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Seasonal prevalence, body condition score and risk factors of bovine fasciolosis in South Africa

Ishmael Festus Jaja[a,*], Borden Mushonga[b], Ezekiel Green[c,d], Voster Muchenje[a]

[a] Department of Livestock and Pasture Science, University of Fort Hare, Alice 5700, South Africa
[b] School of Veterinary Medicine, Faculty of Agriculture and Natural Resources, University of Namibia, Namibia
[c] Department of Biochemistry and Microbiology, University of Fort Hare, Alice 5700, South Africa
[d] Department of Biotechnology and Food, Science, Faculty of Science, University of Johannesburg, Doornfontein, South Africa

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ABSTRACT

Fasciolosis is an important zoonotic disease that is responsible for a significant loss in food resource and animal productivity. The objectives of this study were to determine the seasonal prevalence and risk factors associated with *Fasciola* infection in cattle. The results were obtained by coprology, antemortem and post-mortem survey of three abattoirs (HTPA1, n = 500, HTPA2, n = 400, and LTPA, n = 220). The seasonal prevalence of *Fasciola* infection was 10.4%, 12.8% and 10.9%, during summer, 11.2%, 10.8% and 8.6%, during autumn, 9.8%, 6.5% and 5.9% during winter and 8.2%, 7.8% and 5.9%, during spring in the three abattoirs HTPA1, HTPA and LTPA respectively. There was a significant association ($p < 0.05$) between the intensity of infection and body condition score (BCS) of cattle at each abattoir. Factors such as age [HTPA1 (OR = 3.6, CI = 1.2, 10.2), and LTPA (OR = 3.8, CI= 2.4, 6.1)], sex [LTPA (OR = 4.2, CI= 2.5, 7.0)], breed [HTPA2 (OR = 2.3, CI = 1.3, 4.1) and LTPA (OR = 2.5, CI= 1.3, 5.0)] and BCS had significant ($p < 0.01$–0.001) influence on the prevalence of fasciolosis. In conclusion, the infection with *Fasciola* spp was higher in the summer than in the winter; a positive association was established between the prevalence of fasciolosis and poor body condition in study animals. This study, therefore, suggests that fasciolosis could be causing substantial production losses, mainly due to cattle weight loss and liver condemnation.

1. Introduction

Fasciolosis is a disease predominantly found in ruminants and wildlife. *Fasciola hepatica and Fasciola gigantica* are the two main species responsible for most infections. *Fasciola hepatica* is cosmopolitan in nature because of its ability to infect a variety of species, while *Fasciola gigantica* is more common in tropical countries, though both species are found in Africa and Asia (Dorny, Praet, Deckers, & Gabriel, 2009; Mas-Coma, Bargues, & Valero, 2005). Fasciolosis is a disease of both veterinary and public health importance, infecting over 600 million animals. The infection causes massive loss through liver condemnation, reduced production of milk, meat, and wool, veterinary care, metabolic disease as well as mortality (Khanjari et al., 2014; Terefe, Wondimu, & Gachen, 2012; Toet, Piedrafita, & Spithill, 2014; Zeleke, Menkir, & Desta, 2013). Reports on economic losses due to fasciolosis in South Africa are scanty. However, in other African countries, several millions of dollars have been lost due to this disease (Cadmus & Adesokan, 2009; Dawa, Abattoir, Mebrahtu, & Beka, 2013; Kock, Wolmarans, & Bornman, 2003; Mucheka, Lamb, Pfukenyi, & Mukaratirwa, 2015; Pfukenyi & Mukaratirwa, 2004). Globally, the production losses due to *Fasciola* infections in livestock exceed US$3 billion/year (Buffoni et al., 2010; Elliott, Kelley, Rawlin, & Spithill, 2015).

Studies carried out in recent years have shown fasciolosis to be a significant public health problem. About 17 million persons in several countries are infected and 180 million people at risk of the infection worldwide (Ashrafi & Mas-Coma, 2014; Dorny et al., 2009; Mas-Coma et al., 2005; Torgerson & Macpherson, 2011). In South Africa, three cases had previously been reported in 1964, and two new cases recently reported in the Western Cape Province (Black, Ntusi, Stead, Mayosi, & Mendelson, 2013). The number of infected people in Asia and Africa could be higher than stated as many cases are not reported (Ahmadi & Meshkehkar, 2010; Ashrafi & Mas-Coma, 2014). Also, human cases where estimates are based on faecal egg count may be underestimated as patients with pre-patent, ectopic and low-grade infections excrete very low egg numbers (Slifko, Smith, & Rose, 2000).

Rainfall, solar radiation, and global warming are common conditions promoting the distribution of *Galba truncatula* and *Radix natalensis* which are the intermediate host of *Fasciola* spp. (Elliott et al., 2015;

* Corresponding author.
E-mail address: ijaja@ufh.ac.za (I.F. Jaja).

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Novobilský, Novák, Björkman, & Höglund, 2015). In South Africa, these snails are commonly found in streams, water channels, dams, ditches, ponds, rivers and swamps (Black et al., 2013; Kock et al., 2003). Under such wet conditions, cercariae develop from the snail and swim until they find and attach to vegetation, sheds it tails and secrete a protective coat, forming the encysted infective stage called metacercariae. Cattle become infected primarily by ingesting the metacercarial cysts on the soil, forage and contaminated drinking water (Ashrafi & Mas-Coma, 2014; Kaplan, 2001; Mucheka et al., 2015).

The need for improvement in disease surveillance in livestock is crucial, especially, as many emerging diseases that cause illnesses in humans are zoonoses (Thomas-Bachli, Pearl, Friendship, & Berke, 2012). In this regard, abattoir meat inspection plays a significant role in the surveillance and detection of a variety of diseases of human and animal health consequence (Alton, Pearl, Bateman, McNab, & Berke, 2010). More so, determining the status of fasciolosis creates awareness of the importance of the parasites to livestock productivity and their zoonotic importance (Kock et al., 2003; Mucheka et al., 2015). This survey becomes necessary in the absence of regional information on the prevalence of fasciolosis in cattle in the Eastern Cape Province. The aim of this study was to determine the seasonal prevalence of *Fasciola* infection, its effects on body condition score in cattle slaughtered at the selected abattoirs and to identify the risk factors associated with the disease.

2. Materials and methods

2.1. Ethical considerations

The research protocol was approved by the University of Fort Hare Research Ethics Committee, and an approval certificate was issued with reference number MUS071SJAJ01. A similar approval was obtained from the Department of Agriculture Forestry and Fisheries (DAFF) and the participating abattoirs.

2.2. Study area

The study was conducted at two high through-put abattoirs (HTPA1 and HTPA2), and one low through-put abattoir (LTPA). The HTPA1 is situated at 32.97°S and 27.87°E in the Buffalo City Metropolitan Municipality, while the HTPA2 is located 31°54′S and 26°53′E in Enoch Mgijima municipality in the Chris Hani district of the Eastern Cape Province (ECP), South Africa. The LTPA is located in Raymond Mhlaba municipality, having the coordinate 32`.80S and 26`.90 E in the Amathole District of the ECP, South Africa. The study area receives approximately 480–850 mm of rainfall per year mostly in the summer. The ECP is situated about 586–2371 m above sea level, on average this high altitude causes the area to be occasionally covered in snow. The Köppen climate classification system (Fig. 1) describes the ECP as cold semi-arid climate (BSk) to temperate oceanic climate (Cfb) (Markus, Jürgen, Christoph, Bruno, & Franz, 2006). The ambient temperature of the ECP during the period of study ranged from 18 °C to 39 °C with a mean temperature of 20.5 °C. The vegetation in the area varies from grasslands and thicket to forests and bushveld with *Acacia karroo, Themeda triandra and Digitaria eriantha* being the most dominant plant species. Agriculture statistic report shows that 28, 334 farmers are involved in livestock farming in the EC Province (Lehohla, 2013).

2.3. Study design and signalment of cattle

A cross-sectional study of cattle in three abattoirs was conducted using antemortem (AMI) and post-mortem inspection (PMI). The study was carried out from July 2013 to June 2014 to determine the seasonality and severity/intensity of *Fasciola* infection in cattle slaughtered in the Eastern Cape Province. During the AMI, several risk factors were identified and faecal samples collected and scored for consistency. The faecal samples were collected for all the seasons including autumn (1st March to 31st May), winter (1st June to 31 August), spring (1st September to 31st November) and summer (1st December to 28 February) (WeatherSA, 2014). Sampled animals were marked and identified from slaughter to evisceration (PMI) for the purpose of liver inspection. Animal's body condition score was determined using the method described by Tsotetsi and Mbati (2003). The age of animal was identified using records from the farmers. Where such records did not exist, age estimation was done using dentition (FSIS, 2013; Torell, Bruce, Kvasnicka & Conley, 1998). The animals were separated into two age groups to ease statistical analyses. Cattle ≤ 3 years were termed as young while those > 3 years were termed old. Study animals include males and females of different ages, which were transported to the abattoir from various locations. In the EC Province, the traditional livestock farming system that is common among rural farmers are extensive or semi-intensive where animals are grazed on fields and are occasionally supplemented with hay. Commercial farms favour a more organized pasture based feeding system. Animal breeds were identified by the use of abattoir records, where records were unavailable, or else breed phenotypic characteristic were used to establish breed type (Dupuy et al., 2013; Mpakama, Chulayo, & Muchenje, 2014; Soji, Mabusela, & Muchenje, 2015).

2.4. Sampling method

The sampling procedure was carried out using systematic random sampling. Sampling units were selected at equal intervals with the first cattle being selected randomly. The sample size was determined at a 90% confidence interval and 5% margin of error and an expected prevalence of 50% using the formula as given by Thrusfield (2005) and validated using a sample size calculator (Raosoft Inc USA see www.raosoft.com). In the preceding year, the total number of slaughtered animals were 26401 in the three abattoirs (HTPA1 = 21803, HTPA2 = 4078, and LTPA = 520). In the present study, the sample size was calculated to be 268, 254 and 179 for the three abattoirs namely HTPA1, HTPA2, and LTPA respectively. Slaughter records from the preceding year showed that a large number of animals were slaughtered at the abattoir. Thus, the sample size was increased to 500, 400 and 220 animals for the respective abattoirs to minimize the margin of error to below the 5% mark and to improve statistical precision (Regassa et al., 2013).

2.5. Coprological sampling

During the AMI, Faecal samples of (n = 500 from the HTPA1), (n = 400 from the HTPA2) and (n = 220 from the LTPA) were collected per rectum using sterile surgical gloves and were examined grossly for their consistency as 'well formed watery, soft or loose', and then categorized as either diarrheic or non-diarrheic. The faecal samples were then stored in the sample containers, and labeled with unique identification numbers which include age, sex, date, breed and sample number of each cattle before storing them in an ice-packed cool box pending examination. The samples were transported to Grahamstown veterinary laboratory, Eastern Cape Province, South Africa. The eggs of *Fasciola* spp. were identified microscopically by size and morphological appearance. While the numbers of eggs per gram of feces (EPG) were determined by sedimentation method using a McMaster chamber (Dorchies, 2007; Martínez-Pérez, Robles-Pérez, Rojo-Vázquez, & Martínez-Valladares, 2012) and the intensity of infection were extrapolated using a severity index defined by Royal Veterinary College London and Food and Agriculture Organisation index of 2009. The intensity of infection according to egg per gram (EPG) was subdivided into three namely, 1–500 (mild infection), 501–1000 (moderate infection) and above 1000 EPG (severe infection) (Degefu, Abera, Yohannes, & Tolosa, 2011). During the PMI, livers from cattle slaughtered were inspected for flukes by cutting open the major bile ducts into

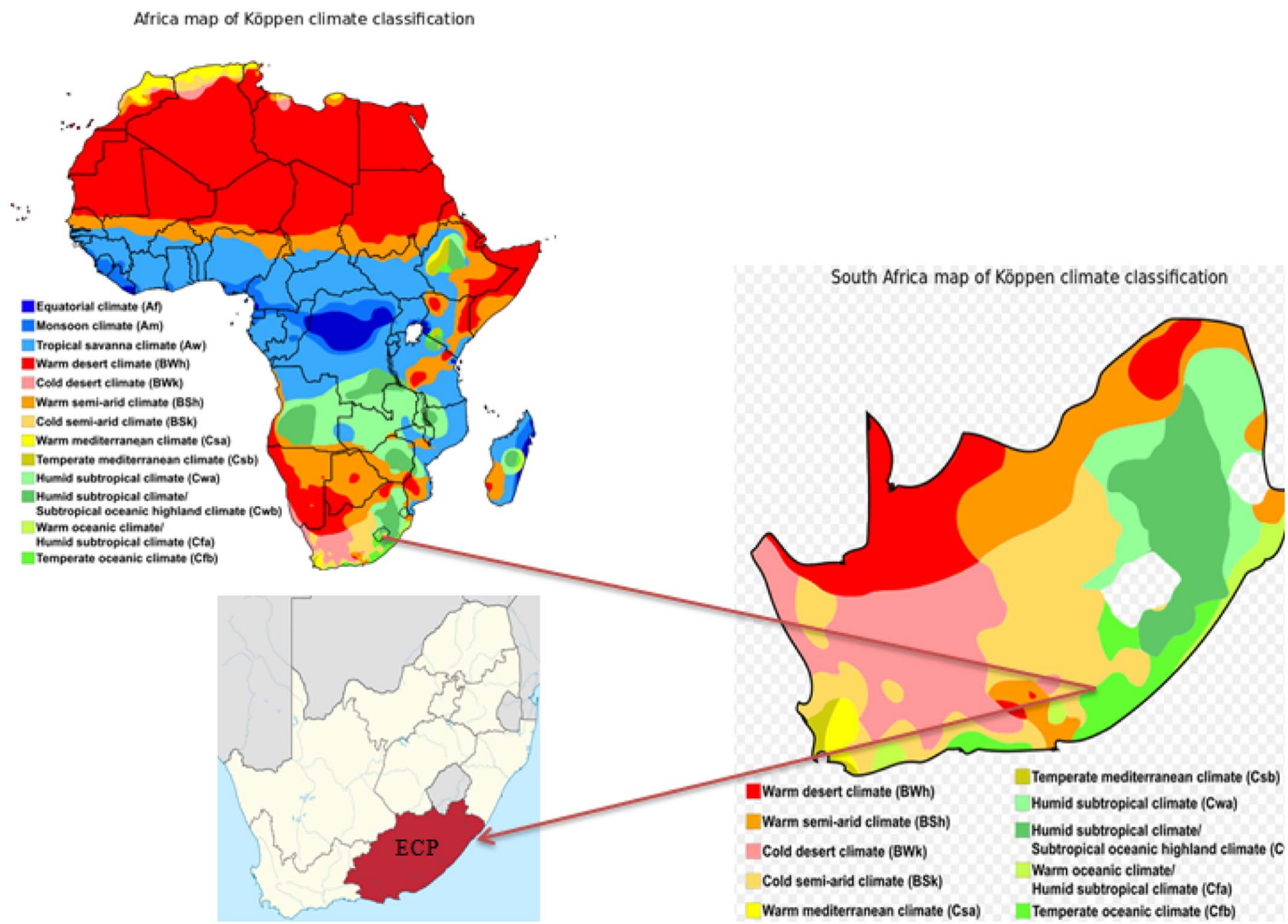

Fig. 1. Map of Africa of Koppen climate classification system with a pointer showing the map of South Africa and the Eastern Cape Province (ECP).

the liver parenchyma. The presence of adult flukes was recorded so as to compare the result with those of the coprology.

2.6. Statistical analysis

The data was captured in the standard data sheet and preliminary quantitative data analysis performed using Microsoft® Excel (2007) mathematical functions. The information was later imported into the Statistical Package for Social Sciences (SPSS) version 22 (SPSS Inc., Chicago, IL) for exploratory data analysis to validate the data and evaluate crude associations by using 2 × 2 cross-tabulation tables in which descriptive statistics and summary measures were calculated. The statistical association between seasonal prevalence (winter, spring, summer and autumn) and risk factors were evaluated separately for each abattoir (HTPA1, HTPA2, and LTPA) using chi-square analysis of independence and logistic regression. The degree of association of the prevalence and the risk factors was determined using Odds Ratio. The proportions and intensity of infection (mild, moderate and severe) was calculated as the number of positive faecal samples over the total number of faecal samples examined in each category (mild, moderate and severe). The seasonal prevalence of fasciolosis was calculated as the number of positive faecal samples per season divided by the total number of faecal samples obtained in the same season and expressed as a percentage of the total number of previously selected cattle in that season.

3. Results

The percentage of animals infected with liver fluke was (39.6% and 25.6%), (37.8% and 24.8%) and (32.3% and 19.5%) for HTPA1, HTPA2, and LTPA during PMI and coprological survey (cprlg) respectively. Liver flukes were found more in summer and autumn than in winter and spring. A similar trend was observed during *Fasciola* egg count (Table 1). In Table 3, animals with good body condition (BCS) shed less egg of fasciola ($p < 0.001$) compared to those with animals with poor BCS. However, animals with moderate BCS had the highest prevalence of infection at the HTPA. In the LTPA, it was observed that no animal with good BCS was infected. Conversely, at the LTPA, no animal with poor BCS had a mild infection of fasciolosis. Regarding the intensity of *Fasciola* infection, the results show a significant association ($p < 0.001$) between BCS and the intensity of infection in all abattoirs (Table 2). Sex and breed were the two most important risk factors that were significantly associated ($p < 0.001$) with a high rate of fasciolosis at the HTPA1 and HTPA2. The association between the prevalence of Fasciola and sex/breed in the three abattoirs were (30.6, 60.9 and 27.4) and (56.7, 70.5 and 9.1) for HTPA1, HTPA2, and LTPA respectively. Local breeds (22.6%, 22.2%, and 14.5%) recorded more ova of *Fasciola* than cattle cross (17%, 15.5 and 17.7%) in both HTPA1 and HTPA2 in contrast with the LTPA where faecal samples from crossed animals harboured more eggs of *Fasciola*. Other risk factors that were commonly associated with the prevalence of *Fasciola Spp* can be found in Table 3. At the low throughput abattoir (LTPA), factors such as age (young: 18.2% and old: 14.1%) and sex (male: 29.1% and female: 3.2%) BSC were positively correlated ($p < 0.001$) with the level of fasciolosis observed in cattle.

Table 1
Seasonal prevalence of bovine fasciolosis [HTPA1 (n = 500), HTPA2 (n = 400), and LTPA (n = 220)] in the liver and faecal samples from July 2013 to June 2014.

Abattoir	Season	No examined	No positive (Cprlg)	Prevalence (Cprlg)	X^2	Sig
HTPA1	Winter	125	49(23)	39.2(18.4)	0.9	NS
	Spring	113	41(25)	36.3(22.1)		
	Summer	129	52(38)	40.3(29.5)		
	Autumn	133	56(42)	42.1(31.6)		
	Total	500	198(128)	39.6(25.6)		
HTPA2	Winter	100	26(17)	26(17)	19.5	***
	Spring	104	31(14)	29.8(13.5)		
	Summer	96	51(22)	53.1(22.9)		
	Autumn	100	43(46)	43(46)		
	Total	400	151(99)	37.8(24.8)		
LTPA	Winter	53	13(8)	24.5(15.1)	5.5	NS
	Spring	57	15(11)	26.3(19.3)		
	Summer	56	24(10)	42.9(17.9)		
	Autumn	54	19(14)	35.2(25.9)		
	Total	220	71(43)	32.3(19.5)		

HTPA1 and HTPA2: high throughput abattoirs, LTPA: low throughput abattoir, X^2: chi-square, No examined: number of animals examined, No positive: number of liver with *Fasciola* spp, Cprlg: coprology, Sig: significance level, ***: significant at $p < 0.001$, NS: not significant.

Table 2
Association between body condition score and severity of *Fasciola* spp. in slaughtered (n = 198, n = 151, n = 71) cattle from July 2013 to June 2014 in the three abattoirs (HTPA1, HTPA2, and LTPA).

		Classification by the level of intensity (%)					
Abattoir	BCS	Mild	Moderate	Severe	Total	X^2	Sig
HTPA1	Poor	23 (11.6)	39 (19.7)	20 (10.1)	82 (41.4)	45.4	***
	Moderate	67 (33.9)	9 (4.5)	20 (10.1)	96 (48.5)		
	Good	15 (7.6)	5 (2.5)	0 (0)	20 (10.1)		
	Total	105 (53.0)	53 (26.8)	40 (20.2)	198 (100)		
HTPA2	Poor	25 (16.6)	30 (19.9)	27 (17.9)	82 (54.3)	17.6	***
	Moderate	21 (13.9)	20 (13.2)	0 (0)	41 (27.2)		
	Good	10 (6.6)	10 (6.6)	8 (5.3)	28 (18.5)		
	Total	56 (37.1)	60 (39.7)	35 (23.2)	151 (100)		
LTPA	Poor	0 (0)	26 (36.6)	20 (28.2)	46 (64.8)	51.5	***
	Moderate	5 (7)	14 (19.7)	0 (0)	19 (26.8)		
	Good	6 (8.5)	0 (0)	0 (0)	6 (8.5)		
	Total	11 (15.5)	40 (56.3)	20 (28.2)	71 (100)		

N/B: HTPA1 and HTPA2: high throughput abattoirs, LTPA: low throughput abattoir, X^2: chi-square, Sig: significant level, ***: significant at $p < 0.001$.

4. Discussion

The abattoir is the final destination for most food animals and is important in the farm to fork chain for meat product. Animals processed at these facilities represent, to some extent, a valid cross-section of the livestock population in the EC Province, and thus the abattoir can be a source of information on the epidemiology of animal diseases (Alton et al., 2010; Dupuy et al., 2013; Jaja, Mushonga, Green, & Muchenje, 2016; Regassa et al., 2013). Considering the endemic nature of liver fluke in most tropical and sub-tropical climates and its negative impact on animal production, the overall use of abattoir slaughter data coupled with coprology are beneficial. Results from this study constitute the first documented information on the seasonal prevalence of fasciolosis in slaughter-bound cattle in the Eastern Cape Province and are important in the formulation of the appropriate anthelmintic program against this parasite.

Table 3
The association between various risk factors, body condition score and prevalence of bovine fasciolosis in cattle [HTPA1 (n = 500), HTPA2 (n = 400), and LTPA (n = 220)] from July 2013 to June 2014.

Abattoirs	Risk factors		No examined (%)	P (%)	OR (95% CI)	X^2	Sig
HTPA1	Age	Young	355(71)	30.80	1	7.30	*
		Old	145(29)	8.80	3.6 (1.2, 10.2)		
	Sex	Male	323(64.6)	19.80	1	30.60	***
		Female	177(35.4)	19.80	1.1 (0.7, 1.4)		
	Breed	Local	185(37)	22.60	1	56.70	***
		Crosses	315(63)	17.00	1.0 (0.5, 2.0)		
	BCS	Poor	161(32.2)	21.60	1	75.60	***
		Moderate	209(41.8)	10.40	2.2 (1.1, 4.8)		
		Good	130(26)	7.60	1.2 (0.9, 1.8)		
HTPA2	Age	Young	274(68.5)	23.20	1	5.40	*
		Old	126(31.5)	14.50	1.1 (0.6, 2.0)		
	Sex	Male	219(54.8)	11.20	1	60.90	***
		Female	181(45.2)	26.50	1.3 (0.8, 1.9)		
	Breed	Local	134(33.5)	22.20	1	70.50	***
		Crosses	266(66.5)	15.50	2.3 (1.3, 4.1)		
	BCS	Poor	153(38.2)	18.50	1	14.90	***
		Moderate	146(36.5)	13.00	3.8 (2.4, 6.1)		
		Good	101(25.2)	6.20	2.5 (1.4, 4.6)		
LTPA	Age	Young	85(38.6)	18.20	1	13.90	***
		Old	135(61.4)	14.10	3.8 (2.4, 6.1)		
	Sex	Male	145(65.9)	29.10	1	27.40	***
		Female	75(34.1)	3.20	4.2 (2.5, 7.0)		
	Breed	Local	69(31)	14.50	1	9.10	**
		Crosses	151(68.6)	17.70	2.5 (1.25, 5.0)		
	BCS	Poor	60(27.3)	7.30	1	1.50	NS
		Moderate	97(44.1)	15.90	1.2 (0.5, 2.5)		
		Good	63(28.6)	9.10	0.8 (0.3, 1.8)		

HTPA1, 2: high throughput abattoir, LTPA: low throughput abattoir, P: prevalence of fasciolosis, OR: odd ratio, CI: confidence interval, X^2: chi-square, *: significant at $p < 0.05$, **: significant at $p < 0.01$, ***: significant at $p < 0.001$, NS: not significant.

The current study showed a proportion of liver condemnation of between 32–39.6%. Reports on liver condemnation due to fasciolosis in South Africa is scanty both at regional and national levels (Kock et al., 2003). However, a 10% rate of condemnation of liver in cattle and sheep because of fasciolosis was reported in 1956 (Black et al., 2013). Thus, this shows an increase in the prevalence of fasciolosis in the province. The findings in this study are similar to those conducted in neighbouring Zimbabwe, where a prevalence of 37.1% of fasciolosis in the liver of cattle was established (Pfukenyi & Mukaratirwa, 2004). Conversely, a higher prevalence rate of 53.9% was reported in a study of fasciolosis in Zambian cattle at selected abattoirs by (Phiri, Phiri, Sikasunge, & Monrad, 2005). However, studies conducted elsewhere in Africa (Cadmus & Adesokan, 2009; Mellau, Nonga, & Karimuribo, 2011, 2010; Phiri, 2006; Regassa et al., 2013); Asia (Khanjari et al., 2014; Khoramian et al., 2014; Lat-lat et al., 2006; Yibar et al., 2015) and Europe (Alton, Pearl, Bateman, McNab, & Berke, 2012; Dupuy et al., 2013; Dupuy, Demont, Ducrot, Calavas, & Gay, 2014; Theodoropoulos, Theodoropoulou, Petrakos, Kantzoura, & Kostopoulos, 2002; Thomas-Bachli, Pearl, Friendship, & Berke, 2014) corroborated the finding in the present study.

Differences in the prevalence of fasciolosis in the three abattoirs may be caused by multiple factors, including changes in climatic condition, ambient temperature and solar radiation (Dorny et al., 2009; Gajadhar, Scandrett, & Forbes, 2006; Kaplan, 2001; Khanjari et al., 2014; Martínez-Pérez et al., 2012). The underlying factors adequately support the replication of intermediate host causing heighten infections in cattle. The availability of the intermediate host responsible for the transmission of *Fasciola spp*. in South Africa, has been reported. Although *P. columella* is more widely distributed in South Africa, *R. natalensis* has been shown to be the paramount intermediate host of *F. gigantica* in the country, while *G. truncatula* is common in low-temperature regions of South Africa and Lesotho (Kock et al., 2003). In Europe, *G. truncatula* is the intermediate host of *F. hepatica*, but its role in the epidemiology of fasciolosis in South Africa is unknown. Likewise, the role of *P. columella* in the transmission *of F. hepatica* and *F. gigantica* in South Africa has not been validated (Kock et al., 2003). More so, livestock husbandry/management practices such as excessively irrigated and swampy pasture field as well as abandoned unhygienic drinking troughs encourage the multiplication of snail species. Also, farmers poor knowledge, access to adequate veterinary services and improper use of anthlminthics may alter the dynamics of *Fasciola* spp. in endemic areas and further promote the prevalence of fasciolosis (Bekele, Tesfay, & Getachew, 2010; Musemwa et al., 2008; Seimenis, 2012).

The low sensitivity of the sedimentation technique used may have contributed to the difference noted in the result of this study (cprlg and PMI). On the other hand, the PMI include livers with gross pathology caused by immature fluke infection, which cannot be detected through coprological examination (Pfukenyi & Mukaratirwa, 2004). Several studies (Keyyu, Kassuku, Msalilwa, Monrad, & Kyvsgaard, 2006; Nzalawahe, Kassuku, Stothard, Coles, & Eisler, 2014; Pfukenyi, Mukaratirwa, Willingham, & Monrad, 2007; Phiri et al., 2005; Tsotetsi & Mbati, 2003) have been conducted on the prevalence of *Fasciola* spp. using egg counting method. Many of these research reported results which were consistent with our finding.

The intensity of infection and the effect of fasciolosis was greater in cattle with poor BCS. Many studies on the relationship between BCS and fasciolosis has shown that there is a positive association between fasciolosis and cattle weight loss (Abunna, Asfaw, Megersa, & Regassa, 2010; Aragaw, Negus, Denbarga, & Sheferaw, 2012; Dawa et al., 2013; Demssie, Birku, & Biadglign, 2012; Equar & Gashaw, 2012; Howell et al., 2012; Terefe et al., 2012; Wondwosen, Addis, & Tefera, 2012). The outcomes of these studies underpin the relevance of the findings of the present study. However, it is expected that animals in good intensive management systems and with adequate veterinary care should be in better body condition than cattle extensively managed with little veterinary input. In Uganda, a study of bovine fasciolosis at increasing altitudes showed that most animals at low altitude under free grazing feeding system were significantly underweight with a high prevalence of *Fasciola* eggs in contrast to animals at high altitude regularly fed plantain leaves (Howell et al., 2012).

In a related study, Demssie et al. (2012) observed 85.9% prevalence rate of fasciolosis in animals with poor body condition, 55.1% in medium body condition and 34.5% prevalence in animals with good body condition animals. At the sub-acute/chronic stage of infection, inappetence and anorexia related to the activities of migrating flukes leads to weight loss, weakness and suppressed immunity (Tsegaye, Mulugeta, & Begna, 2011; Wondwosen et al., 2012). The significant positive association ($P < 0.001$) between body condition score and the intensity of infection observed in this study (Table 3), may be a direct consequence of the pathogenesis of fasciolosis. Considering the important role of the liver in homeostasis and the overall metabolism of animals, loss of body condition score in infected cattle could be as a result of *Fasciola* infection and likely relate, in part, to metabolic perturbation (Alvarez Rojas et al., 2015).

The result of the current study revealed that infection rate was significantly higher in young animals than in old animals in all the three abattoirs (Table 3). Age and breed can influence natural bovine fasciolosis in an endemic area, cattle at this age frequently graze pastures, which may increase the likelihood of infection with *F. hepatica* metacercariae (Sánchez-Andrade et al., 2002). More so, the low prevalence in older cattle can be due to the high immunogenicity of the parasite, which aids in the stimulation of acquired immunity in older animals (Khan, Sajid, Khan, Iqbal, & Hussain, 2010). The difference in the occurrence of the *Fasciola* infection between young and old cattle in the three abattoirs could also be due to the stage of disease, sampling method and previous use of antihelminthic medication before transportation to the slaughterhouse. The prevalence of *Fasciola* in male and female cattle differ due to several reasons, including grazing disparity between both sexes especially if the cow is pregnant, sampling methods, and the fact that female animals are mainly used for reproductive purposes and seldom for beef production hence are likely not to be regularly slaughtered at abattoirs, thereby affecting the number of females sampled during the study (Dawa et al., 2013; Khan et al., 2010; Zeleke et al., 2013).

Despite the small number of local breeds slaughtered at both the HTPA1 and HTPA2 (Table 3), the occurrence of fasciolosis in these animals is understandable, given that, poorly resourced rural farmers predominantly farm local breeds and seldom have access to veterinary care and modern farming techniques (Musemwa et al., 2008). Furthermore, local breeds in many communities graze open fields and have access to stagnant water, from where infection with *Fasciola* metacercariae may likely occur. The differences in the number of sampled breeds (local and exotic/crosses) can be attributed to the export potential of exotic breeds over local breeds since both HTPA1 and HTPA2 are export abattoirs. Other factors likely responsible for the slaughter of fewer local breeds may be due to their poor meat yielding capacity, suitability for meeting criteria of carcass classification system, low demand by import markets and high rate of condemnation of meat/offals from poorly managed animals (MSA, 2000; Ndou et al., 2011; Scholtz, Bester, Mamabolo & Ramsay, 2008; Soji et al., 2015). On the other hand, the LTPA is not an export abattoir, and it is located proximal to rural settlement and receives cattle supply from its surrounding communities. These communal cattle producers may not have medicine and proper disease control infrastructure. Therefore, their animals may be susceptible to disease due to the high costs, absence or inappropriateness of the available animal health and production inputs (Musemwa et al., 2008; Seimenis, 2012; Soji et al., 2015).

5. Conclusion

This study demonstrated a high prevalence and a high intensity of liver flukes in cattle with poor body conditions in three abattoirs in the Eastern Cape Province of South Africa. The results suggest that fasciolosis causes a reduction in cattle body weight and may lead to substantial production losses and bovine liver condemnation at slaughter. Some of the factors associated with the prevalence of fasciolosis were identified, and these include age, sex, and breed of the animals and BCS. The development of nematode and trematode resistance to various groups of anthelmintics is a major problem facing the livestock industry. An investigation on the use, dosage, and storage, as well as anthelminthic resistance, is recommended. Also, farmers' knowledge of parasite life cycles and the dynamics that contribute to their spread should be assessed as this will assist in the timely application of prophylaxis. There is also the need for more studies aimed at understanding the challenges faced by farmers in the implementation of modern farming techniques. Rigorous and sustained integrated herd health planning to mitigate the prevalence and intensity of fluke infections is required. The report of new cases of human fasciolosis in South Africa and the nexus between animal and human *Fasciola* infection justifies calls for continuous epidemiological surveillance.

Competing interests

The authors declare that they have no financial or personal relationships which may have inappropriately influenced them in writing this article.

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