OPEN ACCESS
Advances in Animal and Veterinary Sciences

Research Article

Prevalence and Risk Factors Associated with Bovine Schistosomiasis in the North, Adamawa and West Regions of Cameroon

Alain Kouam Simo[1], Roland Nankam Chimi[1*], Stevine Ngoueni Megouo[1], Ariane Megne Fossouo[1], Félicité Flore Djuikwo-Teukeng[2], Mamoudou Abdoulmoumini[3]

[1]School of Veterinary Medicine, Higher Institute of Health Sciences, Université des Montagnes Bangangte, Bangangte P.O. Box 208, Cameroon; [2]School of Biomedical Sciences, Higher institute of Health Sciences, Université des Montagnes Bangangté, Bangangte P.O. Box 208, Cameroon; [3]Laboratory of Parasitology, School of Science and Veterinary Medicine, University of Ngaoundere, P.O. Box 454 Ngaoundere, Cameroon.

Abstract | Schistosomiasis is a neglected zoonosis in Cameroon, but remains enzootic in some agro-ecological zones of the country. This study evaluated the prevalence and risks factors of bovine schistosomiasis in the North, Adamawa and west, regions of Cameroon. A total of 700 cattle were examined in slaughterhouses in the Adamawa, North and West regions from February to September 2023.Screening methods by visual exploration of the mesenteric veins in search of adult worms and coproscopic analysis using the filtration technique were used. This last technique, although being the technique of choice because it is done on animals in ante-morten, gives less reliable results than macroscopic observation in post-mortem. Of the 700 animals explored, we had a total 50.6% of animals affected by schistosomiasis with prevalence's of 13.7% and 50% respectively in coproscopy and macroscopic exploration of the mesenteric veins. A multivariate analysis between the factors predisposing the appearance of schistosomiasis and its prevalence showed us significant variations, the region of origin of the animals ($p=0,0001$), the department (p=0,0001), the breed ($p=0,0001$), body condition score ($p=0,0001$), body condition ($p=0,002$), watering site ($p=0,0001$). Bovine schistosomiasis is endemic in the northern and Adamawa regions of Cameroon. This pathology is favoured by factors such as the place of watering, the body condition score, and the place and department of origin of the animal. On this basis, it would be necessary to monitor the management of this disease and put in place means of preventing it.

Keywords | Prevalence, Bovine schistosomiasis, *Schistosoma bovis*, Adamawa, North, Cameroon

Received | April 09, 2024; **Accepted** | May 17, 2024; **Published** | July 12, 2024
***Correspondence** | Roland Nankam Chimi, School of Veterinary Medicine, Higher Institute of Health Sciences, Université des Montagnes Bangangte, Bangangte P.O. Box 208, Cameroon; **Email:** rnankam@udm.aed-cm.org
Citation | Kouam SA, Nankam CR, Ngoueni MS, Megne FA, Djuikwo-teuKeng FF, Mamoudou A (2024). Prevalence and risk factors associated with bovine schistosomiasis in the north, Adamawa and West regions of Cameroon. Adv. Anim. Vet. Sci., 12(8):1614-1621.
DOI | https://dx.doi.org/10.17582/journal.aavs/2024/12.8.1614.1621
ISSN (Online) | 2307-8316

INTRODUCTION

Schistosomiasis, also known as bilharzia or snail fever, is a helminthiasis that occurs in tropical and subtropical areas and is caused by trematodes of the genus Schistosoma, of which several species have been described, affecting both humans and animals (Luogbou *et al*., 2015). It currently affects 200 to 300 million people in around 74 countries (Mekonnen, 2020). The vast majority (80-85%) of schistosomiasis cases are found in sub-Saharan Africa (Mekonnen, 2020). This parasitic infestation also affects animals, more specifically cattle and rarely other domestic animals in Africa and Asia (Endris and Alemneh, 2017). These animals can be infested by 19 species of schistosomes, five of which are the focus of particular attention in veterinary medicine due to the severity of the associated infection observed in domestic ruminants in Africa (*S. curassoni*, *S. matthei*, *S. bovis*) and Asia (*S. mekongi* and *S. japonicum*) (King *et al*., 2015). Ruminants, and cattle in particular, are prone to schistosomiasis, the pathology being much more marked in the acute and sub-acute phase (6 to 12 weeks after infestation) where animals are noted with a reduction in meal intake associated with inappetence leading to weight loss ranging from 44 to 50% (with an average of 6kg/week). Mucoid and bloody diarrhoea was also observed, along with a mortality rate of 7.3% (Mccauley *et al*., 1984; Saad *et al*., 1984). Anaemia was observed between the 5th and 12th week post-infection, and hyper-proteinemia and eosinophilia were observed in affected animals. In the chronic phase (9 months after infestation), appetite is apparently normal but weight loss of 2 kg/week is observed (Dargie, 1980; Alexandra, 1998). These economic losses (mentioned above) are therefore considerable in the livestock sector, mainly due to mortality (around 7.3%), reduced fertility, lower productivity and stunted growth following weight losses of 44-50%. (Lefevre *et al*., 2010; Okpala *et al*., 2004; Pichford and Visser, 1982).

Two studies carried out in Cameroon report a prevalence of 79.5% in cattle in the North Cameroon region and 19.5% in cattle slaughtered in Yaoundé and Douala abattoirs (Ousseni, 1990; Djuikwo-Teukeng *et al*., 2019). Although this information is available, data on the epidemiology of the disease in cattle in Cameroon are not fully known throughout the country. As Djuikwo-Teukeng *et al*. (2022) demonstrated, cattle watering points are home to molluscs that can be intermediate hosts for bovine and human schistosomiasis, making this a public health problem. Genuine knowledge of the epidemiology in Cameroon's priority cattle-breeding areas (the north of the country and the west) would enable us to place particular emphasis on the measures to be taken to combat the disease as a public health problem.

MATERIALS AND METHODS

Institutional review board statement

The animal study protocol was approved by the Institutional Review Board (or Ethics Committee) of Universite des Montagnes (N° UdM-BUR-CPR-2021/006) for studies involving animals. The regional delegations in charge of animal health authorized the investigation in the three regions of Cameroon: Adamawa (N° 08/21/RA/DREPIA/SRSV), North (N° 39/21/1/RN/DREPIA/SRSV) et West (N° 04/23/MINEPIA/SG/DREPIA-O/SRAG). The animal production development company (SODEPA) in charge of the beef food chain has authorized (N°1079/I/2022/SODEPA/DG/DPC/SDT/SR) the investigation and collection of data in the slaughterhouses of these three regions. Slaughterhouse staff were informed of the purpose of the study and the approximate duration of the interview, and their informed consent was sought prior to their participation in the survey.

Study area description

The study was carried out over an 8-month period from February to September 2023, in abattoirs in the North (Guider, Pitoa and Garoua I districts), Adamawa and West (Dang, Ngaoundere II and Meiganga districts) and West (Bafoussam and Foumban districts) regions (Figure 1). The North and Adamawa regions constitute, along with the Far North region, most of the production of ruminants in Cameroon. The Adamawa region extends from 6°30′0″ north latitude to 13°30′0″ east longitude and the prevailing climate is cool, ranging between 22 and 25°C. The northern region extends between 8° and 10° north latitude and 12° and 16° east longitude, and the climate is hot and semi-arid, with a rainy season from mid-May to September, while the rest of the year is characterized by heat and drought. The western region lies between 5°32′60″ north latitude and 10°34′80″ east longitude and has an equatorial Cameroonian climate with temperatures varying between 11°C and 30°C, with an average of 22°C. The climate, the mobility of the animal and human populations and the agricultural activity of these three regions are favorable factors for the survival of intermediate hosts, which could allow the endemicity of schistosomiasis. The animal populations studied consisted of cattle (zebus and bulls) slaughtered in abattoirs in these different localities. The cattle were aged from 2 to over 10 years of both sexes, and of four different breeds. A mini-questionnaire was administered at the butchers to get an idea of the provenance of the animals slaughtered, the production system used for these animals, which shed light on feeding and watering sites, and the animal's physical condition, which was taken into account in the animal's assessment.

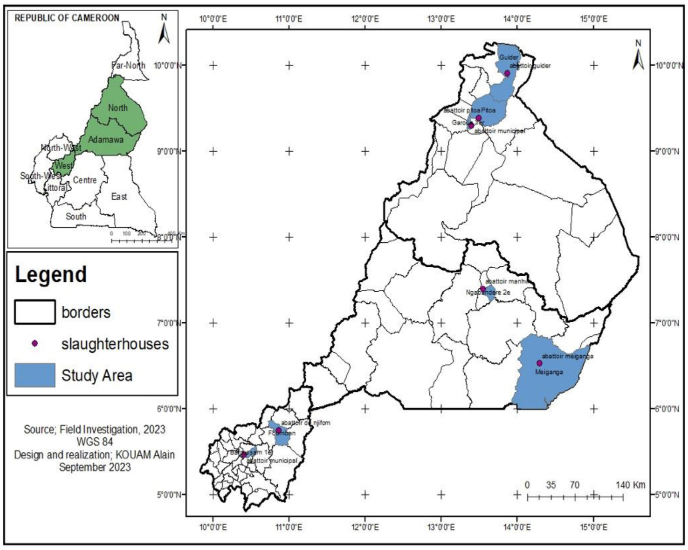

Figure 1: Map showing the study regions (Adamawa, North, West) in Cameroon.

Links Researchers

Sampling procedures

The minimum size of 250 sample was calculated according to the formula proposed by Thrus Field's (Thrusfield, 2018). This formula calculates the minimum sample size, taking into account the 5% precision with a value for a normal distribution corresponding to a confidence level of 95% and the expected prevalence. The expected prevalence of 79.5% of bovine schistosomiasis in Cameroon obtained by Ousseini in 1990 was used (Ousseni, 1990). Random sampling on two levels was used in this study. Firstly, simple random sampling was carried out among abattoirs in the three regions studied. A total of 8 abattoirs were selected and distributed across these regions. Secondly, simple random sampling was carried out among the animals slaughtered per day in the chosen abattoir. All cattle slaughtered in abattoirs in the selected regions were included in the study. The random choices we make about our animals and slaughterhouses, as all animals carrying the disease do not always show the same signs whether we are at the beginning or end of the infection. This inclusion criterion made it possible to obtain a sample of 700 cattle faeces from which the mestitic vein was examined.

Data collection and examining the viscera

After identifying the animals and their origins, a thorough examination was conducted to determine breed, age, sex and body condition before slaughter. The age of animal was determined according to the time of eruption and the degree of wear of the teeth, as described by Ron *et al*. (2003). The body condition score was based on the visibility of the sides, the spinous processes and the chest muscle as described by Lalman *et al*. (2021). After slaughter, the viscera were recovered and emptied of their contents, and the mesenteric veins were observed using a torch on the reverse side of the viscera for transparency. The adult schistosomes observed were collected in a petri dish with a solution of sodium isocitrate and NaCl (8.5 g NaCl + 7.5 g sodium isocitrate in 1 liter of spring water). Using a binocular magnifying glass, the worms obtained are separated and deposited in 1.5 mL Eppendorf tubes containing 95% ethanol.

Method of coproscopic exam by filtration

Faeces were collected directly from the rectum before slaughter or directly after slaughter. The samples collected (faeces) were transferred to sampling pots and placed in a cooler at a temperature of 4°C allowing the development of microorganisms to be stabilized and these will be sent to the laboratory for analysis. Subsequently for analysis, the filtration method is used to search for schistosome eggs. This method consists of recovering a quantity of faecal matter (50g), mixing it with water and passing the mixture through sieves of decreasing size ranging from 315 µm to 45 µm. The mixture is poured into the first 315 µm mesh sieve, the pressure water is poured through this allowing the eggs to pass through these different sieves which will be harvested in the 45 µm mesh sieve. On this last sieve is obtained a pellet, of which about 0.5ml added to distilled water is poured each time into 3 to 4 Petri dishes for observation with a binocular magnifying glass with the 4X objective in search of egg of schistosome.

Data analysis

Data were analyzed using the R Foundation for Statistical Computing software package: R i386 4.1.2 (Copyright 2021) (R Core Team, 2019). Prevalence was calculated using this software. Chi-square test and logistic regression analysis were used to compare the proportions of positivity of detected samples between different regions and between different animals in order to identify risk factors associated with bovine Schistosomiasis. The confidence level was set at 95% for all analyses, and differences were considered significant at $P \leq 0.05$. and $P \leq 0.01$.

RESULTS AND DISCUSSION

Distribution of population animal by major characteristics

Table 1 shows first presente the characteristics of the cattle studied in the study regions. Table 1 shows that cattle from the northern region (46%) were the most represented in this study, with females predominating (70.1%). Most of these animals were aged between 6 and 10 years, and the Goudali breed was predominantly represented (43.3%), followed by the White Fulani breed (32.3%). They were mostly in normal body condition (68.6%).

Table 1: Distribution of population animal by major characteristics.

Variable	Categories	N (%)
Regions	North	322(46)
Sex	Female	491(70.1)
Age	(6-10 ans)	352(50.2)
Breed	Goudali	303(43.3)
Body condition note	Normal	360(51.4)
Body condition	Good	480(68.6)
Breeding mode	Extensive	528(75.4)
Watering site	River	552(78.9)

Prevalence of bovine schistosomiasis as a function of the characteristics of cattle slaughtered in the study slaughterhouses

The Table 2 presente prevalence of bovine schistosomiasis as a function of the characteristics of cattle slaughtered in the study slaughterhouses. Out of a total of 700 animals examined, 354 (50.6%) were positive for schistosomiasis. Of these, 96 (13.7%) tested positive for adult worms on

Table 2: Prevalence of bovine schistosomiasis as a function of the characteristics of cattle slaughtered in the study slaughterhouses.

Variable	Categories	N (%)	Visualization for adults N(%)	Egg visualization N(%)
Prevalence	Animals	354(50.6)	350(50)	96(13.7
Region	North	322(46)	265 (82.3)	78(24.2)
	West	100(14.3)	11(11)	0
Sex	Female	491(70.1)	244(49.7)	68(13.5)
	Male	209(29.9)	106(50.7)	32(15.3)
Age	(2-5 ans)	342(48.9)	176(51.5)	52(15.2)
	> 10 ans	6(0.9)	4(66.7)	1(16.7)
Physical condition	Poor	42(6)	33 (78.6)	13(31)
	Good	480(68.6)	231(48.1)	58(12.1)
Breeding mode	Semi extensive	172(24.6)	100(58.1)	22(12.8)
Watering site	River	552(78.9)	259(46.9)	80(14.5)

Table 3: Binary logistic regression model for factors associated with bovine schistosomiasis infection rate in the study area.

Variable	Categories	N(%)	Visualization for adults			Egg visualization		
			n (%)	OR (95% IC)	P-value	%	OR (95% IC)	P-value
	North	322(46)	265 (82.3)	Ref		78(24.2)	Ref	
	Adamawa	278(39.7)	74 (26.6)	12.82(0.43-0.8)	0.0001	22(7.9)	3.72 (0.48-1.17)	0.0001
Regions	West	100(14.3)	11(11)	0.34 (1.18-2.90)	0.0013	0	0 (0.64-2.29)	0.0037
Departe-ments	Vina	200(28.6)	65(32.5)	Ref		16(8)	Ref	
	Bénoué	252(36)	206(81.7)	9.30 (1.26-2.36)	0.0001	68(27)	4.25 (0.83-1.97)	0.0001
	Mayo-louti	70(10)	59(84.3)	11.14 (0.38-1.05)	0.0001	10(14.3)	1.96 (0.49-2.02)	0.1249
	Mbéré	78(11.2)	9(11.5)	0.27 (0.49-1.273)	0.0004	6(7.7)	0.96 (0.30-1.41)	0.932
	Foumban	50 (7.1)	10(20)	0.52 (0.56-1.77)	0.0845	0	0.0 (0.25-1.67)	0.0387
	Bafoussam	50(7.1)	1(2)	0.04 (1.02-3.37)	0.0001	0	0.0 (0.75-3.22)	0.0387
Breeds	White fulani	226(32.3)	127(56.2)	Ref		41(18.1)	Ref	
	Goudali	303(43.3)	114 (36.6)	0.47 (1.14-2.08)	0.0001	30(9.9)	2.02 (0.77-1.82)	0.006
	Red-fulani	165(23.5)	108(65.5)	1.48 (0.37-0.76)	0.0648	28(17)	1.08 (0.36-1.08)	0.764
	Holstein	6(0.9)	1 (16.7)	0.16 (0.02-1.70)	0.0547	1(16.7)	0.90 (0.13-10.39)	0.926
Sex	Female	491(70.1)	244(49.7)	Ref		68(13.5)	Ref	
	Male	209 (29.9)	106(50.7)	1.04 (0.69-1.32)	0.8043	32(15.3)	1.12 (0.56-1.44)	0.613
Age	(2-5 ans)	342(48.9)	176(51.5)	Ref		52(15.2)	Ref	
	(6-10 ans)	352(50.2)	170(48.3)	0.88 (0.91-1.65)	0.404	47(13.4)	0.86 (0.64-1.5)	0.485
	> 10 ans	6 (0.9)	4(66.7)	1.89 (0.58-13.51)	0.46	1(16.7)	1.2 (0.13-10.39)	0.921
NEC	Normal	360(51.4)	153(42.5)	Ref		45(12.5)	Ref	
	Fat	36(5.2)	25(69.4)	3.07 (0.35-1.38)	0.0019	6(16.7)	1.40 (0.16-1.76)	0.476
	Fat+	7(1)	4(57.1)	1.80 (0.48-13.06)	0.438	2(28.6)	2.80 (0.11-1.39)	0.207
	Skinny	47(6.7)	33(70.2)	3.19 (0.99-3.39)	0.0003	6(12.8)	1.02 (0.56-2.76)	0.958
	Skinny	26(3.7)	17(65.4)	2.56 (0.85-4.40)	0.0232	7(26.9)	2.58 (0.11-2.10)	0.037
	Skinny-	7(1)	4(57.1)	1.80 (0.69-6.01)	0.438	0	0.0 (0.11-8.39)	0.318
	Normal-	105(15)	60(57.1)	1.80 (2.52-6.63)	0.0081	23(21.9)	1.96 (0.95-2.78)	0.016
	Normal+	112(16)	54(48.2)	1.26 (1.72-4.11)	0.2872	11(9.8)	0.76 (0.94-2.69)	0.443
Physical condition	Good	480(68.6)	231(48.1)	Ref		58(12.1)	Ref	
	Average	178(25.4)	86 (48.3)	1.01 (1.05-2.09)	0.9655	29(16.3)	1.42 (0.68-1.77)	0.156
	Poor	42(6)	33 (78.6)	3.95 (2.09-3.08)	0.0002	13(31)	3.26 (0.78-3.66)	0.0006
Breeding mode	Extensive	528(75.4)	250(47.3)	Ref		78(14.8)	Ref	
	Semi-extensive	172(24.6)	100(58.1)	1.54 (0.75-1.50)	0.014	22(12.8)	0.85 (0.43-1.24)	0.518
Watering site	Borehole water	75(10.7)	60(80)	Ref		11(14.7)	Ref	
	River	552(78.9)	259(46.9)	0.22 (0.31-0.67)	0.0001	80(14.5)	0.98 (0.45-1.23)	0.953
	Well water	15(2.1)	8(53.3)	0.50 (1.11-2.52)	0.2993	3(20)	1.94 (0.06-4.23)	0.365
	Tap water	58(8.3)	22(37.9)	0.15 (0.67-1.99)	0.0001	6(10.3)	0.67 (0.72-2.91)	0.459
Infestation rate	none	350(50)	0	Ref		4(1.1)	Ref	
	Important	67(9.6)	67(100)	0 (0.41-0.48)	0.0001	19(28.4)	34.24 (1.51-4.81)	0.0001
	Light	106(15.1)	105(99.1)	0.22 (0.37-0.45)	0.0001	23(21.7)	23.97 (1.10-3.13)	0.0001
	Medium	177(25.3)	177(100)	0 (0.29-0.37)	0.0001	54(30.5)	37.98 (2.93-7.07)	0.0001

Values in a column with "*" differ significantly at $p < 0.05$; n: number of positive animals; IC: confiance interval; OR: Odd ratio.

faecal examination and 350 (50%) tested positive for adult worms on visceral examination. The prevalence of both adult worms and eggs in faeces was higher in the northern region, at 82.3% and 24.2%, respectively. These prevalences are lower in the western region, with 11% and 0%, respectively. Although females were slaughtered the most, according to our two methods of analysis, males were more infested than females: 50.7% versus 49.7% for the presence of adult worms and 15.3% versus 13.5% for the presence of eggs in faeces. The most slaughtered animals are those aged 2 to 5 years, with an infestation of 51.5% and 15.2% respectively for adult worm visualization and egg presence, but the most infested class (66.7% and 16.7%) is that over 10 years old. Fonction on body condition, the most infested animals were those in poor condition (78.6% and 31%, respectively). They were obtained mainly from farms with extensive farming systems, but the most infested system was semi-extensive (58.1%). Most of the animals' drinking water came from rivers, and almost half (46.9%) were infested with adult forms of schistosome.

Table 4: Linear regression model analysis of the association of cattle risk factors with *Schistosoma bovis* positivity by exploration of mesenteric veins and the presence of eggs in faeces in the northern (Adamawa and North) and western regions of Cameroon.

Variable	Presence of adult schistosomes		Presence of schistosome eggs	
	P-value	$\chi 2$	P-value	$\chi 2$
Regions	0.0001*	255.99	0.0001*	51.86
Departments	0.0001*	269.24	0.0001*	59.07
Breeds	0.0001*	40.46	0.03*	8.50
NEC	0.0005*	26.26	0.04*	13.72
Physical condition	0.007*	14.59	0.002*	12.01
Breeding mode	0.014*	6.04	0.51	0.42
Watering site	0.0001*	32.92	0.59	1.88
Infestation rate	0.0001*	33.92	0.0001*	103.1

Risk factors associated with bovine schistosomiasis in the North, Adamawa and West regions

Table 3 shows a logistic regression of risk factors, and Table 4 shows the risk factors at animal level associated with *Schistosoma bovis* positivity with the presence of adults and the presence of eggs in faeces in a multivariate analysis using linear regression at $P < 0.05$. Taking into account the presence of adults, *Schistosoma bovis* was significantly correlated with region (p=0.0001), department (p=0.0001), breed (p=0.0001), body condition score (p=0.0005), physical condition (p=0.007), rearing method (p=0.014), watering site (p=0.0001) and infestation rate (0.0001). The presence of *Schistosoma bovis* eggs was significantly correlated with region (p=0.0001), department (p=0.0001), breed (p=0.03), body condition score (p=0.04), physical condition (p=0.002) and infestation rate (0.0001).

The results of the present study show a variation in the prevalence of bovine schistosomiasis depending on the site of origin of the animals and the parameters studied. Coproscopic examinations for schistosome eggs and post-mortem examinations for adult worms carried out in this study revealed a prevalence of 13.7% and 50% respectively. Our results are close to those reported by Chanie *et al.* (2012), Temesgen *et al.* (2022), but differ from those reported by Abebe *et al.* (2019) for coproscopic examination. These similarities and differences may be due to the Ethiopian climate, which is similar to our study areas in Cameroon. With regard to macroscopic examination, our results differ from those of Temesgen *et al.* (2022) and Djuikwo (2019), who found lower prevalences. This difference may be due to the method used to explore the mesenteric veins and the study period, as we covered the dry season, when animals move around more in search of green pasture. The low prevalence of bovine schistosomiasis recorded by faecal examination compared with that recorded by macroscopic observation of the mesenteric vessels may be related to the fact that adult parasites became established in the mesenteric veins at different stages and the stage of infestation may determine the emergence of eggs in the faeces. Similarly, the quantity of eggs emitted per day in the case of *Schitosoma bovis* is approximately 01 to 4.6 eggs per hour (Brumpt, 1930), which could explain the fact that at times no eggs were present in the 30g of faecal material analysed. This may also be due to the host organism's immune response to the schistosomes, which is not primarily directed at eliminating adult worms but rather at suppressing worm fecundity (Lawrence, 1974) which therefore leads to a reduction in egg production. Our results are better than those reported by Melkamu (2016) in Ethiopia, who found prevalences of bovine schistosomiasis of 10% and 22% respectively. Although there is a difference between the two methods, it may be advisable to carry out a blood test (serology) to see if the eggs are circulating in the bloodstream in animals that do not yet have the eggs in their faeces. This would make it possible to reconcile the results of visceral exploration and coproscopy.

These prevalences were observed mainly in animals in the North and Adamawa regions. Such a high prevalence could be explained by the fact that the various infested regions show an abundance of intermediate hosts, as shown by Hansen and Perry (2013), who relate the prevalence of schistosomiasis in an area to the presence of intermediate hosts and their ability to develop and survive in the environment associated with large permanent bodies of water. This prevalence is lower than that observed by (Ousseini, 1990) in the abattoirs of Garoua and Maroua, which was 79.5%. Such a difference could be explained by changes in the conditions under which cattle are reared, which are much more controlled in terms of feed and health, giving less access to high-risk areas and systematic health checks on farms. However, our prevalence is higher than that obtained by (Djuikwo *et al*., 2019), which was 19.5%. This study was carried out in the Yaoundé and Douala slaughterhouses with animals from various origins from which the infestation rate could be lower. This trend was consistent with other studies (Gebru *et al*., 2015; Yeneneh *et al*., 2012) but inconsistent with other results (Tsega and Derso, 2015; Solomon, 2008; Aylate *et al*., 2017; Ameni *et al*., 2001). This may be due to the fact that most of the local breeds present in our study have the ability to walk long distances and are therefore able to come into contact with large rivers infested with schistosome cercariae. This aptitude as a great walker enables them to make transhumance in search of pasture and are therefore in contact with areas at risk of *Schistosoma bovis* infestation. In our work, although females are the most represented, males are the most infested with schistosomiasis, both in terms of the search for adult worms and the presence of eggs in faeces. Our results are in agreement with those of (Chanie *et al*., 2012; Setargew *et al*., 2012; Merawe *et al*., 2014; Gebru *et al*., 2015; Solomon, 2008; Yeneneh *et al*., 2012). This can be explained by the fact that males move around more during the year than females, which move around less than males at a given time of year due to their physiological state.

A higher prevalence of *Schistosoma bovis* was noted in cattle with poor general condition (body condition score) with significant variation. This is in agreement with the results reported by Merawe *et al*. (2014) and Belayneh and Tadesse (2014). Some authors, notably Urqhart *et al*. (1997) and Hansen and Perry (1994) had reported that bovine schistosomes use host nutrition and compromise host immune competence, leading to predisposition to certain pathologies. We can also say that immunity doesn't just prevent the maturation of the challenge infection, but rather suppresses worm fecundity, resulting in a lower number of eggs in the faeces, which helps us understand the difference between our two analysis methods.

The rate of schistosome infestation varied significantly according to physical condition, body condition score and rearing system ($P<0.05$). It is a fact that animals belonging to the extensive management system are more exposed to infestation by schistosome parasites than those kept indoors, because animal control is less stringent than in the intensive farming system. Due to the lack of control, these animals are in permanent contact with the risk zones, i.e. the water zones containing furcocerci eliminated by the molluscs. These results are in agreement with those obtained by (Belayneh and Tadesse 2014), (Yezina 2019) and Kifle *et al*. (2022) in Ethiopia. Breeders would be well advised to provide pasture on their farms, and to ensure that watering sources are perfectly controlled to limit infestation of the animals.

CONCLUSIONS AND RECOMMENDATIONS

Bovine schistosomiasis is an endemic disease in the North and Adamawa regions, the study shows a variation in prevalence depending on the search methods for the pathogen. Similarly, significant variations were observed in the different variables analyzed in particular (the region of origin of the animals, the department, the breed, the score of body condition, the physical condition, the breeding system, the site of watering). Insufficiencies in screening for the disease lead to the maintenance of intermediate sources and hosts of the parasite and contribute to infestations and re-infestations of cattle, thus leading to a slight drop in productivity and a risk of hybridization with human schistosomes which could harm health of man and animal.

ACKNOWLEDGEMENT

The authors would like to thank all the butchers at the various abattoirs who made their work easier, as well as the SODEPA managers who provided access to these abattoirs.

NOVELTY STATEMENT

This article determines the prevalence and risk factors of bovine schistosomiasis in cattle using a novel approach which is the filtration method rarely used in cattle.

AUTHOR'S CONTRIBUTION

Mamoudou Abdoulmoumini, Félicité Flore Djuikwo-Teukeng and Alain Kouam Simo participated in the design and planning of the study. Alain Kouam Simo, Stevine Ngoueni Megouo and Ariane Megne Fossouo collected the data in the field. Alain Kouam Simo and Roland Nankam Chimi drafted the first version of the manuscript and processed the data. Mamoudou Abdoulmoumini and Félicité Flore Djuikwo-Teukeng revised the manuscript.

Conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Abebe Y, Urga B, Alebie G (2019). Prevalence and risk factors of bovine schistosomiasis in Northwestern Ethiopia. BMC Vet. Res., 15: 12. https://doi.org/10.1186/s12917-018-1757-9

Alexandra MVDC (1998). L'infection Murine par *Schistosoma bovis* analyse des paramètres parasitaires et immunologiques. Thèse scie de la vie et la santé février.

Ameni G, Krok B, Bogale T (2001). Preliminary study on the major bovine trematodeinfection around Kemissie, northeastern Ethiopia and treatment trial with praziquantel. Bull. Anim. Hlth. Prod. Afr., 49: 62–67.

Aylate A, Hussen M, Tilahun A, Kiros A (2017). A cross-sectional study on bovine schistosomiasis in and around Kemissie, Dawa Cheffa District. J. Vet. Med. Anim. Hlth., 9: 72–77. https://doi.org/10.5897/JVMAH2016.0459

Belayneh L, Tadesse G (2014). Bovine schistosomiasis: A threath in public health perspective in Bahir Dar Town, Northwest Ethiopia. Acta Parasitol. Glob., 5(1): 01-06.

Brumpt E (1930). La ponte des schistosomes. Ann. Parasitol. Hum. Comp., 8(3-4): 263-297. https://doi.org/10.1051/parasite/1930083263

Chanie M, Dejen B, Fentahun T (2012). Prevalence of cattle schistosomiasis and associated risk factors in Fogera cattle. J. Adv. Vet. Res., 2: 153–156

Dargie JD (1980). The pathogenesis of *Schistosoma bovis* infection in sudanese cattle. Trans. R. Soc. Trop. Med. Hyg., 74(5): 560-562. https://doi.org/10.1016/0035-9203(80)90137-6

Djuikwo-Teukeng F, Blin M, Bech N, Reguera Gomez M, Zein-Eddine R, Kouam SA, Allienne JF, Boissier J (2022). Hybridization increases genetic diversity in Schistosoma haematobium populations infecting humans in Cameroon. Infect. Dis. Poverty, 11: 37. https://doi.org/10.1186/s40249-022-00958-0

Djuikwo-Teukeng F, Kouam Simo A, Alienne JF, Rey O, Njayou A, Tchuem-Tchuente LA, Tchuem Tchuenté LA, Boissier J (2019). Population genetic structure of *Schistosoma bovis* in Cameroon. Parasit. Vectors, 12(56): 11. https://doi.org/10.1186/s13071-019-3307-0

Endris M, Alemneh T (2017). Bovine schistosomiasis: Mini review. Sci. Fed. Vir Res. J., 1(2): 1-6. https://doi.org/10.29011/2637-9988/100010

Gebru A, Asaye M, Alemneh T (2015). The prevalence of bovine Shistosomiasis in Dembia Woreda. Ethiop. Acta Parasitol. Glob., 6: 112–116.

Hansen J, Perry B (1994). The epidemiology, diagnosis and control of helminth parasite of ruminants: A hand book of animal production and health division, FAO, Rome, Italy. Int. Hlth., 3: 372.

Kifle T, Bayile T, Fesseha H, Mathewos M, El-Magd M (2022). Prevalence of bovine schistosomiasis and associated risk factors in Tis Abay District, Northwest Ethiopia. Vet. Med. Int., 2022: 8940576. https://doi.org/10.1155/2022/8940576

King KC, Stelkens RB, Webster JP, Smith DF, Brockhurst MA (2015). Hybridisation in parasites: consequences for adaptative evolution pathogenesis, and public health in a changing world [En ligne]. PLoS Pathog., 11: e1005098. https://doi.org/10.1371/journal.ppat.1005098

Lalman D, Selk G, Stein D (2021). Body condition scoring of cows. Oklahoma Cooperative Extension Service AFS-3283. September 2021.

Lawrence JA (1974). Schistosoma mattheei in sheep: The host-parasite relationship. Res. Vet. Sci., 17: 263–264. https://doi.org/10.1016/S0034-5288(18)33695-6

Lefevre CP, Blancou J, Chermette R, Uilenberg G (2010). Infectious disease of livestock. 1st ed. Paris: Lavoizer.

Luogbou D, Netongo P, Bayemi H, Mbacham W, Tchuem Tcuente LA (2015). Detection of hybrid schistosoma haematobium group species in Cameroon By PCR-RFLP of the second internal transcribed spacer (ITS-2) [En ligne]. World J. Pharmaceut. Res., 4: 196-1980.

Mccauley EH, Majid AA, Tayeb A (1984). Economic-evaluation of the production impact of bovine schistosomiasis and vaccination in the Sudan. Prevent. Vet. Med., 2(6): 735-754. https://doi.org/10.1016/0167-5877(84)90030-8

Mekonnen G (2020). Review on bovine schistosomiasis and its current status and public health importance in Ethiopia. Munich, GRIN Verlag. 18: 30.

Melkamu (2016). Study on prevalence and associated risks factors of bovine and human schistosomiasis in Bahir Dar and its surrounding areas. J. Ann. Res., 6(6): 967-975. https://doi.org/10.5958/2277-940X.2016.00139.X

Mengist Y, Yilak N (2019). A cross sectional study on the prevalence and possible risk factors of bovine schistosomiasis in and around Gozamen District, Northwest Ethopia. Int. J. Adv. Res. Biol. Sci., 6(2): 110-117.

Merawe M, Amsslu K, Hagos Y, Afera B (2014). Intestinal schistosomiasis of bovine and ovine in Fogera district, South Gondar zone, Amhara National Regional State, Ethiopia. Acta Parasitol. Glob., 5: 87–90.

Okpala HO, Agwu E, Agba MI, Chimezie OR, Nwobu GO, Ohihoin AA (2004). A survey of the Prevalence of schistosomiasis among pupils in Apata and Laranto areas in Jos, plateau state. Online J. Hlth. Allied Sci., 1: 1–4.

Ousseini S (1990). Schistosomoses des ruminants domestiques au Cameroun septentrional: Enquêtes aux abattoirs de Garoua et Maroua [Thèse en ligne]. Médecine vétérinaire : Université Cheik Anta Dioup Dakar; pp. 112.

Pichford RJ, Visser PS (1982). Schistosoma mattheei Veglia and LE roux, 1929, egg output from cattle in a highly endemic area in the eastern Transvaal. Onderstepoort. J. Vet. Res., 49: 233–235.

R Core Team (2019). R: A language and environment for statistical computing. R foundation for statistical computing, Vienna, Austria. http://www.R-project.org/.

Ron T, Ben B, Bill K, Ken C (2003). Methods of determining age of cattle. Cattle Producer's Library - CL pp. 712.

Saad AM, Hussein MF, Dargie JD, Tayloret MD (1984). The pathogenesis of experimental schistosoma-bovis infections in sudanese sheep and goats. J. Comp. Pathol., 94(3): 371-385. https://doi.org/10.1016/0021-9975(84)90025-2

Savassi B, Mouahid G, Lassica C, Mohaman S-D, Garcia A, Courtin D, Alienne JF, Ibikounlé M et Moné H (2020). Cattle as natural host for Schistosoma haematobium (Bilharz, 1852) Weinland, 1858 x Schistosoma bovis sonsino, 1876 interactions, with new cercarial emergence and genetic patterns [En ligne]. Parasitol. Res., 119(8): 01-17. https://doi.org/10.1007/s00436-020-06709-0

Setargew M, Fentahun T, Chanie M (2012). Prevalence of bovine Shistosomiasis in Fogera District, South Gondar zone, Amhara National Regional State, Northwest Ethiopia. Glob. Vet., 9: 612–616.

Solomon A (2008). Observation on the prevalence the prevalence of *Schistosoma bovis* infection in Bahir Dar area. North Central Ethiopia. Glob. Vet., 3: 13–16.

Temesgen K, Tirumengist B, Haben F, Mesfn M (2022). Prevalence of bovine schistosomiasis and associated risk factors in Tis Abay District, Northwest Ethiopia. Vet. Med.

Int., 7 pages. https://doi.org/10.1155/2022/8940576

Thrusfield M (2018). Veterinary epidemiology. Fourth edition. John Wiley Sons. https://doi.org/10.1002/9781118280249

Tsega M, Derso S (2015). Prevalence of bovine schistosomiasis and its associated risk factor in and around Debre Tabor town, north west of Ethiopia. Eur. J. Biol. Sci., 7: 108–113.

Urquhart GM, Armour J, Duncan JL, Dunn AM, Jennings FW (1997). Veterinary helminthology: Veterinary Parasitology. New York: Churchill: Livingstone Inc.

Yeneneh A, Kebede H, Fentahun T, Chanie M (2012). Prevalence of cattle flukes infection at Andassa livestock research center in north-west of Ethiopia. Vet. Res. Forum, 3: 85–89.

Yezina M, Nigussie Y (2019). A cross sectional study on the prevalence and possible risk factors of bovine schistosomiasis in and around Gozamen District, Northwest Ethiopia. Int. J. Adv. Res. Biol. Sci. . 6(2): 110-117. https:// DOI: http://dx.doi.org/10.22192/ijarbs.2019.06.02.013