable reason to explain AR to avermectins would be the frequent use of IVM to treat ticks in the NOA. Other researchers also observed reduced effects of macrocyclic lactone treatments in controlling

Cooperia pectinata, *C. punctata*, and *Haemonchus* infections in subtropical regions (Anziani et al. 2001; Lyndal-Murphy et al. 2010; Zanetti Lopes et al. 2014).

GIN genera recovered from faecal cultures were similar to those described by Santos et al. (2010) in Brazil. The analysis of the seasonal variation of nematode genera released in faeces of the untreated group (Fig. 3) shows a decrease in winter of *Haemonchus*, with only the genus *Cooperia* remaining in that season. This decrease is difficult to explain, since moderate winter temperatures would not affect survival of free-living *Haemonchus* larvae; by contrast, in cows, the presence of *Haemonchus* was higher. One of the results that indicated a difference between the study region and the Pampas plains (Suarez 1990) is the absence of the genus *Ostertagia*, which would be associated with temperate and cold climates. In the treated groups, the presence of *Cooperia* definitively prevailed after treatment.

Production results show that at the start of the observation period, there was a post-treatment response in LWG of the STG group, which was evidenced in the decrease of epg. This response shows the treatment efficacy at the end of summer, when early weaned calves start to become reinfected and nematode loads increase. Similarly, until mid-winter, significant differences were recorded as a response to treatments; however, LTG always had lower responses, which could be associated with the lower efficacy of IVM. Treatment in September also had differences ($p < 0.05$, Table 1) in LWG, with higher values for STG, but to a lower degree than for UTG, probably due to the long time interval until December and the probable reinfestation of STG, once the effect of MXD on GNIs was lost. The prolonged effect of MXD on the genus *Cooperia* is known to be lower than on *Haemonchus* and to extend only from 2 to 3 weeks (Eysker et al. 1996).

Similar responses of LWG to treatments were reported in the central region of Argentina, which were attributed to the effect of mixed parasite infections due to *Ostertagia ostertagi*, *Trichostrongylus axei*, *Cooperia oncophora*, and *Haemonchus placei* (Suarez 1990). However, the responses obtained in this work were due to an infection caused almost exclusively by *Cooperia pectinata* and *C. punctata*, which suggests the harmful effect of these species on LWG of replacement heifers. Some works have described the effects of these *Cooperia* species on calves, such as anorexia, loss of plasma proteins, growth delay, soft faeces, and, as observed in necropsy, thickening of intestinal villi and excessive amount of mucus (Armour et al. 1987; Stromberg et al. 2012). Furthermore, works conducted in Minas Gerais (Brazil) consider *C. punctata* and *C. pectinata* more pathogenic than *C. oncophora* (Guimaraes et al. 1990).

Interestingly, there was a lack of compensatory LWG in UTG and LTG during summer with respect to STG, when treatment was interrupted for 112 days. This phenomenon was evidenced in infections caused mainly by *Ostertagia*, but not in infections caused mainly by *Cooperia* sp. (Suarez and Cristel 2005; Fiel et al. 2013).

The differences detected among treatments would certainly have been higher if the groups had grazed in separate plots, since this assay, as many other that attempt to measure the effect of GINs, has design deficiencies that are inherent to conditions in the field. Indeed, when different groups graze together in the same plots, paddock contamination interferences between groups may occur; thus, the effect of larvae on the treated group cannot be prevented, therefore reducing the positive effect of the anthelmintic. Experiments conducted in La Pampa province with treatments in different plots but with similar forage offer showed higher negative effects than other studies in which treatment groups graze together, but in the former type of trial, maintaining pastures in similar conditions in the different plots is difficult (Suarez et al. 1991).

The genus *Cooperia* and, to a lesser degree, *Haemonchus* were the prevailing GINs, with *Oesophagostomum* and *Trichostrongylus* being also present throughout the study. The highest incidence of GINs on replacement heifers was evidenced through the epg values, which peaked in early winter. Differences in LWG among groups in response to treatments showed the effect of GINs on growing beef cattle in the NOA region and the lack of compensatory weight gain at the end of treatments and indicate the need to further study control strategies that are suitable for different production systems.

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Compliance with ethical standards The procedures adopted has been approved by the Ethical Review Committee (CICUAL: Institutional Committee of Care and Use of Experimental Animals) of the University of La Plata, Argentina.

Conflict of interest The authors declare that they have no conflict of interest.

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