Prevalence and risk factors for gastrointestinal parasitosis of small ruminants at the end of the rainy season in peri-urban livestock farms in Tahoua, Niger

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Abstract

In the Sahelian regions of Niger, gastrointestinal parasites are considered one of the main causes of suboptimal productivity in small ruminants. This study aims to analyze the groups of gastrointestinal parasites involved, the factors influencing variations in parasite load, and their prevalence. The methodology was based on a questionnaire survey conducted in nine (9) villages and a coprological analysis carried out using the Mac Master method on 270 faecal samples from caprine and ovine species. Logistic regression was used to highlight the risk factors associated with each type of parasitism encountered. The most widespread farming system was still traditional, with feed based mainly on natural grazing. The coprological results identified a prevalence of nematode eggs (79.3%), cestodes (7.8%), coccidian oocytes (58.9%) and co-infection of 49.3%. Average parasitic egg excretions were quantified as follows: 1,527 nematode eggs/g faeces, 928 cestode eggs/g faeces and 3,485 coccidian oocytes/g faeces. These parasite loads and their prevalences varied significantly according to species, breed, sex, age, body condition, and the nature of the water source used to water the animals. These animal-related characteristics were the main risk factors for parasitosis, and their impact was highly significant. The extent of the parasite infestation reported in this study opens up the question of how to manage gastrointestinal parasitism on our farms, which has hitherto been considered a minor disease.

Keywords: Parasitosis, Co-infection, Risk factors, Breeding practices, Small ruminants

INTRODUCTION

In agro-pastoral livestock systems in Sahelian zones, animals are multifunctional, fulfilling many roles (Guichard, 2004). Among all these functions, the economic importance of livestock production and its contribution to household income remains central for livestock farmers (Corniaux, 2009). Small ruminants have a major influence on the economic sustainability of rural communities thanks to their fertility, fecundity, prolificity, early maturity and adaptability to a stressful environment (Alary *et al.*, 2011; Amole *et al.*, 2017; Heliot *et al.*, 2021). They are also valued for their high recovery rate, particularly after a significant exogenous shock (Guichard, 2004).

Despite all this potential, optimal productivity is rarely achieved. Gastrointestinal parasitosis is thought to be one of the main causes of sub-optimal animal productivity (Djawe *et al.*, 2019).

In the peri-urban farms of Tahoua, the zootechnical data recently collected indicate a decline in the general condition of the animals that is sufficiently marked to suggest a suspicion of digestive strongylosis (Hassane, 2020). Over 41% of goats and 30% of sheep were found to have poor body condition, with females paying the heaviest price. In the majority of flocks, the average weight of the animals in relation to their age was below zootechnical standards, and inconsistencies were noted in the relationship between the body condition and the body weight of the animals (Hassane, 2020).

Although parasitism is not as spectacular as the bacterial and viral epizootics that sometimes decimate entire farms, its impact on livestock productivity is no less significant (Mensah *et al.*, 2006; Tamssar, 2006; Pousga *et al.*, 2019). Parasitism has an impact on mortality in young animals, delays growth with a poor feed conversion rate and increases the susceptibility of host animals to disease (Li *et al.*, 2022). Lesions in the intestinal tract lead to major production losses.

Faced with this reality, livestock managers have for several years been carrying out research into ways of controlling the most important helminthiasis (Tager-Kagan, 1986). Precise knowledge of the inventory of the main parasites in livestock and of the spectrum of parasites, as well as of the groups at risk in the different agro-ecological zones, is the prerequisite for a better epidemiological and economic approach to the control of gastro-intestinal parasites. The main objective of this study is therefore to analyze the prevalence and risk factors of gastrointestinal parasitosis of small ruminants in the peri-urban herds of Tahoua in Niger.

MATERIAL AND METHODS

Study area

The town of Tahoua is located in Niger between 14° 53'25'' North and 5° 15' 51'' East (Figure 1). The climate of the Tahoua region is Sahelian, hot and dry, with an average annual rainfall of 400 mm. The average daily temperature (29.5°C) has a minimum in December-January of 24°C and a maximum in April of 35°C. Humidity in the production environment varies from 20% to 49% depending on the month of the year. The vegetation is steppe-like, subject to the action of the wind, the effects of which result in the formation of mobile sand dunes. Agriculture is the main activity, employing around 90% of the population of the Tahoua region. Livestock farming is practised in the urban and peri-urban environment of Tahoua and is developing well in both traditional and improved forms. The peri-urban community of Tahoua breeds all the domestic animal species known in Niger, with a predominance of small ruminants, which account for 81.5% of the livestock population.

Sampling and data collection

The study of gastrointestinal parasitosis was carried out on small ruminants of the ovine and caprine species in the peri-urban farms of Tahoua. In the case of sheep, the study focused on two breeds of Fulani sheep (Bali-Bali and Oudah) and a single breed of Tuareg sheep (Ara-ara). The goats used in this survey are represented by a single breed, the Sahel goat.

The survey on gastrointestinal parasitosis was conducted during the end of the rainy season in the peri-urban villages of Tahoua, from the end of September to the beginning of October 2021. The minimum faecal sample size was calculated using the 'samplingbook' package in R (Serhier *et al.*, 2020). A total of 270 animals from nine (9) villages were studied. The choice of herds for sampling was based on the willingness of the owners to cooperate. The animals, selected at random from the herd, were marked with a wire at hoof level. The faeces were taken directly from the rectum with the hand fitted with plastic and stored in a thermos containing preservatives before being sent to the laboratory for analysis. The characteristics of each animal selected, i.e. species, breed, sex, age, body condition, weight, and the type of rearing to which it was subjected, were noted beforehand using a questionnaire.

Quantitative coproscopy

Mac Master quantitative coproscopy (Kochanowski *et al.*, 2013) was used to quantify eggs per gram of faeces (OPG). This involves crushing 3 g of faeces taken directly from the rectum with 45 ml of a saturated sodium chloride solution in a porcelain mortar. This mixture allows the eggs contained in the faeces to float. The mixture is then filtered through a tea strainer. Using a Pasteur pipette, the two cells of the Mac Master slide were filled for microscopic examination using a 10 X objective. Each cell has a known volume of 0.15 ml so, as the faeces are diluted to 1/15th, the number of eggs counted is that contained in one hundredth of a gram of faeces. To obtain the number of eggs per gram, the result obtained for one compartment is multiplied by 100 or for both compartments by 50.

Parasites were identified by comparing microscopic images with standard identification plates (Chartier *et al.*, 2000; Birindwa *et al.*, 2020), while oocysts were identified on a morphological basis as described by Chartier *et al.* (2000).

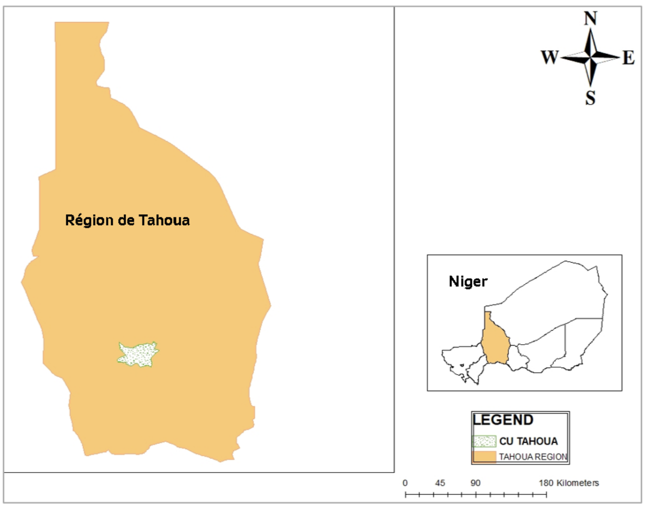

Figure 1: Geographical location of the study area

Qualitative flotation method

This consisted of taking a small quantity of excrement (around 5 g) and mixing it in a mortar with 50 ml of a dense saline solution (sodium chloride). Using a tea strainer fitted with a compress, the mixture was sieved to remove any coarse debris. The resulting suspension was used to fill a test tube to the top. A slide was then placed over the meniscus, avoiding the formation of air bubbles under the slide. The less dense parasitic elements rose to the top of the tube and stuck to the underside of the slide. After a few minutes, the slide is removed and placed on an object slide, which is then examined under the microscope, allowing easy reading and identification of numerous parasite eggs and oocysts. In this study, qualitative flotation was used to enhance the identification of parasite eggs in the event of massive infestation using the Mac Master method.

Statistical analysis

After the coprological analysis, the parasitic species sought for the three classes of nemathelminths, plathelminths and protozoa were analyzed descriptively. The results were presented in the form of a matrix associating, for each of the 270 animals, the gastrointestinal parasites infesting them and the number of eggs counted for these parasites. Prevalence was calculated for each parasite as the ratio of the number of positive cases to the total number of animals sampled. The chi^2 test was used with SPSS (Special Package of Social Science) software (BM Corp, 2021) to analyse variations, at the 5% significance level, in the prevalence of parasitosis according to species, breed, sex, age class, body size, body condition and water source. The degree of EPG infestation was calculated on the basis of infested animals only. Analyses of variance were performed using the GLM procedure in SPSS 21, after normalising the data using logarithmic transformations. The general equation of the model is as follows:

$$\mathbf{Yijklm = \mu + Rai + Sexej + Agek + EmL + Abm + Gabn + eijklmn}$$

where **Yijklm** = EPG load for a given parasite of an animal of breed i, sex j, belonging to age class k with body condition score L and size n; **μ** = overall mean; **Rai=**

fixed effect of breed i, where i = 1(Oudah), 2(Bali bali) 3 (Ara-ara) and 4 (Sahelian goat); **Sex j** = fixed effect of sex, where j = 1 (Male) and 2 (Female); **Agek** = fixed effect of the age class of the animal, with k = 1 (Juvenile < 1 year), 2 (Subadult = [1 to 2 years [ ) and 3 (Adult = [+ 2 years [); **EmL** = fixed effect of the animal's body weight, with L=1 (Good), 2 (Average) and 3 (Poor); **Abm** = fixed effect of the source of drinking water used, with m=1 (Well), 2 (Pond), 3 (Pond and well) and 4 (Borehole); **Gabn** = fixed effect of animal size, with n=1 (Large), 2 (Medium) and 3 (Small); **eijklm** = residual error.

Finally, the risk factors in animals for each parasitosis or strong parasite association with a parasite load above 700 EPG, the threshold above which intervention is recommended, were analysed using logistic regression in R Core Team (2024), the general model of which is written as follows:

$$Logit\ P = \alpha + \sum_{i=1}^{p} \beta i\ Xi$$

where **α** is the estimate of the variation of the dependent variable; **βi** is the estimate of the variation of the dependent variable with respect to the variable **Xi**; **Logit P** is the probability of occurrence of y (subject positive for the parasite studied) as a function of the values of Xi (physical characteristics and animal husbandry practices).

RESULTS

Breeding practices and zootechnical performance of the herd

The most widespread farming system in the peri-urban area of Tahoua remained 100% traditional, with feeding based essentially on natural grazing land, combined with supplementation at the trough (for 69% of the respondents) or roaming (11%). All the animals are kept together. Watering practices varied according to the water sources available locally. The most commonly used sources were the well (55%) and the pond (23%), with 11% of farmers using both sources at the same time. Only 11% of farmers watered their animals from boreholes.

In the case of small ruminants, large and small animals were those that were in slight to moderate body condition (Figure 2b). In addition, average weights in relation to age were below the norm (Figure 2a). In fact, Figure 2a shows that, from the age of 20 months, an increase in age is accompanied by only a slight increase in body weight. This discrepancy between age and weight is far greater in sheep, where low body weight is observed in the majority of animals, even the oldest (Figure 2c). In goats (Figure 2d), although the relationship between weight and age remained within norms, analysis of the body condition score revealed that over 30% of the animals were slight to moderate body condition.

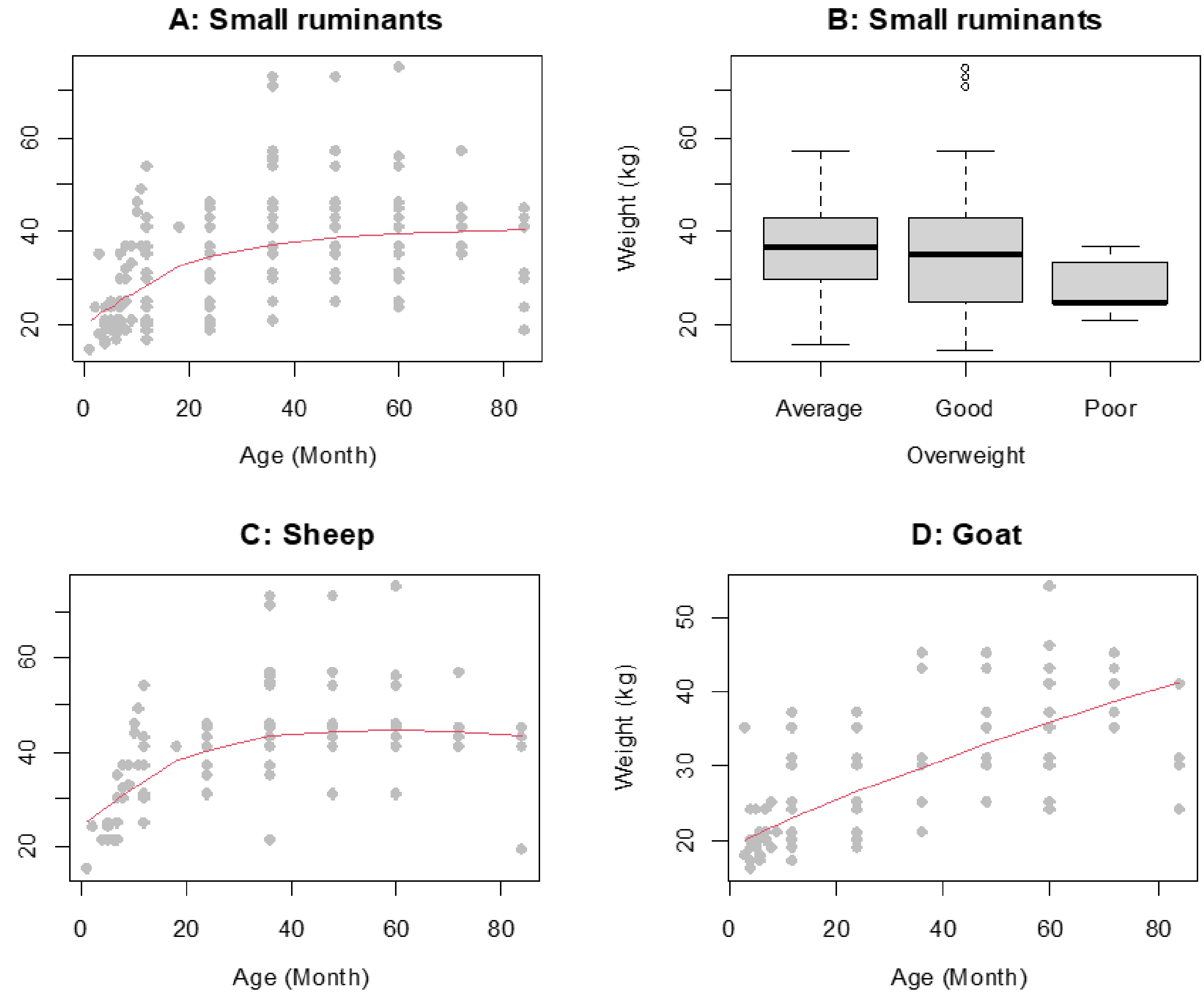

Figure 2: Body weight in relation to age and body condition of small ruminant species

Table 1: Variation in parasitic loads of EPG in small ruminants

[1]Factors	Modalities	Nematode	Coccidia
Overall averages		1527 ± 2689	3485 ± 8730
Species	Goat	974 ± 1036^{a}	2972 ± 7434^{a}
	Sheep	2080 ± 3583^{b}	3899 ± 9672^{a}
	P-value	0,041	0,204
Breed	Ara-ara	2377 ± 2826^{b}	3693 ± 10473^{a}
	Bali-bali	1588 ± 2177^{ab}	3712 ± 8924^{a}
	Oudah	2272 ± 4645^{ab}	4227 ± 9797^{a}
	Sahel	974 ± 1036^{a}	2972 ± 7434^{a}
	P-value	0,049	0,56
Sex	Male	2245 ± 2807^{a}	5300 ± 10633^{a}
	Female	1396 ± 2654^{a}	3063 ± 8216^{b}
	P-value	0,078	0,01
Age class	Adult	1276 ± 2440^{a}	3011 ± 7405^{a}
	Juvenile	2586 ± 3894^{a}	5312 ± 13689^{a}
	Sub-adult	1500 ± 1917^{a}	2988 ± 4005^{a}
	P-value	0,668	0,835
Template	Large	1073 ± 1231^{a}	1387 ± 1640^{a}
	Medium	1589 ± 2968^{a}	3861 ± 9516^{a}
	Small	1777 ± 2932^{a}	3793 ± 9162^{a}
	P-value	0,436	0,323
Body condition	Good	1554 ± 3013^{a}	3151 ± 8530
	Medium	1370 ± 1834^{a}	4016 ± 9305
	Poor	3043 ± 5125^{a}	2600 ± 1438
	P-value	0,953	0,739
Watering	Well	1639 ± 3111^{a}	2996 ± 7230^{a}
	Borehole	746 ± 741^{a}	4426 ± 9962^{a}
	Pond	1722 ± 2396^{a}	3651 ± 8810^{a}
	Pond et Well	1267 ± 1870^{a}	4014 ± 12122^{a}
	P-value	0,708	0,158

[1]Column means with no letters in common are significantly different at the 5% level.

Degree of parasitic infestation

Coprological examinations identified nematode helminths (strongyles and strongyloides), cestodes (*Moniezia expansa*) and protozoa with coccidian oocysts (*Eimeria expansa* and *intricata*). The level of infestation is indicated by the number of eggs excreted per gram (EPG) of faeces.

Parasite quantification showed an average nematode infestation of 1527 eggs/g, an average coccidia infestation of 3485 eggs/g and an average cestode infestation of 928 eggs/g (Table 1). The sheep species contained more coccidia (3899 oocysts), nematodes (2080 EPG) and cestodes (3507 eggs/g), indicating a massive infestation. On the other hand, goats had moderate nematode (974 eggs/g) and cestode (143 eggs/g) infestations, with a heavy coccidia infestation (2972 eggs/g). The average cestode load varied around an average of 928 EPG, from a minimum of 100 EPG to a maximum of 170,000 EPG. The physical characteristics of the animals and the rearing practices studied had little influence on nematode and coccidia parasite loads (Table 1). Analysis of variance revealed no significant differences in cestode and coccidia parasite loads except for species, breed and sex. The ara-ara breed of sheep and males had significantly higher loads.

The distribution of animals according to parasite load shows that overall 36.7% and 39.6% of small ruminants are subject to heavy infestation (more than 700 eggs/g faeces) of nematodosis and coccidiosis respectively (Figure 3b and d). The prevalence of cases of heavy cestode infestation was observed in only 9 individuals, i.e. 3.3% of the animals studied (Figure 3c).

The chi-square test revealed similar distributions of nematode and cestode parasite loads between goat and sheep species, which are similar to the overall structure of small ruminants. On the other hand, this distribution

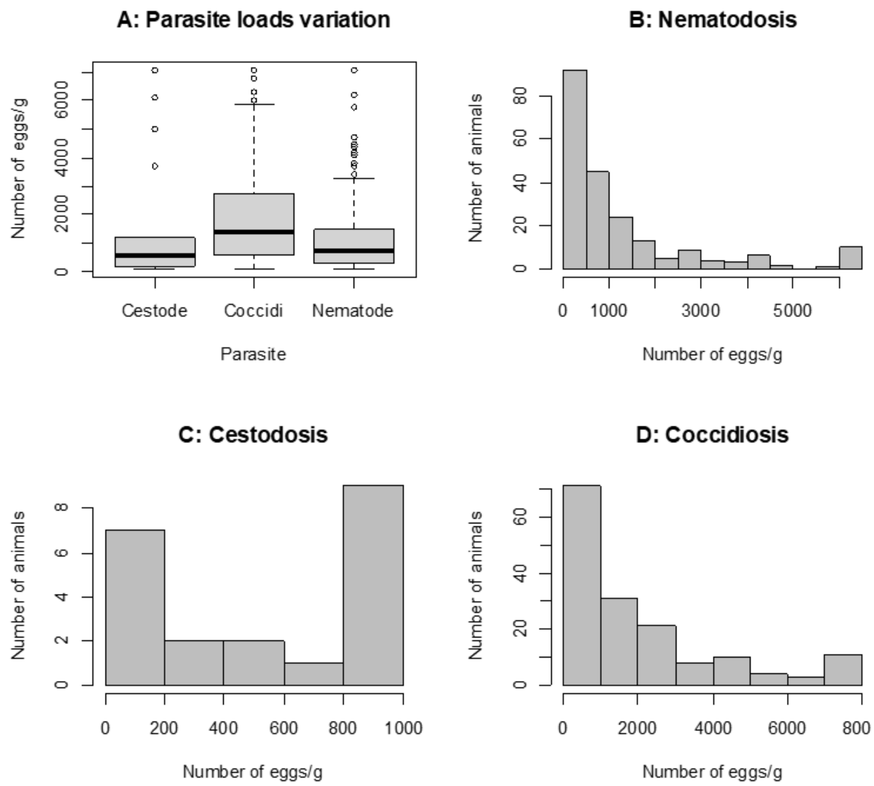

Figure 3: Average and distribution of EPG parasite loads in small ruminants

was significantly different (p= 0.008) between the two species for coccidiosis. The prevalence of parasitic loads of more than 700 eggs/g was 48.9% in sheep and 30.4% in goats; the chi-square test revealed similar distributions of nematode and cestode parasite loads between goat and sheep species, which are similar to the overall structure of small ruminants. On the other hand, this distribution was significantly different (p= 0.008) between the two species for coccidiosis. The prevalence of parasitic loads of more than 700 eggs/g was 48.9% in sheep and 30.4% in goats.

Prevalence of parasitosis and co-infection

The prevalences of parasitoses assessed indirectly from parasitic egg excretions for all small ruminant species were 79.3, 7.8 and 58.9% respectively for nematodosis, cestodosis and coccidiosis (Table 2). The prevalence of coccidiosis was significantly different (p=0.024) in the two species, with a higher prevalence in sheep (65.2%) than in goats (52.6%). Analysis of prevalence also showed a higher level of cestodosis in sheep (10.4%) than in goats (5.2%), with differences bordering on significance (p=0.086). Finally, the same prevalence of nematodes (79.3%) was observed in both sheep and goats.

The chi^2 test showed no significant difference in the prevalence of nematodiasis according to the physical characteristics of the animals studied (Table 2). Only watering practices had a significant impact on the degree of nematode infestation in the herds. The prevalence of nematode egg excretion remained high when both ponds and wells were used as water sources. It should also be noted that the prevalence of nematode egg excretion was higher in small ruminants that were body condition, and that improvements in body condition reduced the prevalence.

For cestodosis, significant differences in its prevalence were observed according to the age of the animals, with juveniles and adults being the least affected (Table 2). Here too, a significant non-significant difference was observed between goats and sheep.

However, the prevalence of coccidiosis varied according to species, breed, size and watering method (Table 2). Coccidiosis was significantly more frequent in ara-ara sheep and in animals of small to medium size. It was significantly lower in Sahelian goats and in larger animals. The watering source that most significantly reduced coccidiosis was the well.

Analysis of co-infection shows that its prevalence is significantly lower in larger animals and in those fed with the puis. A significant non-significant difference was also observed according to the weight of the animals. Small ruminants with a good body weight had less co-infection.

Among the 270 faecal samples analysed, the prevalence of nematodosis as a single parasite was higher (30.7%) than that of coccidiosis and cestodosis, which were 11.1

Table 2: Variation in the prevalence of parasite egg excretion in small ruminants

[1]Factors	Modalities	n	Nematodosis (%)	Cestosis (%)	Coccidiosis (%)	Co-infection (%)
Overall prevalence		270	79.3	7.8	58.9	49.3
Species	Goat	135	79.3a	5.2a	52.6	45.2
	Sheep	135	79.3a	10.4a	65.2	53.3
	P-value		1.00	0.086	0.048	0.223
Breed	Ara-ara	34	75.6a	2.9a	85.3a	64.7
	Bali-bali	45	75.6a	13.3a	57.8b	48.9
	Oudah	56	83.9a	12.5a	58.9b	50.0
	Sahel	135	79.3a	5.2a	52.6b	45.2
	P-value		0.734	0.109	0.007	0.247
Sex	Male	42	78.6a	9.5a	71.4	57.1
	Female	228	79.4a	7.5a	56.6	47.8
	P-value		0.905	0.418	0.072	0.315
Age class	Adult	182	79.1a	6.0a	56.0	47.3
	Juvenile	47	74.5a	2.1a	70.2	46.8
	Sub-adult	41	85.4a	22.0b	58.5	61.0
	P-value		0.452	0.002	0.212	0.277
Body condition	Good	119	75.3a	6.3a	57.6	43.7
	Medium	88	83.8a	10.5a	61.0	57.1
	Poor	7	100a	0.00a	57.1	57.1
	P-value		0.098	0.317	0.860	0.085
Template	Large	59	76.3a	3.4a	39.0a	30.5a
	Medium	145	80.0a	11.0a	64.8b	56.6b
	Small	66	80.3a	4.6a	63.6b	50.0b
	P-value		0.814	0.102	0.002	0.003
Watering	Borehole	30	80.0ab	13.3a	63.3ab	53.3ab
	Pond-Well	30	60.0a	6.7a	73.3b	43.3ab
	Pond	60	85.0b	8.3a	71.7b	65.0b
	Well	150	80.7ab	6.7a	50.0a	43.3a
	P-value		0.043	0.651	0.008	0.033

[1]The proportions of columns having no letters in common are significantly different at the 5% threshold.

and 1.5% respectively. Only twenty (20) or 7.4 % of the animals did not carry any gastrointestinal parasites (Figure 4a). Similarly, parasite quantification showed that di-parasitism and mono-parasitism were more prevalent in small ruminants, with proportions of 45.2% and 43.3% respectively. Triple parasitism was less frequent (4.1%).

Parasitic associations were significantly similar (p=0.105) in both species, with a fairly marked dominance of the double nematode-coccidiosis association and a low prevalence of the triple association (Figure 4 b and c).

Analysis of parasitic associations by species showed that in sheep, the most important single-parasitism was nematodosis and coccidiosis, with 27% and 14% respectively. The double nematode/coccidia association (43.7%) was the most frequent. Other types of double cestode/coccidia association and cestodosis monoparasitism were almost non-existent (0.7%). Parasite quantification in goats showed that it was mainly mono- and di-parasitism that were more frequently detected.

Detailed analysis of risk groups

Logistic regression of the risk factors for nematodosis showed that the breed and the source of drinking water were still significantly decisive (p<0.05, Table 3). Marginal effects indicate that Sahelian goats and oudah breeds are respectively 19 and 20.2% less likely to develop nematodosis parasitism than Tuareg ara-ara sheep. Also, the combined use of ponds and wells reduced this parasitism by 20.5% in small ruminants compared with animals that were always watered only at wells.

Olds ratios clearly show the significant degree of risk associated with breed and source of drinking water (Figure 5). The Olds ratios, on the other hand, indicate that male sex, medium to large body size and poor body condition are non-significant risk factors.

Table 3: Risk factors for nematodosis in small ruminants

[1]Factors	Modality	Df /Dx	Odds Ratio	2.5 %	97.5 %	P-value
Breed	**Reference =Ara-ara**					
	Bali-bali	-0.111	0.598	0.230	1.53	0.287
	Oudah	-0.202	0.375	0.146	0.94	0.037 *
	Sahel	-0.190	0.433	0.187	0.99	0.048 *
Sex	**Reference = Female**					
	Male	0.139	1.788	0.797	4.07	0.160
Age class	**Reference =Adult**					
	Juvenile	0.057	1.277	0.502	3.22	0.604
	Sub-adult	0.074	1.371	0.601	3.09	0.448
Template	**Reference = Large**					
	Small	-0,090	0.888	0.437	1.82	0.743
	Medium	-0.027	0.666	0.256	1.70	0.398
Body condition	**Reference = Good**					
	Medium	0.050	1.244	0.714	2.16	0.439
	Poor	0.082	1.412	0.250	7.14	0.676
Watering pratices	**Reference =Well**					
	Borehole	-0.126	0.550	0.210	1.33	0.199
	Pond	0.030	1.138	0.603	2.132	0.688
	Pond and Well	-0.205	0.3505	0.1198	0.891	0.038*

[1] * $p < 0.05$; ** $p < 0.01$

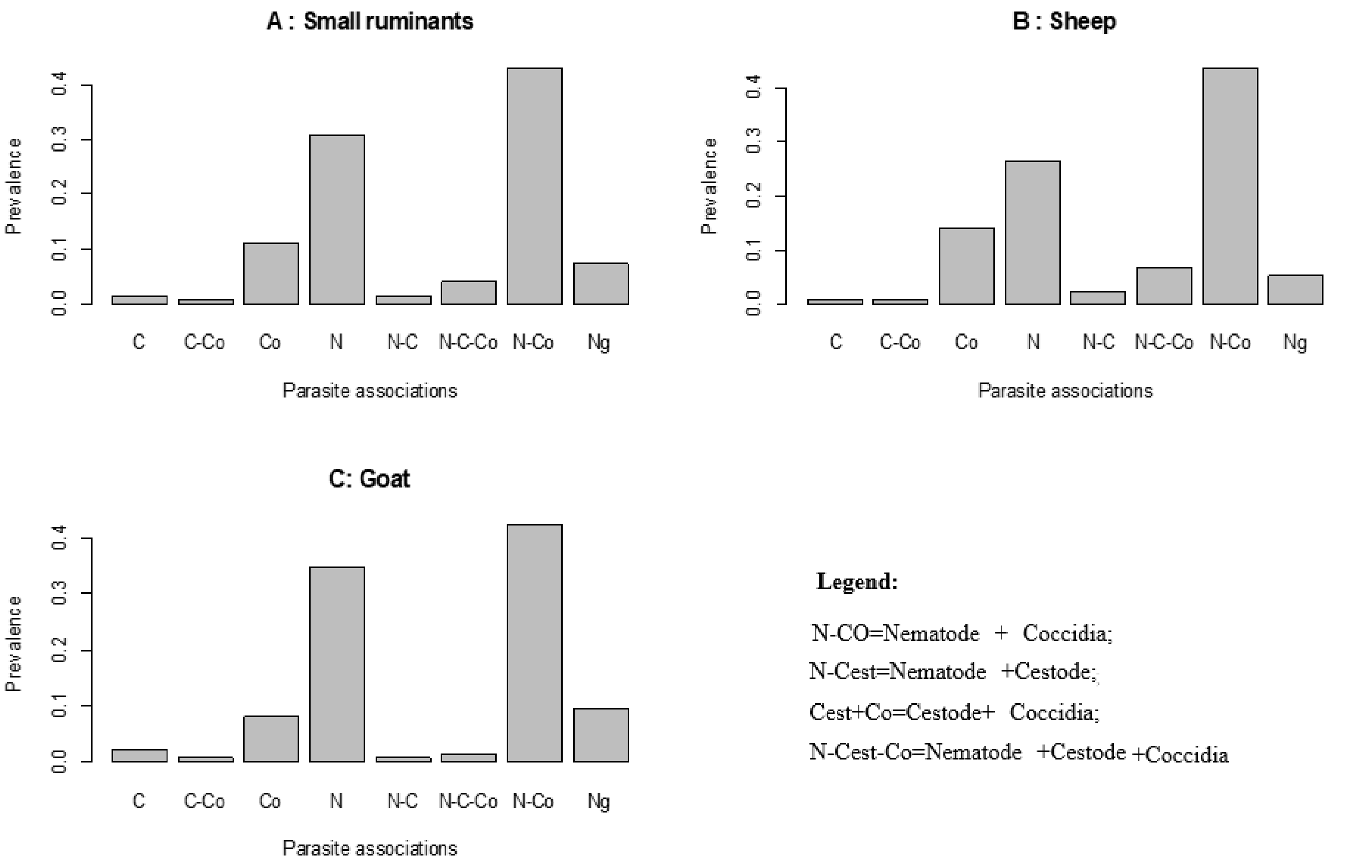

Figure 4: Prevalence of parasitosis and parasitic associations in small ruminants

Logistic regression also showed that breed, watering source and size were still significantly (p<0.05) determinants of risk factors for coccidiosis (Table 4). Marginal effects indicate that Sahelian goats and Fulani sheep were 26.7 and 22.9% more likely to avoid developing coccidiosis parasitism than Tuareg ara-ara sheep respectively. The combined use of ponds and wells reduced this parasitism by 20.5% in the animals compared with those that were always watered only at wells. The probabilities indicate that males, animals of medium to large size, and watering of the animals at the waterhole or with the well are secondary risk factors, as they are not significant.

Table 4: Risk factors for coccidiosis in small ruminants

[1]Factors	Modality	Df / Dx	Odds Ratio	2.5 %	97.5 %	P-value
Breed	Reference =Ara-ara					
	Bali-bali	-0.229	0.331	0.120	0.876	0.029 *
	Oudah	-0.102	0.638	0.250	1.58	0.337
	Sahélienne	-0.267	0.314	0.131	0.724	0.008**
Sex	Reference = Female					
	Male	0.173	2.030	0.882	4.790	0.099
Age class	Reference = Adult					
	Juvenile	-0.053	0.794	0.299	2.052	0.637
	Subadult	0.005	1.020	0.440	2.327	0.962
Body condition	Reference =Good					
	Medium	-0.035	0.860	0.481	1.527	0.609
	Poor	-0.018	0.925	0.161	4.826	0.926
Template	Reference = Large					
	Medium	0.232	2.737	1.263	6.313	0.014*
	Small	0.230	2.591	0.950	7.310	0.066
Watering pratices	Reference =Well					
	Pond	0.214	2.415	1.252	4.706	0.009**
	Pond-Well	0.067	1.321	0.544	3.139	0.530
	Borehore	0.325	3.847	1.595	9.617	0.003**

[1] * p < 0.05; **p < 0.01

The significant risk factors (p < 0.05) for the development of co-infection in small ruminants were the size of the animal and the source of water used to water the animals (Figure 6). The values of the marginal effects from the logistic regression of co-infection reveal that animals that watered from a pond were 23% more likely to develop co-infection than those that watered from a well (p=0.003). Medium-sized animals were also 12% more likely to develop co-infection than large animals.

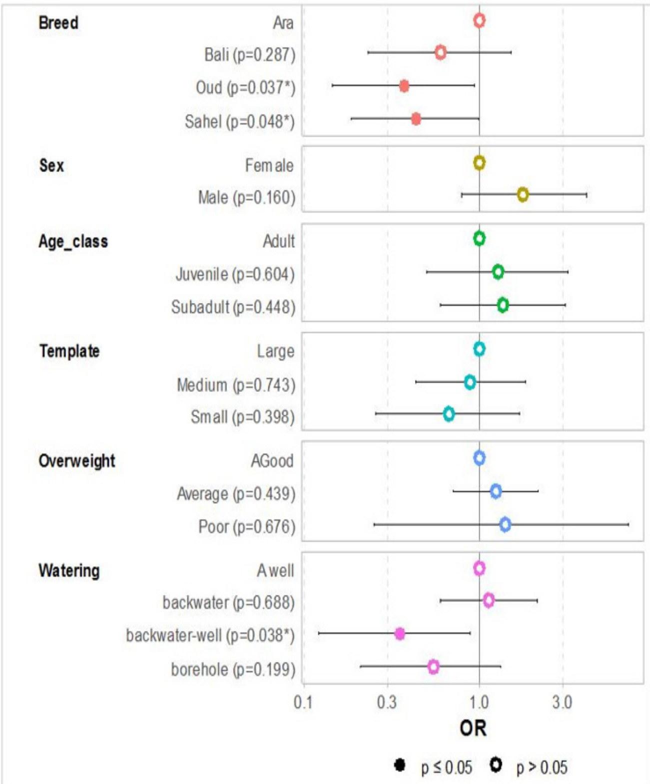

Figure 5: Odds ratios for logistic regression of nematodosis

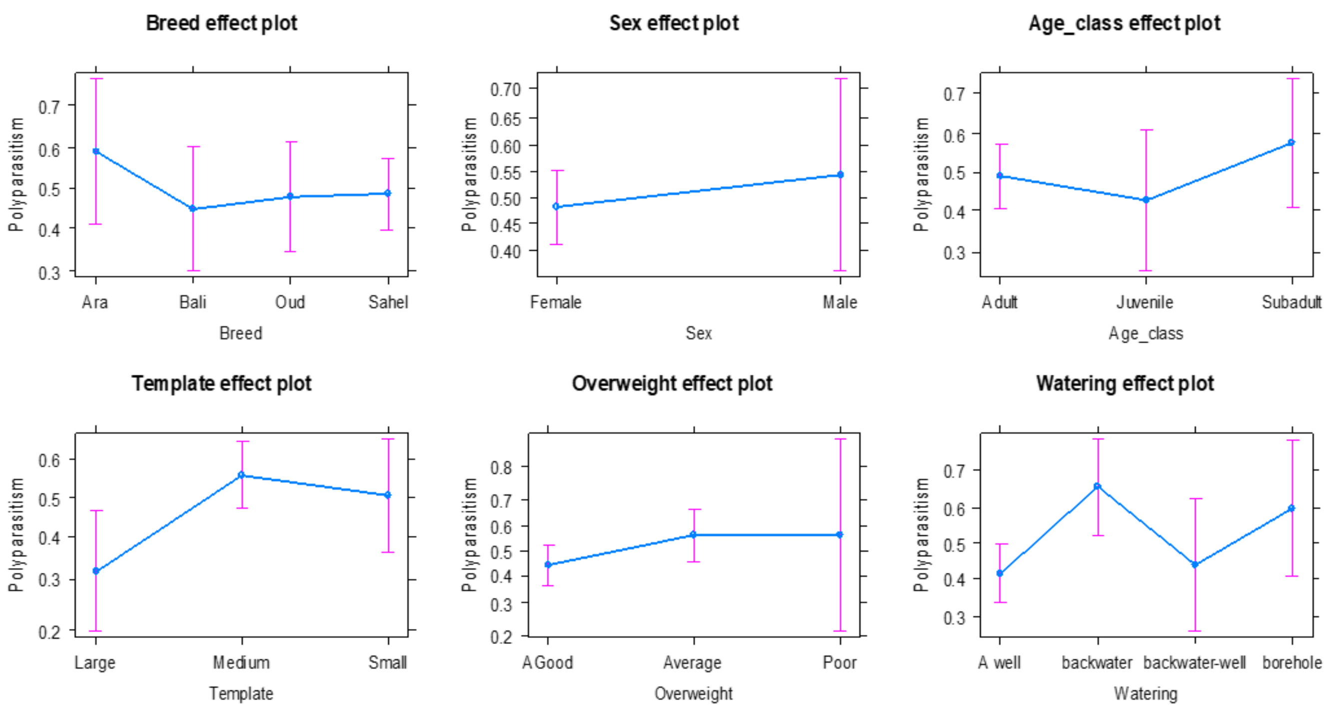

Figure 6: Effects of risk factors on co-infection in small ruminants

DISCUSSION

This study of small ruminants on peri-urban farms in the Tahoua region provided information on the composition of the parasitic fauna of three groups of parasites: nematodes, cestodes and coccidia. It revealed a preponderance of co-infection in goats and sheep. Their prevalence and degree of infestation were assessed according to risk factors.

In the peri-urban farms studied, average parasite loads varied according to the three parasite classes, from 974 to 2972 eggs/g of faeces in goats and from 2080 to 8390 eggs/g of faeces in sheep. According to Giboudeau (2008), the parasite infestation threshold can be assessed at various levels. For nematodes, above 600 EPG, the infestation is heavy, moderate when the parasite load is in the 300-400 EPG range and considered light when the parasite load is below 300 EPG. For coccidia, Giboudeau's (2008) typology of the degree of infestation corresponds respectively to parasite loads of more than 1000 EPG (heavy), 600-1000 EPG (moderate) and less than 600 EPG (light). More recent classifications by Autef (2017) impose a lower limit of 500 EPG or even 700 0PG for heavy infestations (Hansen and Perry, 1994; Tisdell *et al.*, 1999; Mamoudou *et al.*, 2016). Compared with these reference standards, we can see heavy parasite loads for coccidiosis and nematodosis in both goats and sheep, and light loads for cestodosis in goats.

In fact, average egg excretion for the three classes of parasites is very high compared with generally accepted levels in small ruminants (Troncy and Chartier, 2000; Sassa *et al.*, 2014) and even in cattle (Ntonifor *et al.*, 2013; Djawe *et al.*, 2019). This high excretion can be explained by the dominance of certain species such as H. contortus, a highly prolific strongle (Barry *et al.*, 2002). Indeed, given their frequency and the intensity of infestation, the most important helminths reported in the same area as that of the present study were Haemoncus contortus, the genera Stilesia, Strongyloides and papillosus (Tager-Kagan, 1986).

Moreover, these parasite loads only reflect the parasite infestation. In fact, egg excretion levels can be influenced by the physiological stage of the animals. Stress during parturition or a lack of nitrogen will result in greater parasite excretion. In addition, the level of infestation depends very much on the species of parasite in question. For species such as Haemonchus contortus and Trichostrongylus colubriformis, the intensity of egg excretion is strongly positively correlated with the degree of infestation (Roberts *et al.*, 1982).

The results showed that the prevalence and egg excretion of the parasites studied were greater in sheep than in goats. The extensive farming method, flock management and grazing behaviour of goats seem to limit the risk of infestation and could explain the low parasite intensity in most animals (Barry *et al.*, 2002). Differences in feed preference between ruminant species could also influence the level of infestation in animals.

Double or triple parasitic association was observed in both goats (45.2%) and sheep (53.3%), with a predominant nematode/coccidian association. Thus, co-infection was observed in 49.3% of the animals studied, compared with 99% in a study reported by Barry *et al.* (2002) where 92% of the subjects examined harboured four or more species. As a reminder, in the same area as the present study, 60 to 80% of animals showed co-infection in which gastrointestinal strongyles were associated with cestodes (Tager-Kagan, 1986). Another form of digestive tract co-infection represented by Eimeria (70%), Bunostomum (55%), Trichostrongylus (40%) and Strongyloides (27%) was also reported (Gretillat, 1981). In parasitic communities, correlations between different populations or species can be positive or negative. The association of cestodes and several species of gastrointestinal nematodes, as observed in the present study, can lead to reduced growth and increased mortality in young (Gretillat, 1981).

With regard to the risk factors associated with gastrointestinal parasitism, young and sub-adult animals, the ara-ara breed of sheep and the use of ponds as a source of water for the animals were the most decisive for at least two of the three groups of parasites studied, with differences that were sometimes highly significant for both prevalence and EPG parasite loads. These strong variations according to age class and breed could be linked to the level of immunity of the host. Indeed, young animals, with their very precarious immunity, are more susceptible to parasites, as noted by Wymann *et al.* (2005) in calves. This may also be linked to the late acquisition of immunity to parasites in young animals. The risk factors associated with parasitism by the three main gastrointestinal parasites, namely the animal's young age, breed and poor hygiene, are corroborated by previous studies (Bélanger *et al.*, 2007; Rozette, 2009).

CONCLUSION

A high prevalence and loads of heavy egg excretions of nematodes, cestodes and coccidia were observed in small ruminants from peri-urban farms in Tahoua. A high degree of co-infection involving these parasites was also observed in almost half the animals studied (49.3%). We still need to analyse the spectrum of species - such as those often blamed for major losses in productivity - in order to make a more accurate diagnosis and possibly assess the issues involved in combating these parasites with a view to improving the productivity of small ruminant herds.

The main risk factors for parasitosis, the impact of which was highly significant, were species, breed, body condition, animal size and water source. The study also revealed that, in these peri-urban areas, farming systems remain 100% traditional, with feed based essentially on natural grazing. In these conditions, where antiparasitic treatment is not effective, let alone regular, control of these parasites by selective treatment of animals should be developed, targeting in particular the risk groups highlighted in this study by logistic regression, namely juvenile animals, animals in poor nutritional condition and high-risk breeds such as the Tuareg ara-ara sheep. Supplementation is also needed to improve the nutritional level of the animals.

The extent of the parasite infestation reported in this study opens up the question of how to manage gastrointestinal parasitism on our farms, which has hitherto been considered a minor disease.

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