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Epidemiology of Goat Nematode Infections in Different Ecological Regions of Argentina´S Northwest

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Authors' contributions

This work was carried out in collaboration among all authors. Author VHS study conception, design, work supervision, data collection, material preparation, analysis and writing-original draft preparation. Author GMM: data collection, work supervision, writing-review. Author LHO data collection, processing and analysis of fecal samples, writing-review. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

The aim of this work was to study the etiology and epidemiology of gastrointestinal nematodes (GIN) of goat from the Arid valleys and canyons (AVC), Tempered valleys (TV) and the Semiarid Chaco (SC) regions of northwestern Argentina. Ten flocks were studied and 35 to 40 goats per flock (total= 420 goats) were fecal matter sampled each 30-40 days. Individual eggs per gram of faeces (epg) and faeces cultures were performed. Differences among epg were compared using Kruskal–Wallis non-parametric test. The epg of the three regions showed the same trend: an increment from February reaching the highest average epg peak in April-May and then a fall towards the summer. Goat flocks of TV region showed the highest epg compared to the other two regions, which generally showed low epg values. *Haemonchus* sp. and *Trichostrongylus* spp. were the predominant nematode genera recovered in the three regions, although in a smaller proportion *Teladorsagia*, *Oesophagostomum*, *Nematodirus*, *Trichuri*s, *Skrjabinema* and *Strongyloide*s genera were also recovered. These results show that GIN would be a limiting factor of caprine production in the TV and only during critical periods and under some breeding systems in the other regions.

Keywords: Goat; gastrointestinal nematode; epidemiology; ecological region; Northwestern Argentina.

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1. INTRODUCTION

Goat production in northwestern Argentina (NWA) is mainly extensive and it is mostly in smallholder hands who manage a subsistence economy, based on the self-consumption and sale of their excedent products (cheese and kid meat). In a much smaller proportion, there are family goat dairy industries that have invested in capital and inputs and are based on semi-intensive systems [1]. This NWA region is characterized from east to west by going from a semi-arid Chaco plain with a warm climate to a mountainous relief that includes elevated semiarid temperate valleys to arid valleys and canyons located more than 2000 meters above sea level.

Nevertheless, all these types of different agroecological regions of goat production have serious productive unresolved problems that affect system competitiveness and sustainability. Among these limitations that we can mention are health problems and poor sanitary flock´s management [2-4]. One of these health issues is the infection by gastrointestinal nematodes (GIN), a very important recognized worldwide factor limiting goat health, milk and meat production [5-8]. In NWA region, nematode infections are also a serious constraint, affecting economic competitiveness and even causing high animal mortality [9,10]. These works, recognized *Haemonchus contortus* and *Trichostrongylus colubriformis* as the most harmful genus in a temperate valley zone. Despite this background information, more epidemiological information in this vast and diverse ecological area is still lacking to elaborate control strategies in the diverse goat productive systems from northwestern Argentina.

Therefore, the aim of this work was to study the etiology and epidemiology of goat GIN in several representative productive systems of NWA regions.

2. MATERIALS AND METHODS

2.1 Study Regions and Experimental Animals

The studies were conducted in three different agro-ecological regions of the NWA (Fig. 1).

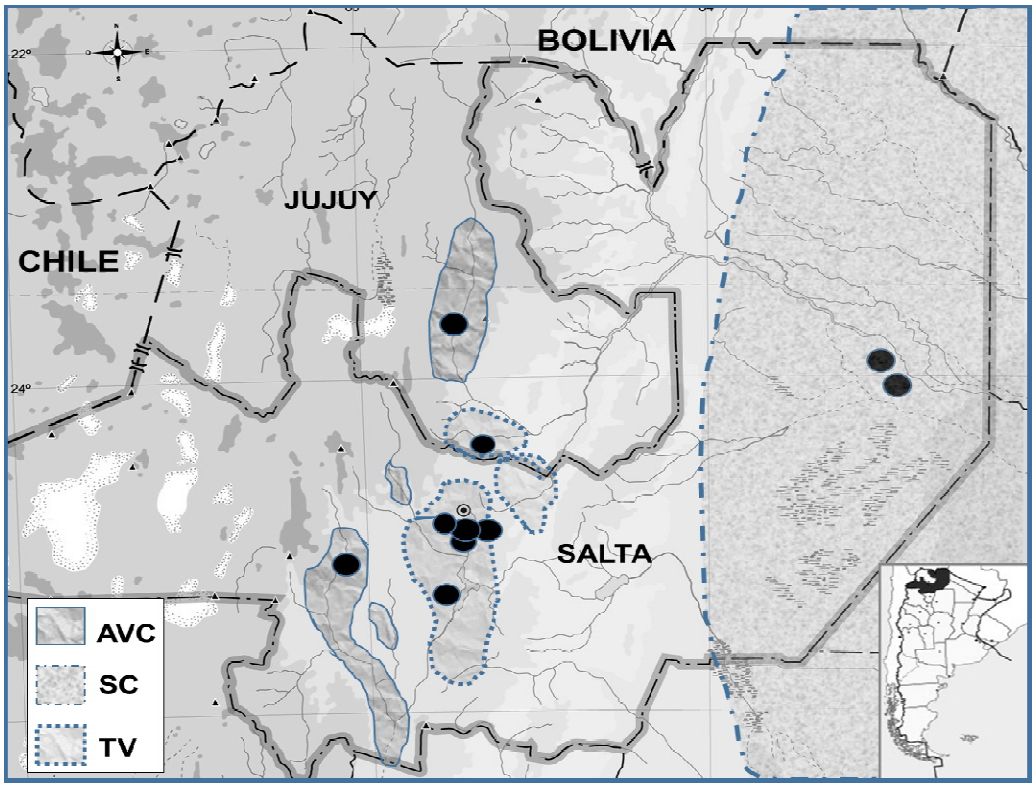

Fig. 1. Northwester Argentina: ecological regions and places (circles) where the studies were carried out

Two flocks were located in the department of Rivadavia Salta, at 215-245 m.a.s.l. in the Semiarid Chaco (SC) region. This area has a very irregular seasonal rainfall regime, with an annual mean rainfall of 450-530 mm. Six flocks were located in the central region of Temperate Valleys (TV) around 800 to 1600 m.a.s.l, with an annual mean of 630-800 mm. These two regions of Salta province have a dry period extending from May to November. Two flocks were in the Arid Valleys and Canyons (AVC) region of Salta and Jujuy provinces between 2000 and 2900 m.a.s.l., with a mean of 190-280 mm of rainfalls concentrated only during summer [11].

The average number of goats sampled per flock throughout the study varied between 35 to 45 animals. A total of 420 goats were sampled and were mostly adult female goats of Criollo biotype crossed with Anglo Nubian breed in extensive systems or pure breeds (Saanen or Anglo Nubian) in semi-intensive systems.

2.2 Goat Management

TV flocks were management on winter-spring irrigate lucerne and crop pastures and most of them before kidding in June –July were housed and supplemented with grain and hay; pastures were grazed by 5 to 10 goats per hectare. Contrarily, SC flocks were extensive grazed natural pastures, bushes and shrubs under a semiarid forest and most of them were kidding from April to June. One of the AVC flocks was taken to graze extensively (E) on natural pastures up the hills during summer-early autumn and then was taken to feed flood irrigated lucerne, agricultural residues or natural pastures in the vicinity of their farm. The other AVC flock was management semi-intensively (SI) on irrigate pastures, annual crops or agricultural residues all the year at a rate of 5 goats per hectare. Both AVC flocks were kidding mainly from May to June.

2.3 Parasitological Analysis

The study and sampling time of the different region goat flocks ranged from June 2013 to July 2018. Faecal samples were taken every 30-40 days from the start of each year study. Individual nematode egg counts per gram of faeces (epg) were determined using the modified McMaster technique [12], where 1 egg represents 10 epg. Faecal cultures were performed in each group to assess the generic composition of nematode populations according to Suarez [13] and nematode larvae were identified using the morphological characters described previously [14].

Caprines that grazed together with the sampled group and died because any health problem or slaughtered for owner´s consumption during the trial, were necropsied or examined for GIN recovered and identified according to Suarez [13].

2.4 Data Analysis

Data analysis was carried out using descriptive statistics (means and percentages). Faecal egg counts (x) were tested by analysis of variance at $P = .05$ and $P < .001$, with previous normalization by logarithmic transformation ($x= \log10 (x+1)$) using InfoStat Statistical Software [15].

3. RESULTS

3.1 Climatic Data

Mean temperatures and monthly precipitations of each region were within the historical averages for each ecological region (Fig. 2).

3.2 Parasitological Analysis

TV flocks egg counts showed a significant ($P <.001$) increment from February reaching the highest average peak (epg= 3100) in April and then a second significantly higher ($P = .05$) epg counts around the kidding period. Then, towards November, epg dropped to low levels, which persisted to January (Fig. 3).

Egg counts of SC flocks were low throughout the study period, only showing a significant ($P < .001$) increase (epg= 1340) in April-May (Fig. 3).

AVC (E) flock had very low epg counts during all the monitoring time, showing its highest count (epg= 607) in April. In a different way, AVC (SI) flock showed values also considered low but higher than those of flock (E), these epg values rose towards the autumn, reaching their peak (epg= 1396) in May. A significant ($P = .05$) epg elevation was seen in autumn (Fig. 4).

Haemonchus sp. (TV= 62,2%; AVC= 45,5%; SC= 59,0%) and *Trichostrongylus* spp. (TV=32,3%; AVC=51,1%; SC= 39,1%) were the dominant nematode genera recovered in the three regions. To a lesser extent, *Teladorsagia* sp. from VT and AVC (TV=5,5%; AVC=3,4%) and *Oesophagostomum* sp. from SC (1,9%)

were also recovered (Fig. 5). And in a much smaller proportion eggs of *Trichuris*, *Nematodirus*, *Strongyloides* and *Skrjabinema* were seen.

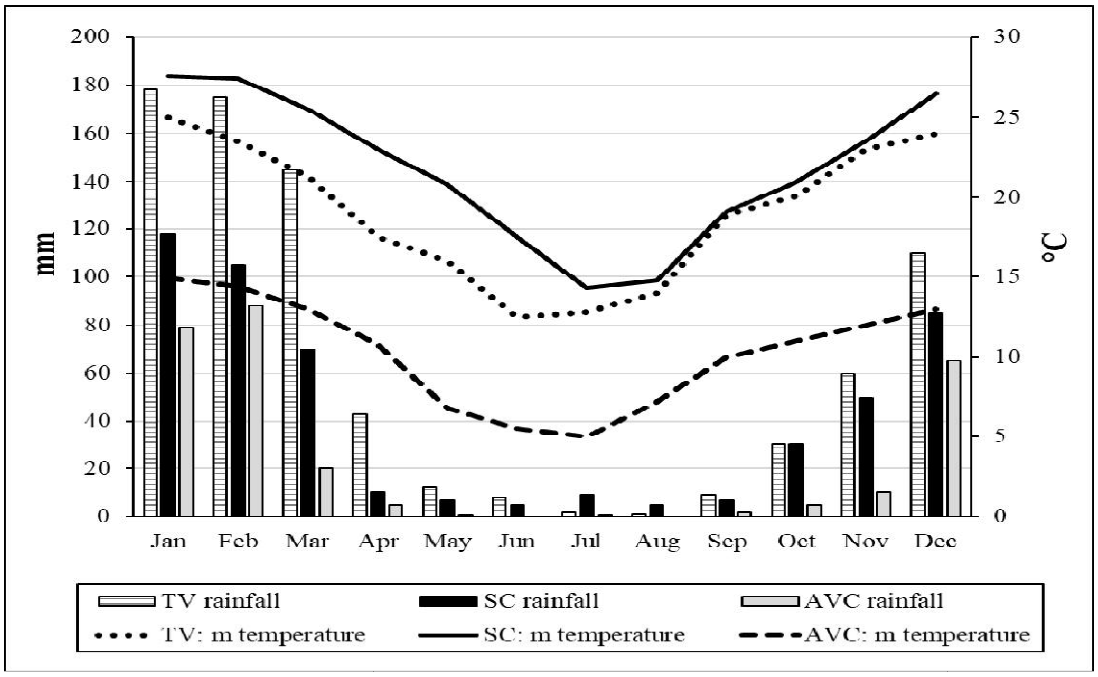

Fig. 2. Mean monthly temperatures and precipitations recorded during the study periods in the three regions, Temperate Valleys (TV), Semiarid Chaco (SC) and Arid Valleys and Canyons (AVC)

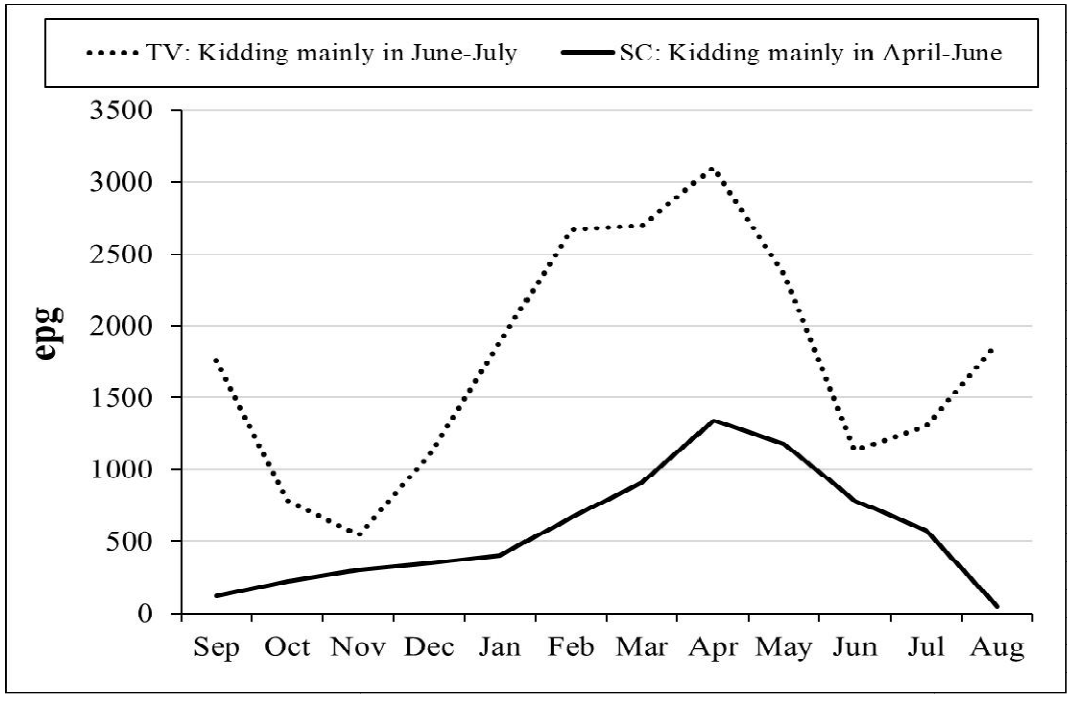

Fig. 3. Mean faecal egg counts per gram (epg) of the goat flocks during the experiment periods in the Temperate Valleys (TV) and Semiarid Chaco (SC) regions

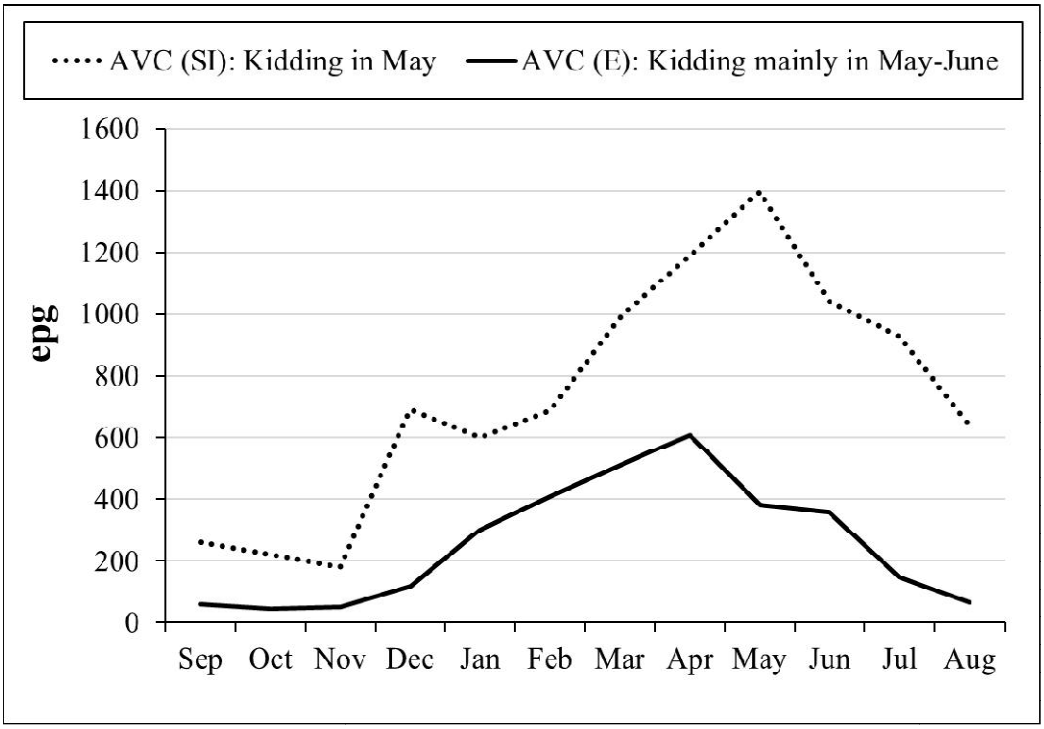

Fig. 4. Mean faecal egg counts per gram (epg) of the two goat flocks in the Arid Valleys and Canyons (AVC) region. SI: semi-intensive system; E: extensive system

Worms recovered from dead or slaughtered for family consumption goats showed the GIN species present in the different regions (Table 1).

4. DISCUSSION

These current results evidenced that *Haemonchus contortus* and *Trichostrongylus colubriformis* were the prevalent GIN in all goat flocks of the different regions and productive systems during the studied periods. Both, the genera recovered from faecal cultures and the species identified from necropsies confirm this evidence. Literature shows that *H. contortus* is less tolerant of cold and more tolerant of heat than *T. colubriformis*, in agreement with the greater abundance of *T. colubriformis* in TV region where the climate is temperate compared to its lower abundance in the SC region [16-18]. In the three regions studied characterized by a dry period without rainfalls, the cause of the proportion of eggs developing to L3 appears to be temperature and moisture.

Within a context of low parasite burdens only in the AVC region, *Trichostrongylus axei* had higher abundance than *T. coubriformis*. The aridity and lower temperatures of AVC region probably affects the development of *T. axei* to a lesser extent than that of *T. colubriformis*. In the Patagonia region in Southwestern Argentina, Olaechea [19] also showed that as aridity increased, the numbers of *T. colubriformis* decreased while those of *T. axei* increased. Likewise, O'Connor et al. [18] reviewed the ecological characteristics of common ovine *Trichostrongylus* genus and showed that egg hatching and larval development to L3 at 10 °C is marginal for *T. colubriformis* and satisfactory and moderate for *T. axei* [20].

In the case of the other two GIN genera found to be much less abundant, it was expected that the hot climate of the SC would affect *Teladorsagia circumcincta*, which is the least tolerant of heat and most cold-adapted [18,21]. In contrast, the genus *Oesophagostomum* that was found in the SC region seems to be more tolerant of heat.

Regarding the epidemiological trend of the GIN, the egg counts show a similar curve regardless of the region studied. This shows that the three regions climate, characterized by a summer rain period would favor the development of GIN free-living larval stages from mid-summer and the worm burdens and epg counts increase towards mid-autumn.

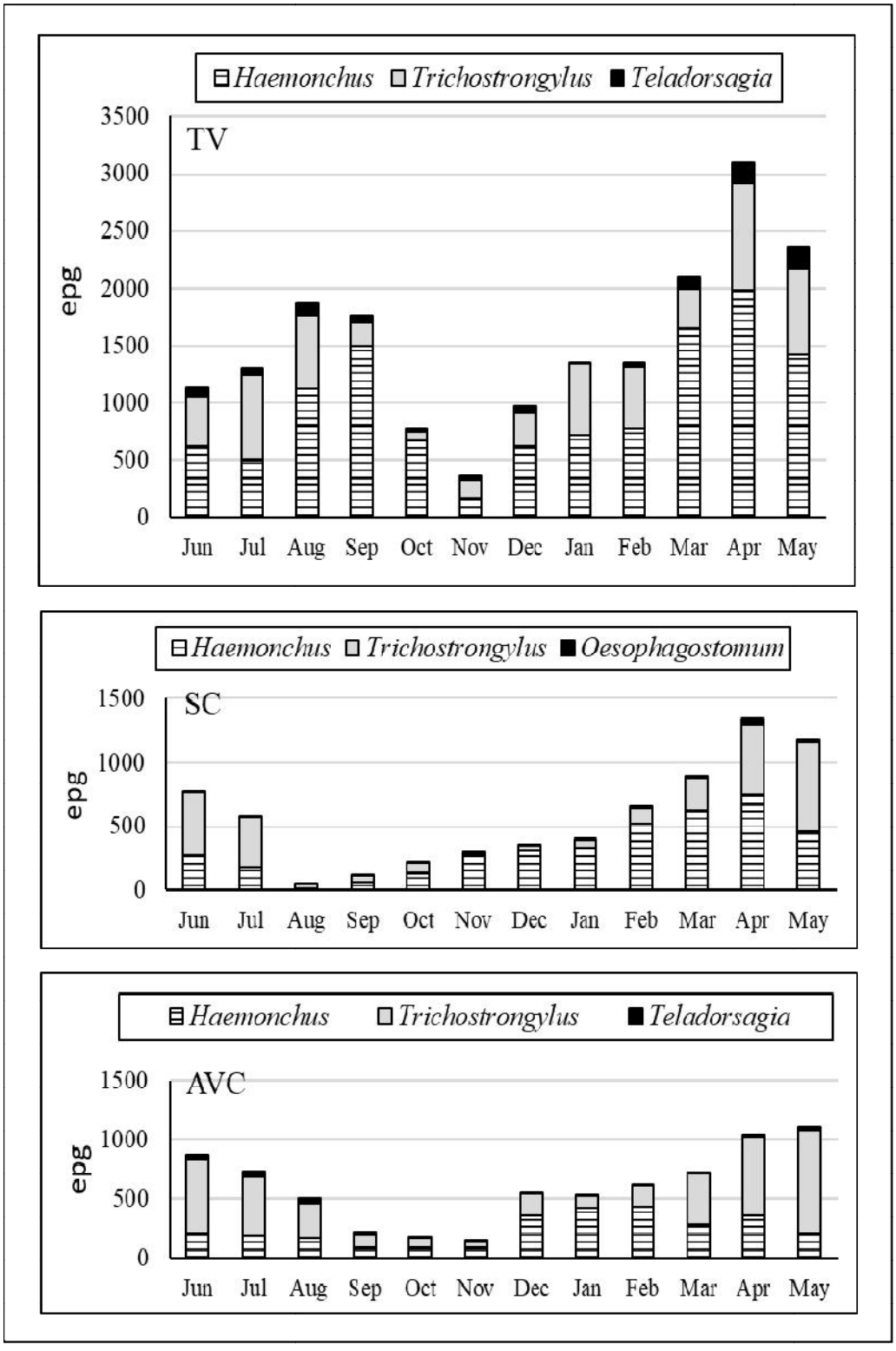

Fig. 5. Mean nematode genera identified from goat faeces culture and proportion of each genus as detected from mean egg count during the study in the different regions. TV: Temperate valleys; SC: Semiarid Chaco; AVC: Arid Valleys and Canyons

Table 1. Number of examined caprines and worm species averages recovered from dead or slaughtered undosed caprines in Semiarid Chaco (SC), Temperate Valleys (TV) and Arid Valleys and Canyons (AVC) regions

Regions	TV	AVC	SC
Species / Examined caprines	**n= 23**	**n= 7**	**n= 6**
Haemonchus contortus	2234	450	534
Teladorsagia circumcincta	317	15	0
Trichostrongylus axei	616	533	8
Trichostrongylus colubriformis	12241	280	2572
Nematodirus spathiger	0	52	0
Trichuris sp.	52	2	0
Oesophagostomum spp.	2	15	11
Strongyloides papillosus	1	0	0

Is known that the development, survival and transmission of GIN eggs and infective larvae is influenced by climatic and environmental factors like temperature, humidity and precipitation [18]. Likewise, in the Semi-arid and Humid Pampeana regions located in the central region of Argentina, sheep studies showed the second part of summer and autumn as those periods with the highest parasitic risk due to the increase of GIN burdens [22,23].

The mean epg count levels found in the present studies in the VT region correspond to worm burdens of risk for goat production. Regarding those GIN harmful consequences, there are previous studies that showed *H. contortus* and *T. colubriformis* effects on goat health and milk production in TV semi-intensive systems [10,24].

On the contrary in the AVC region where low epg count were seen, there are only few occasional reports in semi-intensive systems of GIN clinical cases that occurred on alfalfa irrigated pastures towards the end of the summer (Suarez 2015 unpublished reports). Despite the extensive dry period that characterizes the three regions studied, in those farms where pastures and crops were irrigated egg counts were higher. This would be showing the irrigation effect on development of NGI free-living stages. Gruner and Suryahadi [25] reported that flood irrigation of pastures contaminated with parasitized faeces increased air humidity and lowered maximal soil temperatures, relative to non-irrigated pastures, and that GIN development success was proportional to the length of immersion of faeces. Other study [26] evidenced the importance of humidity in the development of *H. contortus*, *T. colubriformis* and *T. circumcincta* eggs.

In the SC region there is only one previously reported case [2]. The high temperatures and the extensive dry period would affect the development of GIN free-living larval stages. This added to the extensive goat management, would be the explanation for the low egg counts observed.

Anthelmintic resistance (AR) was found in the TV region, probably related to the high frequency of anthemintic drug use [9]. In the other two regions there are no reports on AR, although AVC (92,3%) and SC (61,1%) smallholders deworm their goats without previous diagnosis [2,4,27]. The present results show the need to raise awareness among goat producers to use diagnostic epg in order not to overuse anthelmintics and delay the AR development.

5. CONCLUSION

These present results show the importance of monitoring and controlling GIN in the TV region where parasites would be a limiting factor in caprine production. In the other regions, diagnosis by epg counts would only be important during critical times such as autumn or during goat peripartum periods, mainly in semi-intensive irrigation systems used in the AVC region.

ETHICAL APPROVAL

Statement of animal rights: This work did not involve the use of animal for laboratory studies. The procedures adopted has been approved by the Ethical Review Committee (CICUAE: Institutional Committee of Care and Use of Experimental Animals) of the University of La Plata, Argentina.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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