



Original Article

Effect of climatic conditions on the occurrence of sheep endoparasites

Efeito das condições climáticas na ocorrência de endoparasitos de ovinos

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ABSTRACT

This study evaluated the effect of climatic conditions on the occurrence of *Eimeria* sp., strongylids and *Moniezia* sp. by analyzing the excretion of eggs and oocysts in the feces of sheep. In all, 3,509 coproparasitological examinations were performed after the monthly collection of feces of 121 sheep for 29 months. The meteorological data collected were rainfall, insolation, evapotranspiration, relative humidity, and temperature. Principal component analysis was performed to summarize the number of climatic variables. To evaluate the climatic vectors that influenced the variables, *Eimeria* sp., strongylids and *Moniezia* sp., a spatial projection of the ordination of vectors on the first two principal components was performed. To evaluate the mean values of the variables, *Eimeria* sp., strongylids and *Moniezia* sp., a cluster analysis was performed (k-means clustering), according to the categories. An association of *Eimeria* sp. and strongylids with relative humidity and rainfall was observed. *Moniezia* sp. was also related to the minimum temperature. The prevalence of *Moniezia* sp. was the least affected by relative humidity, rainfall, insolation, and evapotranspiration. The highest counts of endoparasites were observed in the offspring category and in the months of higher rainfall.

RESUMO

Este estudo avaliou o efeito das condições climáticas na ocorrência de *Eimeria* sp., estrongilídeos e *Moniezia* sp. analisando a eliminação de ovos e oocistos nas fezes de ovinos. Ao todo, 3.509 exames coproparasitológicos foram realizados após a coleta mensal de fezes de 121 ovinos durante 29 meses. Os dados meteorológicos coletados foram precipitação, insolação, evapotranspiração, umidade relativa e temperatura. A análise de componentes principais foi realizada para resumir o número de variáveis climáticas. Para avaliar os vetores climáticos que influenciaram as variáveis, *Eimeria* sp., estrongilídeos e *Moniezia* sp., foi realizada uma projeção espacial da ordenação dos vetores nos dois primeiros componentes principais. Para avaliar os valores médios das variáveis, *Eimeria* sp., estrongilídeos e *Moniezia* sp., foi realizada uma análise de agrupamento (*k-means clustering*) de acordo com as categorias. Uma associação de *Eimeria* sp. e estrongilídeos com umidade relativa e precipitação foi observada. *Moniezia* sp. foi relacionada à temperatura mínima. A prevalência de *Moniezia* sp. foi a menos afetada pela umidade relativa, precipitação, insolação e evapotranspiração. As maiores contagens de endoparasitas foram observadas na categoria de crias e nos meses de maior pluviosidade.

Palavras-chave:

Eimeria sp.

Ovos por grama de fezes

Moniezia sp.

Estrongilídeos

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INTRODUCTION

Gastrointestinal parasitism is one of the most common infections in ruminants. Clinical signs and damage depend on the parasitic fauna and the severity of the infection. In sheep, these can range from weight loss to lethal disorders such as anemia and diarrhea (PUGH; BAIRD, 2012). In addition, parasitism might lead to the mobilization of proteins for immune response and reduction of feed intake due to anorexia, or increased susceptibility to other pathogens (COOP; KYRIAZAKIS, 1999; SYKES; COOP, 2001).

The consequences of gastrointestinal parasitism infections seem to be similar for different species of parasites but seem to influence milk yield and weight gain more than wool production (TORRES-ACOSTA et al., 2012; MAVROT; HERTZBERG; TORGERSON, 2015), cause significant losses in the production of ruminants (CEZAR; CATTO; BIANCHIN, 2008).

Environmental factors interfere with parasite epidemiology (AHID et al., 2008; BRITO et al., 2009; RIET-CORREA; SIMÕES; RIET-CORREA, 2013). Therefore, control strategies to reduce parasitism in the animals and prevent environmental contamination have been developed, based on epidemiological knowledge and population dynamics of the helminths in the herds and pastures (VIEIRA, 2003). It is necessary to understand the epidemiology of each region for the implementation of specific strategies, and to understand how the environmental variables influence the dynamics of each parasite, since this relationship is usually performed through generalizations.

In this context, little is known about the epidemiology of helminthiasis in sheep raised under tropical semiarid conditions (DUARTE et al., 2012) and the dynamics of infections in the different categories. The objective of this study was to evaluate the influence of climatic conditions on the occurrence of *Eimeria* sp., strongylids and *Moniezia* sp., by analyzing the excretion of eggs and oocysts in the feces of sheep.

MATERIAL AND METHODS

The procedures performed in this experiment were approved by the Ethics Committee on Animal Experimentation and Animal Welfare of the Unimontes, under protocol 075/2014.

Animals and fecal analysis

In all, 3,509 coproparasitological examinations were performed, after monthly collection of the feces of 121 sheep, from August 2013 to December 2015. Fecal samples were collected directly from the rectal ampoules of the animals, stored in a universal collector, and transported to the laboratory in a thermal box containing ice. Egg count per gram of feces (EPG) and the count of oocysts per gram of feces (OPG) were performed according to the modified Gordon & Whitlock

technique (UENO; GONÇALVES, 1998). The arithmetic mean of the EPG counts was calculated with respect to the year, month, and category.

Samples were collected in four rural properties under similar food and sanitary management, located in the semi-arid region of the State of Minas Gerais, Brazil. Sheep were set free on the pastures of *Cenchrus ciliaris*, a predominant species in the region, from 7 to 17 h, and were then rounded up in groups. The animals were supplemented with mineral mix throughout the year. There was no constant monitoring on the properties, and worming procedures were concentrated in the months of September to December, which are the months of rainfall in the region. The animals were classified into the following categories: lactating females, females (pregnant or not), males (above six months of age) and lambs (females and males up to six months of age).

Meteorological data

The meteorological data included rainfall, insolation, evapotranspiration, relative humidity, and minimum, mean, and maximum temperatures. Data were provided by Meteorological Database for Teaching and Research (BDMEP) of the Instituto Nacional de Meteorologia (INMET) (BRASIL, 2016). The parameters were recorded daily, and an arithmetic mean was calculated to obtain the monthly meteorological data.

Statistical analysis

Principal component analysis (PCA) was performed to summarize the number of climatic variables and to, thus, increase the discriminating power of each new variable, which are the principal components (PCs). Since the PCA was performed using standardized data (average equal to zero and variance equal to one), only PCs with an eigenvalue greater than 1 were significant, since this is the variance of each variable individually (TEN CATEN et al., 2011). The PCs were considered significant when the absolute values were higher than 0.7 (JOLLIFFE, 1973).

To evaluate the climatic vectors that influenced the variables *Eimeria* sp., strongylids and *Moniezia* sp., we per on the properties, and worming procedures were concentrated in the months of September to December, which are the months of rainfall in the region. formed a spatial projection of the ordination of vectors on the first two principal components.

To evaluate the mean values of the variables *Eimeria* sp., strongylids and *Moniezia* sp., a cluster analysis (k-means clustering) was performed according to the categories (females, lactating females, lambs, and males) and the months of the year.

RESULTS

The PCs, eigenvalues, and percentage of variance explained are listed in Table 1. The eigenvalues were greater than 1 in the first two PCs. It was observed that

82.52% of the total variance was explained up to PC2. Rainfall, insolation, evapotranspiration, relative humidity, and minimum and average temperatures

comprise these PCs. The maximum temperature does not contribute to the variation in the data.

Table 1 – Principal components, eigenvectors and percentage of variance explained by principal components (VPC).

Item	Principal component					
	1	2	3	4	5	6
Rainfall	-0.78	-0.50	0.08	0.35	-0.13	-0.00
Insolation	0.91	0.07	0.30	-0.07	-0.27	0.02
Evapotranspiration	0.95	0.13	0.01	0.23	0.23	0.05
Relative humidity	-0.94	-0.23	-0.14	-0.16	-0.16	0.06
Min. temperature	0.26	-0.89	0.37	-0.07	0.08	-0.00
Average temperature	0.47	-0.88	-0.08	-0.05	0.03	-0.00
Max. temperature	0.53	-0.31	-0.79	0.01	-0.08	-0.00
Eigenvalues	3.79	1.99	0.88	0.22	0.12	0.01
VPC	54.15	28.37	12.55	3.08	1.76	0.09

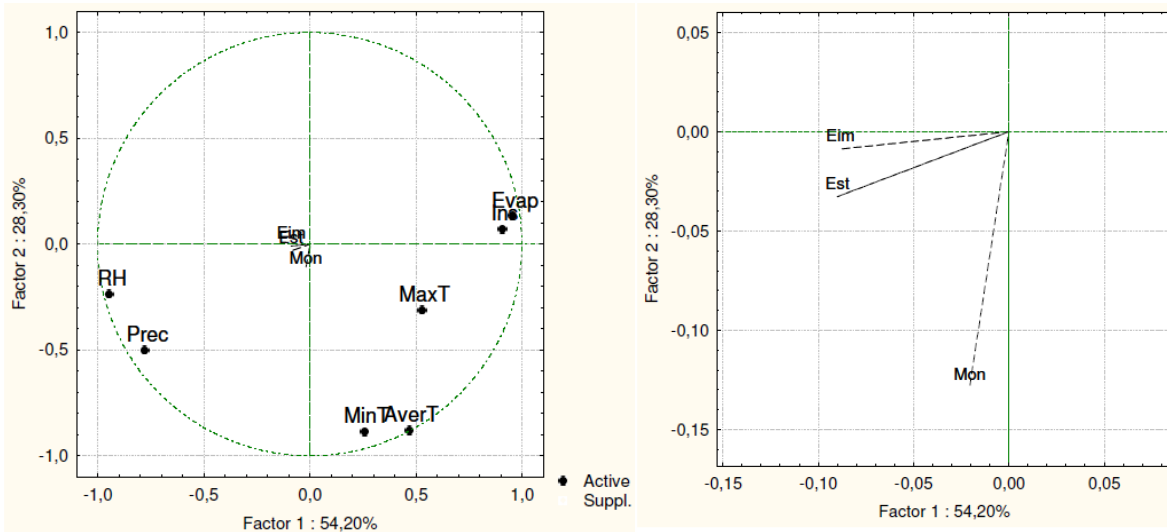
Highlighted values had significance greater than 0.70 in absolute value.

Figure 1 shows the spatial projection of the ordination of the vectors. The spatial distribution of the seven climatic variables is seen in the first two PCs (factors 1 and 2, respectively). It was observed that rainfall and relative humidity have an inverse correlation with insolation and evapotranspiration, due to the positioning in the unit circle. Minimum and average temperatures have a high positive correlation with each other. The maximum temperature vector is closer to the center of the unit

circle of all the vectors, which indicates its minor impact on the variability in the data, corroborating the findings of the PCs.

In the same figure, the variables *Eimeria* sp., strongylids and *Moniezia* sp. are indicated as supplementary vectors. Supplementary vectors do not interfere with the explained variance.

Figure 1 – Spatial projection of the ordination of the vectors on the first two principal components. Increase of the center of the unit circle.



Prec – rainfall; Ins – insolation; Evap - evapotranspiration; RH - relative humidity; MinT - minimum temperature; AverT - average temperature; MaxT - maximum temperature; Eim - *Eimeria* sp.; Est - Strongylids; Mon - *Moniezia* sp.

There is a positive correlation of the *Eimeria* sp. and strongylids vectors with the vectors relative humidity and rainfall, in which the relative humidity is closer to these supplementary vectors. The vectors *Eimeria* sp. and strongylids correlate inversely with insolation and evapotranspiration and lower interference of temperature. The supplementary vector *Moniezia* sp. showed a higher positive correlation with the minimum temperature vector. The prevalence of *Moniezia* sp. is less influenced by relative humidity, rainfall, insolation, and evapotranspiration variables that are correlated.

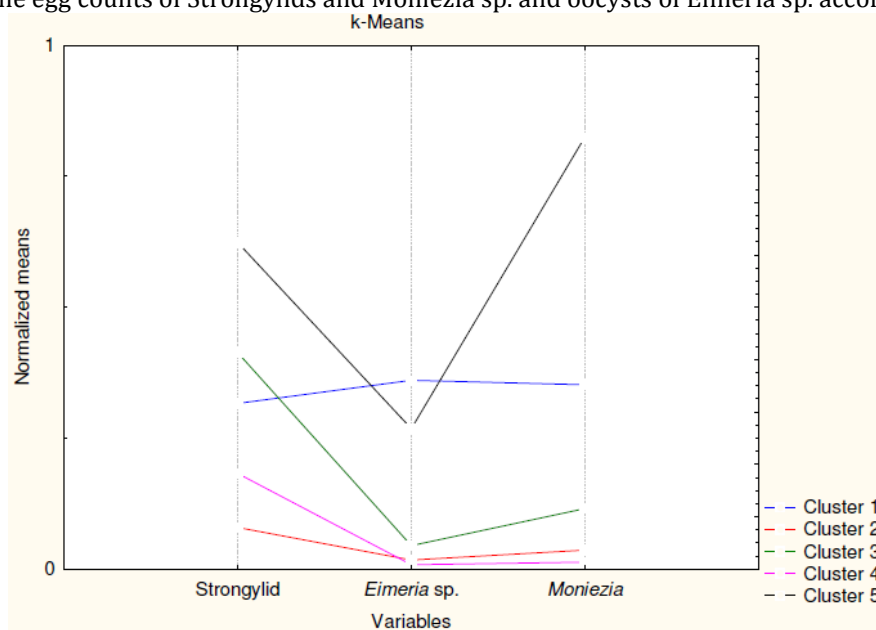
Five clusters were formed for the four categories: 1 (lambs), 2 (females), 3 (males), 4 (lactating females) and 5 (lambs). The category lambs was subdivided into two clusters. The lambs had higher counts of the eggs and oocysts of the three types of parasites (Table 2). The pattern of the means for Clusters 1 and 5, both lambs, was different from the other clusters (Figure 2). The pattern of the means for lactating females and females was similar.

Table 2 – Counts of eggs of strongylids and *Moniezia* sp. and oocysts of *Eimeria* sp. in each cluster according to the categories.

Cluster	Strongylids	<i>Eimeria</i> sp.	<i>Moniezia</i> sp.	Number of cases
1	1205,39	5594,83	339,36	9
2	558,68	318,81	34,95	12
3	1469,92	737,80	111,47	12
4	840,19	173,91	12,69	12
5	2045,30	4178,55	794,32	3

Cluster 1 = lambs (females and males up to six months of age). Cluster 2 = females (pregnant or not). Cluster 3 = males (above six months of age). Cluster 4 = lactating females. Cluster 5 = lambs.

Figure 2 – Pattern of the egg counts of Strongylids and *Moniezia* sp. and oocysts of *Eimeria* sp. according to the categories.



Cluster 1 = lambs. Cluster 2 = females. Cluster 3 = males. Cluster 4 = lactating females. Cluster 5 = lambs.

Three clusters were formed in the distribution of strongylids, *Eimeria* sp. *Moniezia* sp. in the months of the year (Table 3, Figure 3). Cluster 1 comprised of January,

April, May, June, August, September, and October. Cluster 2 comprised of February. Cluster 3 comprised the months of March, July, November, and December.

Table 3 – Counts of eggs of strongylids and *Moniezia* sp. and oocysts of *Eimeria* sp. in each cluster according to the months of the year.

Cluster	Strongylids	<i>Eimeria</i> sp.	<i>Moniezia</i> sp.	Number of cases
1	879,26	1649,25	92,53	7
2	1921,04	568,66	181,38	1
3	1194,16	1825,11	251,89	4

Cluster 1 = jan. apr. may. jun. aug. sep. e oct. Cluster 2 = feb. Cluster 3 = mar. jul. nov and dec.

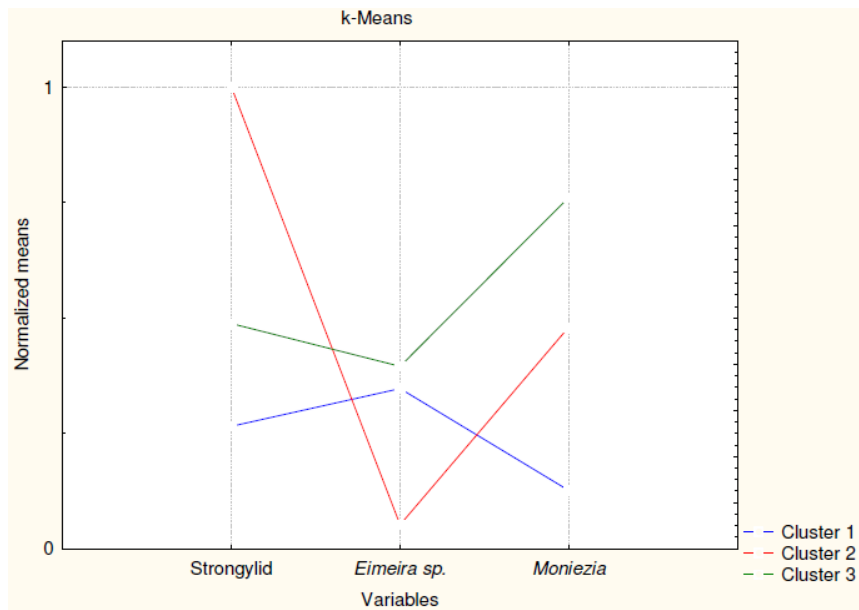
DISCUSSION

The results justify the use of PCA, as there was a decrease in the number of variables to be interpreted and an increase in the discriminating power of each new variable (PC) (TEN CATEN et al., 2011), despite the loss of 17.48% of climatic data.

In the unit circle, projected on the two PCs, the observed parasites have different relationships with the climatic variables, *Eimeria* sp. and strongylids show a different behavior compared to *Moniezia* sp. Ahid et al. (2008) and Brito et al. (2009) correlated and generalized the dynamics of distribution of the above endoparasites with the climatic conditions, which disagrees with this research.

Catto; Ueno (1981), and Souza et al. (2000), mentioned that the main climatic factor regulating the cycle of gastrointestinal nematodes in tropical and subtropical climates is rainfall, which when higher, increases the availability of infective larvae in the pastures. Rainfall and humidity are the factors that support the seasonal patterns of infection in sheep. Morgan; Van Dijk (2012) discussed the relative importance of different species of parasites and the geographic variation in epidemiology. According to Amarante; Barbosa (1995), larval counts tend to decrease in the hot and high rainfall periods, due to the washing effect, which causes the transportation of larvae from the pastures to the soil.

Figure 3 – Pattern of the egg counts of strongylids and *Moniezia* sp. and oocysts of *Eimeria* sp. according to the months of the year.



Cluster 1 = Jan, Apr, May, Jun, Aug, Sep, and Oct. Cluster 2 = Feb. Cluster 3 = Mar, Jul, Nov and Dec.

Nogareda et al. (2006) stated that the effect of temperature is important in the regions where critical levels in the development of the free-living phases of strongylids are attained. This is also in contrast with the results of this study, since only *Moniezia* sp. showed a relationship with temperature.

The occurrence of verminosis and eimeriosis in young animals is higher, due to their lower immunity compared to adults. Moreover, adult animals are a source of infection for the younger individuals (AHID et al., 2008). The fact that two clusters for the lambs were formed, shows that there is a variation within the same category, and indicates the need for a more accurate parasitic control in these animals.

Despite the use of k-means clustering technique, on maximizing the variation of clusters and minimizing the variations within each, the similarity in the pattern of means for lactating females and the other females is seen, compared to the clusters of lambs and males. Despite the similar pattern, two clusters were formed for the females, possibly due to the presence of newborn females in one of the groups, which showed a higher count of strongylids (COSTA; SIMÕES; RIET-CORREA, 2011; FERNANDES et al., 2017; MOLENTO et al., 2013).

Similar to the findings of this study, Ahid et al. (2008) when studying the epidemiology of endoparasites, observed the presence of eggs during almost all months of the year, regardless of the dry or rainy season in the region. This is possibly due to the integrity of the fecal bolus, making them a potential reservoir of larvae, favoring the prolonged survival of the free-living stages (ALMEIDA et al., 2005).

In general, it is noticed that the cluster 1 for months was associated with lower rainfall, whereas the cluster 3 had higher rainfall. Perhaps the month of February remained in a single cluster due to the high prevalence of strongylids that occurs after the long rainy period (AHID et al., 2008). There was no distribution pattern of strongylids, *Eimeria* sp. and *Moniezia* sp. among the clusters of months of the year.

The climatic conditions of the Northeast region of Brazil reported by Costa; Simões; Riet-Correa (2011) were similar to those in this study. As previously discussed, the variables described in this study influenced the endoparasite distribution dynamics (Figure 1, Table 1). However, there is a need for different control strategies throughout the year, especially in the months of Clusters 2 and 3, as they showed higher counts of strongylids.

CONCLUSION

The excretion of eggs of strongylids and oocysts of *Eimeria* sp. are influenced by humidity and rainfall. The eggs of *Moniezia* sp. have a stronger relationship with the environmental temperature. Moreover, the dynamics of endoparasites are not similar; the highest counts are seen in lambs and in the months of higher rainfall.

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