Scientific Paper

Variation in the phenotypic resistance to gastrointestinal parasites in a goat flock

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Abstract

Objective: To evaluate the phenotypic segregation against gastrointestinal nematodes from the fecal egg count in dairy goats of the Martí municipality, in Matanzas province, Cuba.

Materials and Methods: The study was conducted in a dairy goat flock in the Marti municipality, of Matanzas province, Cuba, from May to December, 2017. Individual fecal samples were taken for determining the fecal egg count and the body condition of 52 does was monthly recorded. Quartiles (Q) were established, according to the fecal egg count per month. The animals that in 60 % of the samplings were in Q4, were classified as high eliminators; the animals that in 60 % were in Q1 and 40 % in the intermediate quartiles were low eliminators, but with fecal egg count which was never higher than 1,500 eggs per gram; the category of intermediate eliminators corresponded to the animals that were found in the interquartiles Q2 and Q3.

Results: The goats were segregated in three groups: four classified as low eliminators, 42 as intermediate, and six as high, with egg averages in the fecal counts of 485,9; 1 498,2 and 1 895,8 for each group, respectively. The mode of the body condition in each group did not show differences (3).

Conclusions: The segregation of goats through fecal egg count allowed the identification of the existing phenotypic variability among the animals in the susceptibility to gastrointestinal parasitism. Thus, the bases are created for the evaluation, in the future, of a breeding program through selection, for gastrointestinal parasitism-resistant animals.

Keywords: goats, phenotypic segregation, gastrointestinal nematodes

Introduction

The control of gastrointestinal parasitism (GIP) represents a problem for small ruminant production, because the use of anthelmintics frequently and indiscriminately originates the emergence of resistance to the main drugs (AR) (Martínez-Valladares *et al*., 2015; Arece-García *et al*., 2017). The main nematode species involved in AR development has been *Haemonchus contortus* (Gasbarre *et al*., 2015; Crook *et al*., 2016). However, other species such as *Trichostrongylus colubriformis* (Van Den Brom *et al*., 2015) and *Cooperia curticei* have also been reported (George *et al*., 2018).

Due to the increase in the frequency of AR cases, variety of control alternatives are developed, which do not depend on the exclusive use of chemical synthesis anthelmintics. With them, the parasite infestation rate, the selection pressure to which the drugs are usually subject, as well as the effects of gastrointestinal nematodes on the animals (GIN) are intended to be decreased (Torres *et al*., 2012; Campbell *et al*., 2017; Westers *et al*., 2017).

The selection of those animals that show the capacity to withstand or tolerate parasite infestation is one of the alternatives for GIN control, for which the study of immune response development in the animals, and of the factors that affect it, especially in the presence of *H. contortus*, is important. This is a parasite that causes marked antigen variation (Hussain *et al.,* 2014), and causes in the animal defense mechanisms that allow the elimination of infective larvae and adult parasites (Lacroux *et al*., 2006). These mechanisms depend on several factors, among which adequate feeding is included (Hughes y Kelly, 2006).

The high genetic variability of goats in response to infestations by gastrointestinal nematodes constitutes an advantage for their genetic selection (Estrada-Reyes *et al*., 2019). At present, the identification of these animals constitutes a challenge. With this purpose different validation studies of segregation models in sheep are conducted (Morteo *et al*., 2004; Palomo-Couoh *et al.,*

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2016; Palomo-Couoh *et al.,* 2017), but in goats the studies about the validation of segregation models for gastrointestinal parasitism-resistant or susceptible animals, are scarce. That is why the objective of this study was to evaluate phenotypic segregation against gastrointestinal nematodes, from fecal egg count in dairy goats of Martí municipality, in Matanzas province, Cuba.

Materials and Methods

Location. The study was conducted from May to December, 2017, in a dairy goat flock of Martí municipality, belonging to Matanzas province. This region is located at los 220 57' 9" North latitude and 800 55´ 0" West longitude.

Animals. Fifty-two dairy goats of different phenotype were used, individually identified through tattoos on one of their ears, and in apparent good health status. At the moment of the research, the body weight of these animals was 42,5 kg. As average they were 5,5 years old and had four lactations. During the study, the animals were between the final moments of pregnancy and the weeks after parturition.

Management. The goats grazed in a spontaneous shrub vegetation of *Dichrostachys cinerea* (L.) Wight & Arn.- *Acacia farnesiana* (L.) Willd. (90 % of the area) and the [*Dichanthium caricosum* (L.) A. *Camus-Dichanthium annulatum* (Forssk.) Stapf] complex as basis pasture, in an area of 58,3 ha subject to continuous grazing. They grazed as average, six hours per day and returned in the evening to sheds, where they had water and mineral salts at will. They did not receive additional supplementation.

Deworming was arbitrarily performed, without the existence of a parasite control plan and with no evidence of its record. The treatments were carried out by the farmers based on the estimation of the live weight of the animals with Labiomec® (Ivermectine in doses of 0,22 mg/ kg BW, LABIOFAM[1], Cuba) and Labiozol® (Albendazole Sulfoxide in doses of 5 mg/kg BW, LABIOFAM, Cuba), depending on the anthelmintics availability at drenching.

Measurements in the animals. With monthly frequency, the body condition (BC) of each animal was determined through the methodology described by Ghosh *et al*. (2019). The minimum value of the scale (1) corresponded to weakened animals, and the maximum (5) to those with better body condition. In addition, 10 g of feces were directly extracted from the rectum of each goat and were placed in nylon bags in anaerobiosis. The samples were processed by the modified McMaster technique to determine the fecal egg count (FEC) of GINs. The number of eggs in feces was adjusted to a correction factor of 50 (Arece *et al*., 2004).

Statistical analysis. Each month the arranged FEC distribution was used to generate quartiles (Q), according to the segregation model proposed by Palomo-Couoh *et al*. (2016). The sets of FEC values determined three points, which divided the data set into four equal groups. From this procedure, the classification of the animals was the following:

High eliminators: in 60 % of the sampling the animals were in Q3.

Low eliminators: in 60 % they were found in Q1, and in 40 % in the intermediate quartiles, but never FEC higher than 1 500 eggs per gram.

Intermediate eliminators: corresponded to the animals that were found in interquartiles Q2 and Q3.

The data were processed in the software IBM SPSS® Statistic, to determine quartiles and modes. The FEC was transformed (log FEC+25) to homogenize the variances and obtain the normal distribution of data. Analysis of repeated measures in time was carried out through *PROC MIXED* of SAS (SAS Institute Inc., 2004) to determine the differences in fecal egg count per month and per group, with significance level of 0,05. Tukey's test was used for differentiation among means. Several covariance structures were evaluated, with the best adjustment for type 1 Autoregressive. Parallel to this, the mode of the body condition score was determined.

Results and Discussion

Table 1 shows the classification of goats depending on the parasite rate. Three groups of animals were identified, according to the susceptibility to gastrointestinal parasitism: low, intermediate and high eliminators. The animals classified as low eliminators showed an average of eggs that did not exceed 500 epg; while in high eliminators the average was higher than 1,800 epg, with significant differences ($p < 0,05$) among the groups.

In studies with this same segregation model similar proportions were observed, when determining the phenotypic variations to the infection of gastrointestinal nematodes in Pelibuey sheep (Morteo-Gómez *et al*., 2004). These results showed lower

[1]Cuban entity dedicated to drug development and production, authorized by the Ministry of Public Health of Cuba, the Ministry of Science, Technology and Environment, the State Center of Drug Control and by the Cuban Office of Industrial Property.

Table 1. Segregation of the animals depending on the parasite infestation level.

Classification	n	Fecal egg count, epg			Body condition		
		Mean	Minimum	Maximum	Mode	Minimum	Maximum
Low eliminators	4	485,93[c]	228,53	743,34	3	2,5	3
Intermediate eliminators	42	1 498,21[b]	1 271,41	1 725,01	3	1,5	4
High eliminators	6	1 895,83[a]	1 377,29	2 414,37	3	2	3

Different letters in the same column differ at $p < 0,05$

quantity of resistant animals or low eliminators, with FEC of 418 and 5 911 epg for the low and high eliminator groups, respectively.

Palomo-Couoh *et al.* (2016) reported similar values too, when evaluating several models based on the FEC to segregate Katahdin and Pelibuey sheep. These authors referred that the ewes classified as resistant had lower FEC than the susceptible ones and those which were in the intermediate range. In turn, the susceptible ewes had higher FEC with regards to the intermediate and resistant ones.

The variability in the response to parasite infestation in goats has been proven at least in a portion of one flock that develops certain degree of resistance, due to age or previous exposures to the parasite (Vlassoff *et al.*, 1999). However, unlike the sheep, the studies conducted in goats are scarce, referred to the genetic selection for gastrointestinal parasitism (Heckendorn *et al.*, 2017).

Most of the animals were segregated as intermediate eliminators. When analyzing the flock structure concerning susceptibility, it was observed that 11,5 % of the animals are in the group of animals classified as high eliminators. The aggregated distribution of parasites in the animals is thus proven, where a small minority harbors the highest parasite burden (Zapata-Salas *et al.*, 2016).

When analyzing body condition score in the three groups, the most repeated value (mode) was 3, considered as acceptable for pregnant does (values of 3-3,5) as well as for lactating does (values of 2,5-3) (Ghosh *et al.*, 2019). In future studies, in segregation models, the BC could be considered a GIP-susceptible indicator, for being related to productive and reproductive characteristics (Moeini *et al.*, 2014) and for its consideration in strategies of selective antiparasite treatments (Cornelius *et al.*, 2014).

Figure 1 shows the fecal egg counts per month in each quartile. As should be expected, significant differences are observed ($p < 0,05$) in the FEC in each quartile, with higher infestation level in August and September. This coincides with the last

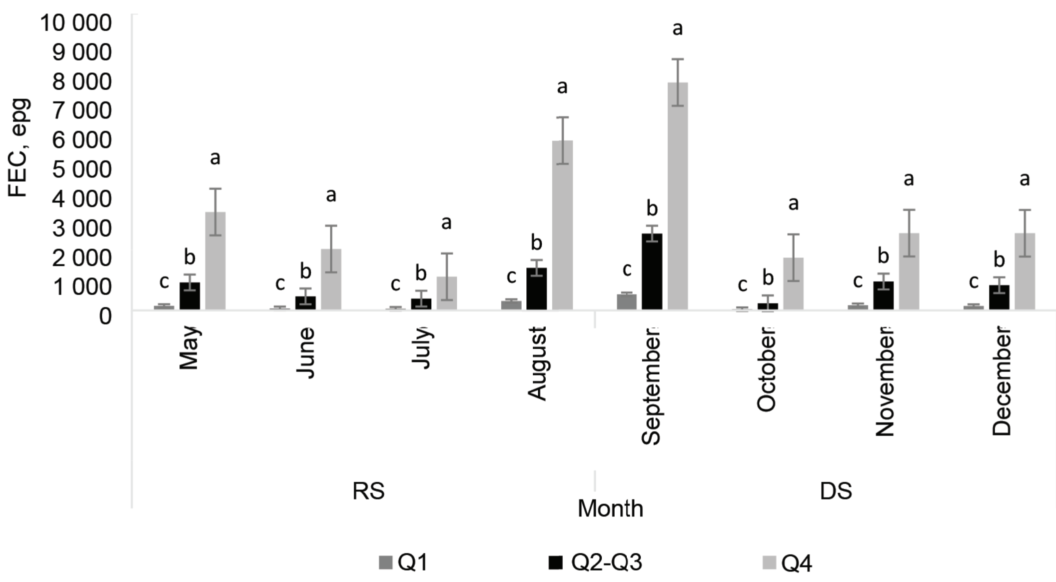

Figure 1. Dynamics of the fecal egg count average in each quartile.
RS-Rainy season, DS-Dry season, FEC-Fecal egg count, Q-Quartile

period of pregnancy and beginning of parturitions, stage in which a phenomenon known as peripartum rise is described. It appears in the last weeks before parturition, as a result of the increase of prolactin levels, which causes cracking of the immune system and allows the increase of parasite fecundity or the output of larvae that remained in hypobiosis (Craig, 2018). This event has high importance from the epizootiological, because it constitutes a parasite strategy for the dissemination of eggs in grazing areas, and thus ensure the species perpetuation after kid infestation.

These results were also influenced by factors related to the nutritional status of the flock, because the quality of the consumed pasture during the dry season (DS) is usually classified from regular to bad (Sánchez *et al*., 2003). The dry matter availability in this season reduces the possibility of establishing an effective immunological response by the animals to infestation (Hoste *et al*., 2008), which leads to a high parasitism level.

When considering that the segregation of resistant animals to GIP depends, to a large extent, on phenotype variation, the indicator FEC is perceived as the most important one, for being highly related to the quantity of adult parasites in the digestive system (Ngongeh, 2017). The utilization of this indicator as genetic selection criterion is very controversial in goats, for having low inheritability (Heckendorn *et al*., 2017). Nevertheless, it could be taken into consideration in multi-trait selection strategies. The challenge of including other parameters to determine the immune response, such as the color of the eye mucosa (count of eosinophils, IgA and IgE concentrations, anemia degree and hematocrit) (Saddiqi *et al*., 2012) and complementary studies that corroborate the real existence of genetically resistant animals (González-Garduño *et al*., 2017), could be assumed.

Conclusions

The segregation of goats through fecal egg count allowed the identification of the existing phenotypic variability among the animals, regarding susceptibility to gastrointestinal parasitism. Thus the bases are created for the evaluation, in the future, of a breeding program through selection, for animals resistant to gastrointestinal parasitism.

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Authors’ contribution

- Leticia de la Caridad Carballo-Silverio. Participated in the conception and design, data analysis and interpretation, wrote and revised the paper.
- Javier Arece-García. Participated in the conception and design, data acquisition, analysis and interpretation, wrote and revised the paper.
- Yoel López-Leyva. Participated in the data acquisition, analysis and interpretation.
- Ramón Luck-Montero. Participated in the data acquisition, analysis and interpretation and revised the paper.

Conflicts of interests

The authors declare that there are no conflicts among them.

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