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Original article

Abomasal nematodes in goats from the subtropical island of Grand Canary (Spain)

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Summary — The prevalence of gastric nematodes in 151 goats on Grand Canary Island is around 56%, with a mean burden of 691 worms/animal. No significant differences of prevalence and intensity were found between the four isoclimatic areas of the island [dry-desert (DD); dry-steppe (DS); temperate-mild (TM); temperate-cold (TC)]. Five nematode species were identified, the most commonly-occurring being *Teladorsagia circumcincta* (observed in 65.8% of parasitized animals) and *Trichostrongylus axei* (51.9%). The distribution of the two species showed opposing trends: *T circumcincta* was more prevalent in the coastal areas (DD), diminishing in frequency closer to the centre of the island (TC), while the reverse was true of *T axei*. The other species identified were *Haemonchus contortus*, *T trifurcata* and *Camelostrongylus mentulatus*: their ranges were restricted to certain areas (*H contortus* in DS and TM; *T trifurcata* in DD, DS and TM; and *C mentulatus* in DD). To analyse the parasite association under natural conditions of an unusual nematode in goats, *C mentulatus*, with the usual parasites a principal component analysis (PCA) was used to assess the overall behaviour of the nematode community and to examine the Euclidean distances of the parasite associations. The mean Euclidean distances obtained for *C mentulatus* showed a tendency to a positive association which has also been observed for the other abomasal nematodes.

abomasal nematode / goat / parasite association

Résumé — Nématodes de la caillette chez les chèvres de l'île subtropicale des Canaries (Espagne). La prévalence des nématodes gastriques chez 151 chèvres de l'île des Canaries est de 56 %, avec une

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moyenne de 691 vers/animal. Aucune différence significative de prévalence et d'intensité n'a été trouvée entre les quatre zones climatiques de l'île (désert, steppe, climat tempéré doux, climat tempéré froid). Cinq espèces de nématodes ont été identifiées, la plus répandue étant *Teladorsagia circumcincta* (observées dans 65,8 % des animaux parasités) et *Trichostrongylus axei* (51,9 %). La distribution des deux espèces montre des tendances opposées : pour *T. circumcincta*, elle était plus fréquente dans la zone côtière (désert), et moins fréquente dans le centre de l'île (climat tempéré froid), alors que c'est l'inverse pour *T. axei*. Les autres espèces identifiées étaient *Haemonchus contortus*, *T. trifurcata* et *Camelostrongylus mentulatus* ; leur présence était restreinte à certaines zones (*H. contortus* dans le désert et la zone de climat tempéré doux ; *T. trifurcata* dans le désert, la steppe et la zone de climat tempéré doux, *C. mentulatus* dans le désert). Pour analyser les associations de parasites dans les conditions naturelles d'un nématode inhabituel chez les chèvres (*C. mentulatus*) avec les parasites habituels, une analyse en composantes principales (ACP) a été employée. Cette analyse a permis l'évaluation du comportement global ainsi que l'estimation des distances euclidiennes entre les espèces composant la communauté parasitaire de nématodes. Les distances euclidiennes moyennes obtenues pour *C. mentulatus* montrent une tendance vers une association positive ce qui a été aussi observé pour les autres espèces de nématodes de la caillette.

nématode de la caillette / chèvre / association de parasites

INTRODUCTION

The effects of abomasal nematode infection are well documented, and it is considered a major cause for production loss (Veracruz et al, 1988).

Although previous analyses in our laboratory have shown that abomasal nematodes are one of the most common parasites in Grand Canary Island goats, no precise data have hitherto been available regarding their real prevalence and their distribution on the island. The island's goats may be considered to form a closed indigenous population, as the importation of small ruminants has been negligible or non-existent since 1980. At the same time, the goat farms could be considered isolated from each other, as a result of the very limited introduction of new animals after the establishment of each farm. Therefore, parasitological studies in a population of this sort are likely to disclose factors more closely related to local conditions than in areas where the animal exchange is more frequent.

The purpose of this study was to determine the prevalence and intensity of abomasal nematodes in goats on Grand Canary

Island in relation to the four isoclimatic zones, in order to assess the possible effect of certain environmental factors on infection levels and on the particular species involved in each case. The paper also examined interspecific associations in these naturally acquired nematode communities following the model proposed by Hoste and Cabaret (1992).

MATERIALS AND METHODS

Goat farming and climatology

The herds in Grand Canary Island are composed of 200–500 dairy goats, and the introduction of new animals after the initial establishment of the herd is rare. The herd breeding type is semi-intensive (grazing on pasture is very limited and located in the south of the island) and supplemented on the farms with corn, wheat bran and dehydrated lucerne. Antiparasitic treatments using levamisole are administered very sporadically.

All the animals examined in this study were adult dairy goats of the local breed (Canarian goat) at the end of their production cycle (after the 4th–6th lactation, weighing 45–50 kg). They were slaughtered at the island's abattoir between October 1994 and March 1995. At the abattoir,

information about the origin of each animal was recorded. The selected animals belonged to 47 different herds.

In Grand Canary Island, following the isoclimatic zone scheme outlined by Rodríguez-Ponce et al (1995), two basic climatological zones can be considered: dry (D) and temperate (T). These are further subdivided to give a total of four zones, as follows:

Dry zones

Dry zones (D) are found below 200 m altitude on or near the coast, and are divided into:

— dry desert (DD), characterized by low precipitation (< 180 mm per year), an average annual temperature > 18 °C and very dry summers. Vegetation consists primarily of *Euphorbia* spp, cacti, succulents and palms;

— dry steppe (DS), with an average annual temperature of > 18 °C, and average precipitation levels of 180–360 mm per year. It can be considered as a steppe-like climate with dry summers, and vegetation similar to that of DD.

Temperate zones

Temperate zones (T) have winter temperatures < 18 °C and considerable winter rainfall. These zones are divided into:

— temperate mild (TM), at an altitude of 200–800 m, characterized by hot, dry summers and mild winters. Annual precipitation level is around 400 mm per year;

— temperate cold (TC), at over 800 m above sea level. Conditions are similar to TM, except that summer temperatures are lower (< 22 °C), and winters are also colder. Average annual precipitation level is between 400 and 800 mm per year. Vegetation includes the Canary pine and laurel forests. These isoclimatic areas are arranged roughly in concentric circles on the island: the coast (except for the north) is DD; inside this, the isoclimatic zone is DS. The next zone is TM, and in the centre of the island is the TC zone. Despite small geographic distances, considerable variations between isoclimatic zones are observed. Several factors such as the Trade winds or the altitude could be responsible for those differences.

The total sample ($n = 151$) was calculated taking into account the Grand Canary Island goat census of 1986, where the goats were distributed

among the different isoclimatic areas as follows: dry-desert (DD) 58%; dry-steppe (DS) 23%; temperate-mild (TM) 13%; temperate-cold (TC) 7%.

The number and percentage of investigated animals from each isoclimatic zone was 78 (51.6%) in DD, 38 (25.2%) in DS, 28 (18.5%) in TM and 7 (4.6%) in TC. When necessary, as for example in the case of the multivariate analysis, the data were grouped to reflect the districts from which the animals were drawn. The distribution of goats according to district and isoclimatic areas is shown in table 1.

Recovery and identification of abomasal nematodes

The abomasum contents of the 151 investigated animals were examined using the methods recommended in the Manual of Veterinary Parasitological Laboratory Techniques (1989). Briefly, the abomasum was ligated and removed from the animals. This was cut open and the stomach wall was washed with tap water. The wash water was collected and made up to a volume of 2 000 mL through the addition of water and sufficient formalin to give a final concentration of 5%. The mixture was agitated and two 40 mL samples were removed. Each sample (40 mL) was examined and the worms counted using a dissecting microscope. The total number of worms counted in both samples were multiplied by 25 to give the number of worms in each abomasum. The observed males were cleared in lactophenol and identified, and the percentage of each species was calculated.

Statistical analysis

Statistical comparison of prevalence and worm burden (overall and per species) between climatic zones, and comparisons between goat population and sample distribution were performed using the Pearson homogeneity test (Snedecor and Cochran, 1974).

The most frequent species were determined using a mean contrast test (Quesada et al, 1984).

Linear regressions were analysed for worm burden and prevalence, both overall and as a function of isoclimates. For this latter purpose (linear regressions as a function of isoclimates), a numerical value was given to each isoclimatic

Table I. Distribution of goats ($N = 151$) by district and isoclimatic areas.

Districts	N° of goats (%)
Dry desert (58% of goat census)	
Telde	13 (8.6)
La Aldea	35 (23.2)
Las Palmas de GC	20 (13.2)
San Bartolomé	10 (6.6)
Total	78 (51.6)
Dry steppe (23% of goat census)	
Valsequillo	12 (7.9)
Santa Lucia	13 (8.6)
Arucas	7 (4.6)
Agaete	6 (3.0)
Total	38 (25.2)
Temperature mild (13% of goat census)	
Santa Brigida	17 (11.3)
Teror	5 (4)
Moya	6 (3.3)
Total	28 (18.5)
Temperature cold (7% of goat census)	
Artenara	7 (4.6)
Total	7 (4.6)

zone as follows: DD=1; DS=2; TM=3; TC=4. There were clear relationships between each isoclimatic zone, their geographic distribution on the island, their altitude above sea level and their average annual precipitation. In our opinion, these relationships made it possible to determine whether or not there was a proportional increase or decrease in the prevalence (% of parasitized hosts), frequency (% of goats harbouring a nematode species) or intensity of abomasal nematodes as one moved from coastal areas (DD) to the centre of the island (TC) using the proposed methodology.

A principal component analysis (PCA) (Batista-Foguet and Martínez Arias, 1989) was performed on the intensity (actual number of worms) and frequency (percentage of each species in one abomasum) data to study the inter-specific associations. In order to ensure a greater number of observations (rows in the matrix), the results were classified according to districts rather than isoclimatic zones. The variables (columns in the matrix) were the five nematode species

observed (*T. trifurcata* was considered as a different species). Two additional active variables were incorporated into the intensity analysis as boundary values: the maximum and minimum worm burden.

Data for both studies (frequency and intensity) were previously standardized as follows: $(x_i - x)/\sigma$. (x_i = actual value; x = mean value; σ = standard deviation). Only three axes were used in PCA as the percentage of accumulated variance on three axes was 89% for frequency data and 84% for intensity data. Mean Euclidean distances (d) were then calculated in the principal component space for each district. Further information was also gained by calculating the following distances: D2 (for each pair of parasites, the average of the 12 d values calculated from the results of the 12 districts) and D4 (mean distance between one species and the other four for the 12 districts). Distances d , D2 and D4 varied from 0 to 2. Values of 1 or lower were considered positive associations, and values higher than 1 were considered as negative associations as described

by Hoste and Cabaret (1992). The calculations were performed using SAS mathematical software (Statistical Analysis System Institute, 1989).

RESULTS

The prevalence rate of abomasal nematodes among the goats was 56%, with a maximum burden of 6 278 worms/animal and an arithmetic mean burden of 691 worms/animal. The results for each of the four isoclimatic zones studied is shown in figure 1. Prevalences were very similar for all areas below 800 m: DD (56.8%), DS (48.5%) and TM (50%); the worm burdens showed a decrease from the coastal areas (DD) to the TM zone: DD (710 worms/goat), DS (683 worms/goat) and TM (496 worms/goat). Animals in the coldest zone (TC) displayed the lowest

worm burden (407 worms/goat) but the highest prevalence (83.3%). The differences between the four zones analysed, in terms of prevalence and worm burden were not found to be statistically significant by the Pearson homogeneity test ($\chi^2 = 2.04$; $P = 0.56$).

Figure 2 shows the frequency of abomasal nematodes for each of the climatic zones studied. Five species were recovered in total. *T circumcincta* was the most common (65.8%). *T axei* infection was recorded in 51.9% of cases. The mean contrast test showed that both species together accounted for the majority of the abomasal worm burden of infected animals ($P = 0.011$). The other nematode species were recovered considerably less frequently: *H contortus* was found in 15.2% of positive animals, *T trifurcata* (although *T trifurcata* is a subspecies

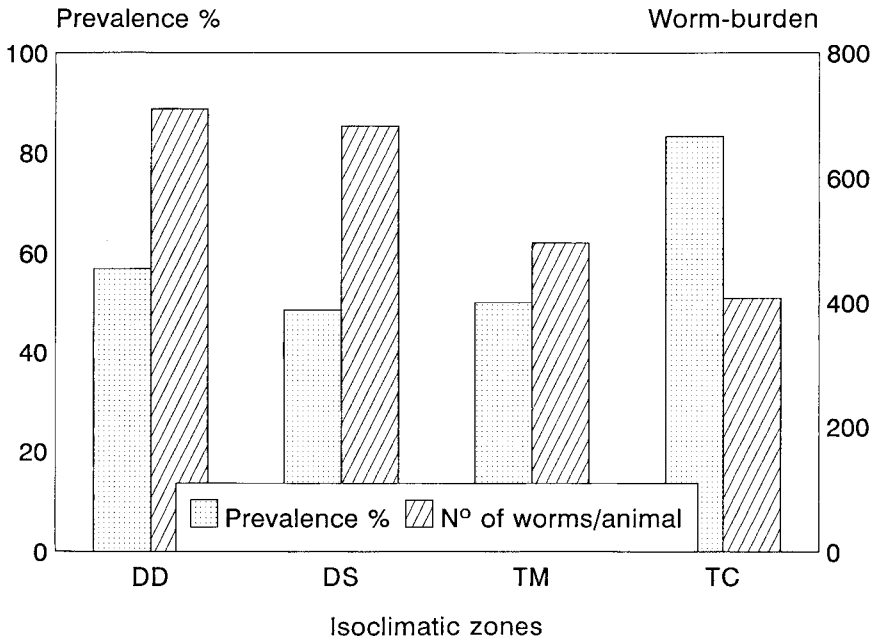


Fig 1. Prevalence and worm-burden of abomasal nematodes for each of the climatic zones studied (DD = dry-desert; DS = dry-steppe; TM = temperate-mild; TC = temperate-cold). Results have been expressed as the percentage of infected (prevalence) and worm numbers (mean value) harboured per goat.

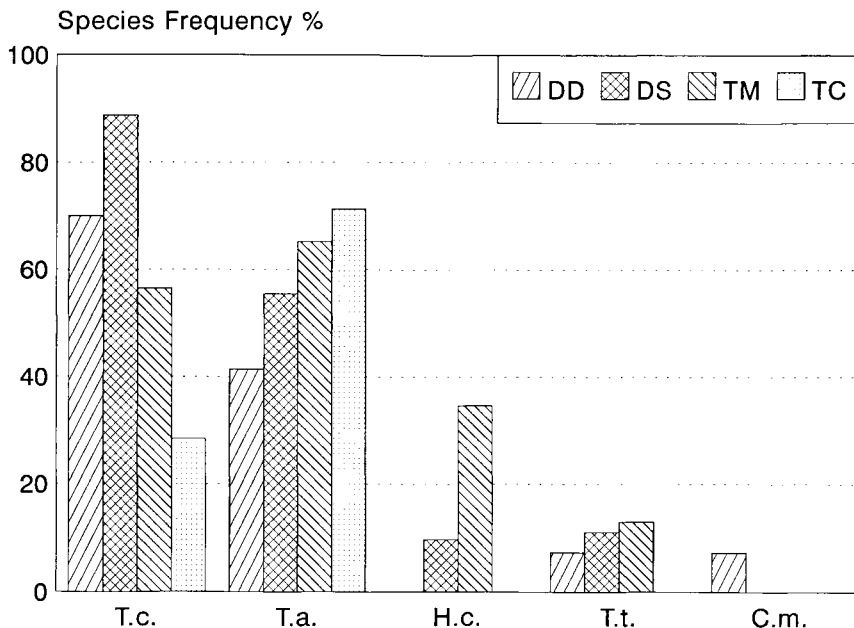


Fig 2. Frequencies of the nematode species for each of the climatic zones studied (DD = dry-desert; DS = dry-steppe; TM = temperate-mild; TC = temperate-cold). Results have been expressed as the percentage of infected goats harbouring each of the nematode species (Tc = *T circumcincta*; Ta = *T axeii*; Hc = *H contortus*; Tt = *T trifurcata*; Cm = *C mentulatus*).

of *T circumcincta*, they were considered as different species to compare with previous studies) in 8.8% and *C mentulatus* in 3.8%. With regards to the isoclimatic zones (fig 2), some species were not recorded in certain zones (*H contortus* in DD and TC, *T trifurcata* in TC, *C mentulatus* in DS, TM and TC). In the isoclimatic zones where these species were observed, statistical comparison of their frequencies revealed no significant differences (*H contortus*: $\chi^2 = 0.23$, $P = 0.62$; *T trifurcata* $\chi^2 = 1.84$, $P = 0.39$).

The percentage of goats harbouring each of the two most common species (*T circumcincta* and *T axeii*) differed significantly for each of the four climatic zones (*T circumcincta*: $\chi^2 = 31.67$, $P = 6.12 \times 10^{-7}$; *T axeii*: $\chi^2 = 8.74$, $P = 0.03$). The percentage of animals harbouring *T circumcincta* tended to

decrease from dry to temperate zones, while the percentage of animals harbouring *T axeii* tended to increase. These tendencies were observed for the *T axeii* frequency when a linear regression was performed ($P = 0.02$; $R^2 = 0.96$).

The intensity of each species (fig 3) followed a similar pattern to the species frequency: the most common parasite species (*T circumcincta* and *T axeii*) presented higher worm counts (729 and 534 worms/goat, respectively) than the less frequent species (*H contortus*, 326 worms/goat; *C mentulatus*, 270 worms/goat; *T trifurcata*, 196 worms/goat).

Principal component analysis (PCA), based on the frequency and intensity data was used to study the interspecific associations.

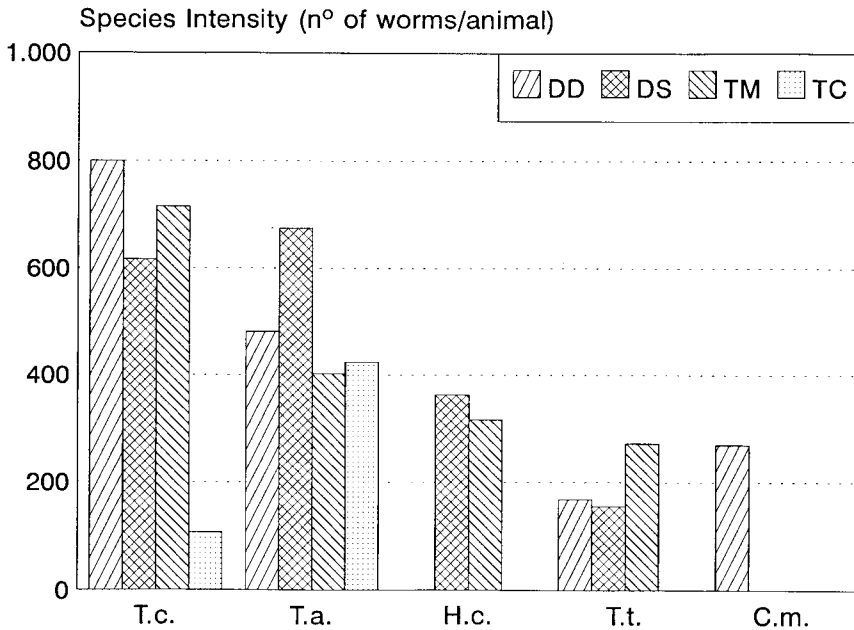


Fig 3. Species intensity of abomasal nematodes, both overall and for each of the climatic zones studied (DD = dry-desert; DS = dry-steppe; TM = T-temperate-mild; TC = temperate-cold). Results have been expressed as the worm numbers (mean value) of each species harboured in infected animals. (Tc = *T circumcincta*; Ta = *T axei*; Hc = *H contortus*; Tt = *T trifurcata*; Cm = *C mentulatus*).

Figure 4 shows the behaviour of distances between each abomasal nematode species and the four other parasites (D4) for both analyses (frequency data (a) and intensity data (b)). The observed values for *C mentulatus* were 0.78 for frequency data and 0.89 for intensity data. The observed D4 showed a tendency to positive association, although in some particular cases competition between *C mentulatus* and the other abomasal nematodes have been observed (in the district of Las Palmas de Gran Canaria, *C mentulatus* showed a D4 value of 1.88 ± 0.07 and 1.8 ± 0.13 for the frequency and intensity data respectively) but such negative association was not the general trend. A very low coefficient of variation (CV) for *C mentulatus* D4 and reduced differences between the maximal and minimal

values of D4 between observed species were also noted.

Figure 5 represents the D2 distances for each pair of species according with PCA, which supplemented and confirmed the information obtained in the previous analysis (D4). The study carried out on frequency data (fig 5b) showed that *C mentulatus* was often opposed to the other species (three of the first four pairs in the figure include this species), but the mean D2 values were always lower than 1. Higher distances were observed when *C mentulatus* was compared with *T trifurcata* and *H contortus*.

The results obtained from the intensity data (fig 5a) showed D2 distances for *C mentulatus* lower than 0.8. All the pairs which included *C mentulatus* had very sim-

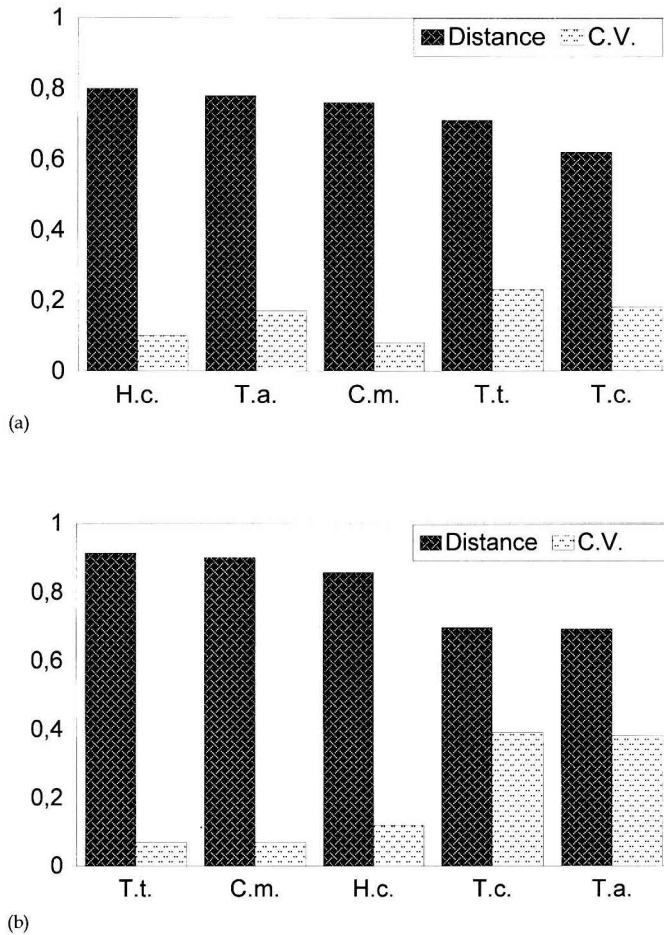


Fig 4. Mean Euclidean distances between each abomasal nematode species and the four other parasites (D4) from results obtained in different districts. Distribution data by the intensity (a) and frequency (b). CV = coefficient of variation. (Tc = *T circumcincta*; Ta = *T axei*; Hc = *H contortus*; Tt = *T trifurcata*; Cm = *C mentulatus*).

ilar D2 values, but high distances were also observed with *H contortus* and *T trifurcata*.

T circumcincta also showed the high positive associations (the lowest d values), particularly with *T axei* (both nematodes were the most frequently observed species) for frequency data, and with *T trifurcata* for intensity data.

DISCUSSION

The overall results indicated that the prevalence of abomasal nematodes in Grand Canary Island goats reached an intermediate value between those observed in neighbouring countries such as Mauritania and Senegal. These tended to vary depending on the season from between 20–30% to

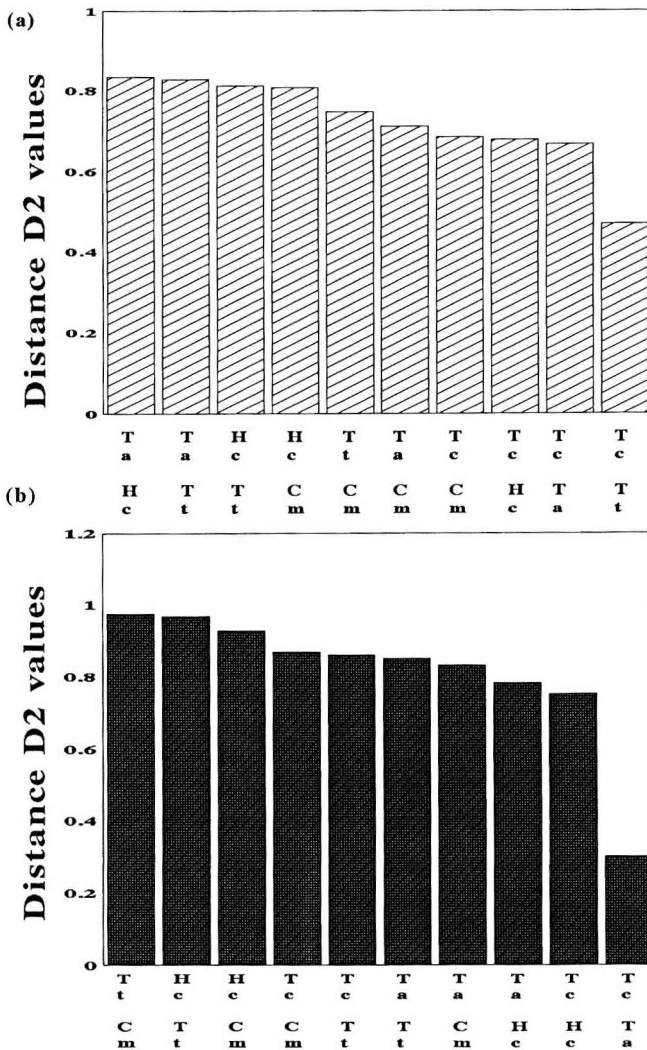


Fig 5. Mean Euclidian distances between each pair of abomasal nematode species (D2) from results obtained in different districts. Distribution data by the intensity (a) and frequency (b). (Tc = *T circumcincta*; Ta = *T axeii*; Hc = *H contortus*; Tt = *T trifurcata*; Cm = *C mentulatus*).

almost 100% of the investigated animals (Jacquiet et al, 1995; Ndao et al, 1995). The samples in the present study were collected during the wettest season which undoubtedly favoured the presence of adult worms (Chiejina et al, 1988; Ndao et al, 1995).

A wider variety of species was identified in our study than in the other studies from the above mentioned countries (Jacquiet et al, 1995; Ndao et al, 1995). Species diversity in the present study resembled more closely the diversity reported in sheep from

Morocco (Pandey et al, 1980) or in goats from the Iberian Peninsula (García-Romero et al, 1995), perhaps because most of the goat imports were originally from the Spanish mainland.

T circumcincta and *T axei* were the only species observed in all four climatic zones studied, suggesting a greater degree of these species adaptability to local conditions. They were also the only species whose prevalence differed statistically from one isoclimate to another. The prevalence of *T axei* was closely related to climatic factors, increasing gradually from the coast to the central area of the island, where the rainfall is greatest. The reverse trend was noted for *T circumcincta*.

With regards to the less frequently observed species (some of which were absent in certain zones), *H contortus* was detected in zones characterized by relatively high humidity and temperature, and by fairly constant temperatures throughout the year.

The distribution of *T trifurcata* was similar to that of *T circumcincta*, although it was not observed in the highest areas of the island. The different frequencies observed for both nematodes agreed with the observations of Cabaret et al (1986) concerning nematode communities in sheep from France and Morocco, where *T trifurcata* was also much less prevalent than *T circumcincta*. These authors suggested that *T trifurcata* could have been less abundant because of poorer resistance to environmental factors or to host defences.

One of the most striking observations in this study was the presence of *C mentulatus*, a species typically associated with camelidae and not hitherto reported in Canarian goats (Cordero del Campillo et al, 1994; Gómez-Calcerrada, 1996). Under experimental conditions, the transmissibility of *C mentulatus* to small ruminants seems to be high (Thornton et al, 1973; Gevrey, 1989). It could explain why in some countries with large camelidae populations, such as Saudi

Arabia or Iraq, *C mentulatus* is frequently observed in both sheep and goats (Alani and Yahay, 1993; El-Azazy, 1995). This parasite has also been observed in sheep from Morocco, but with a lower frequency than in the aforementioned countries (Pandey et al, 1980). Contrary to these observations, in the neighbouring countries of Mauritania and Senegal, where there is also a camelidae population, or on the other islands of the Canarian Archipelago (Gómez-Calcerrada, 1996), this nematode is not detected in small ruminants.

Regarding the PCA analysis which was performed to study the interspecific associations of abomasal nematodes, in particular for *C mentulatus*, this study showed that three components were sufficient to reflect the behaviour of the nematode community, with a high accumulated percentage of variance (intensity = 84%; frequency = 89%). Neither generic distances (D2; fig 5) nor interspecific distances (D4; fig 4) yielded values greater than 1 (see **Materials and methods section**), indicating a positive association in all cases for intensity and frequency data. Similar studies by Hoste and Cabaret (1992) on gastrointestinal nematodes and by Díez-Baños et al (1992) on abomasal nematodes in sheep have also reported that most of the interspecific associations observed were not antagonistic. On rare occasions, these studies noted slight negative interactions, involving *T circumcincta*. In the present study, *T circumcincta*, in fact, showed the greatest positive interaction with other species. In the above mentioned studies, as in the present survey, the results suggested that parasite populations are characterized by both a fair degree of homogeneity and stability. Low CV values and reduced differences between the maximal and minimal distances between observed species (figs 4 and 5) bear out this conclusion. The stability recorded under natural conditions has been accounted for, in the case of ovine gastrointestinal nematodes, by host population factors which tend to

promote positive interactions, thus enhancing the stability of the system (Hoste and Cabaret, 1992).

The mean Euclidean distances obtained for *C mentulatus* were always lower than 1, so *C mentulatus* would show the same general tendency to a positive association which was observed for the other abomasal nematodes. In the same way, these results contribute to the above theory, which states that under natural conditions a parasite community tends towards stability, despite the presence of an uncommon species such as *C mentulatus* in that community. Although this species showed a general tendency to positive associations, in some cases (ie, when the *d* values from a particular district were considered), the observed results showed a slight negative association (mean Euclidean distances higher than 1) between this nematode and others. Although further investigations would be necessary to explain this phenomenon, other factors such as management, farm history, etc, could be involved in these cases affecting the expression of interspecific association (Cabaret and Gasnier, 1994).

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REFERENCES

- Alani AJ, Yahay HQ (1993) Observations on the epidemiology of intestinal helminths in sheep in Ninrah Province (Iraq). *Int J Anim Sci* 8, 51-55
- Batista Foguet JM, Martínez Arias MR (1989) *Análisis Multivariante. Análisis en Componentes Principales*. Colección ESADE. (Hispano Europea, SA ed), Barcelona, Spain, 10-150
- Cabaret J, Morales G, Durette-Desset MC (1986) Caractérisation de *Teladorsagia circumcincta* et *Trifurcata*. II. Aspects morphologiques. *Ann Parasitol Hum Comp* 61, 55-64
- Cabaret J, Gasnier N (1994) Farm history and breeding management influences on the intensity and specific diversity of nematode infection of dairy goats. *Vet Parasitol* 53, 219-232
- Chiejina SN, Fakae BB, Eze BO (1988) Arrested development of gastrointestinal trichostrongylids in goats in Nigeria. *Vet Parasitol* 28, 103-113
- Cordero del Campillo M, Castañón L, Reguera A (1994) *Índice-Catálogo de zooparásitos ibéricos*. 2nd ed, Secretariado de Publicaciones, Universidad de León, Spain, 201-285
- Diez-Baños N, Cabaret J, Diez-Baños P (1992) Interspecific interactions in naturally acquired nematode communities from sheep abomasum in relation to age of host and season in four areas of León, Spain. *Int J Parasitol* 22, 327-334
- El-Azazy OME (1995) Seasonal changes and inhibited development of the abomasal nematodes of sheep and goats in Saudi Arabia. *Vet Parasitol* 58, 91-98
- García Romero C, Miró G, Meana A, Valcárcel F, (1995) Contribución al mapa parasitológico de Castilla-La Mancha: especies de nematodos gastrointestinales en el ganado caprino. Abstracts of *IV Congreso Ibérico de Parasitología*, Santiago de Compostela, Spain, 102
- Gevrey J (1989) Lamas et moutons : observation d'intertransmissibilité helminthique. *Bull Soc Fr Parasitol* 7, 245-249
- Gómez-Calcerrada López V (1996) Mapa parasitológico del ganado caprino en el archipiélago canario. *O Médico Veterinario* 47, 29-36
- Hoste H, Cabaret J (1992) Intergeneric relations between nematodes of the digestive tract in lambs: a multivariate approach. *Int J Parasitol* 22, 173-179
- Jacquet P, Colas F, Cabaret J, Dia ML, Cheikh D, Thiam A (1995) Dry areas: an example of seasonal evolution of helminth infection of sheep and goats in southern Mauritania. *Vet Parasitol* 56, 137-148.
- Manual of Veterinary Parasitological Laboratory Techniques* (1989) Ministry of Agriculture, Fisheries and Food, London, UK
- Ndao M, Belot J, Zinsstag, J, Pfister K (1995) Épidémiologie des helminthoses gastro-intestinales des petits ruminants dans la zone sylvo-pastorale au Sénégal. *Vet Res* 26, 132-139
- Pandey VS, Cabaret J, Ouhelli H, Dakkak A (1980) Etude des nématodes parasites du tube digestif des ovins adultes dans deux régions du Maroc. *Bull Off Int Epizoot* 92, 1345-1349
- Quesada V, Isidoro A, López LA (1984) *Curso y Ejercicios de Estadística*. Alhambra ed, Madrid, Spain, 336-359

- Rodríguez-Ponce E, Molina JM, Hernández S, (1995) Seroprevalence of goat toxoplasmosis on Grand Canary Island, Spain. *Prev Vet Med* 24, 229- 234
- Snedecor GW, Cochran WG (1974) In: *Métodos Estadísticos*. Continental Editorial Co, Mexico DC, 703
- Statistical Analysis System (SAS) Institute Inc* (1989) Users guide. Cary, NC, USA
- Thornton JE, Galvin TJ, Bell RR, Ramsey CW (1973) Transmissibility of gastrointestinal nematodes from blackbuck antelope to cattle, sheep and goats. *J Am Vet Med Assoc* 163, 554-555
- Vercruyse J, Taraschewski H, Voigt WP (1988) Parasitic diseases of the alimentary system. In: *Parasitology in Focus. Facts and Trends*. Melhorn H ed, Springer-Verlag, Berlin, Germany, 481-494