

Full Length Research Paper

Beef edible red offal condemnations in Kgatleng Slaughter Facilities, South eastern Botswana in a wet and dry season period

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The study aimed to determine pathological conditions across two seasons, leading to condemnations of beef edible red offals in Kgatleng District, Botswana. Offals are valued in communities of Botswana. Data from slaughter facilities was evaluated for dry/winter and wet/summer seasons. Financial losses were also determined. 7405 cattle were processed in the two seasons, with 4005 cattle slaughtered in the dry season and 3400 in the wet season. Of the slaughtered cattle, 55.2% (2209) of the dry season and 45% (1531) of the wet season had some forms of pathological conditions that led to condemnations of the offals. Lungs were highly condemned at 26.2% in the wet season and 32.7% during the dry season, followed by livers at 16.2 and 18.4% in the wet and dry seasons, respectively. Emphysema led to a condemnation rate of lungs at 20% and 17% for the dry and wet seasons, respectively. The least condemned offals were the spleen at 2.3% (wet season) and 2.1% (dry season), followed by the kidneys at 0.3% (wet season) and 2% (dry season). Financially, the dry season losses were relatively higher at BWP62 950.55 compared to the wet season at BWP43 863.95. Management strategies should be put in place to avail offals to consumers.

Key words: Beef, edible red offals, pathological conditions, wet and dry seasons.

INTRODUCTION

Botswana depends greatly on cattle for meat and milk consumption, and to generate income from meat and its associated byproducts such as edible organs/offal. Beef cattle farming in Botswana is an important socio-economic and cultural function in the lives of rural communities (Sharma, 2014; BIDPA, 2006). In Botswana, livestock offal's are highly valued across different communities, where they are consumed as a cheaper alternative to

meat, which is relatively more expensive and unaffordable to the rural poor. Different communities and or tribes use livestock offals, that can either be edible or inedible. Amongst edible offals are livers, hearts, tongues, tails, kidneys, brains, sweetbreads (the thymus and/or pancreas gland, depending on an animal's age), tripe (stomach), melt (spleen), chitterlings and natural casings (intestines), fries (testicles), rinds, head meat, lips, fats

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and other trimmings, blood, and certain bones (Bowater and Crustafson, 1988; Devatkal et al., 2004; Marti et al., 2011). Edible beef offals can be grouped into red, amongst them liver, kidneys, spleen, heart and lungs or green offal which include rumen, intestines and omasum. Red offals are not in contact with the contents of the digestive tract as compared to green (grass) offals (Bowater and Crustafson, 1988). These organs are mostly and readily available locally, in slaughter facilities and some retail stores. They tend to be relatively cheaper and affordable compared to standard meat cuts. Offals just like standard meat portions contain essential nutrients and minerals (Gracey et al., 1999; Warriss, 2000). Locally, beef edible offals just like carcasses, are usually inspected by veterinary personnel of the Ministry of Agriculture and Food Security at post-mortem in slaughter facilities, and at times condemned due to diseased conditions and or abnormalities. These condemnations lead to great economic losses to both the farmer and the meat processing industries.

Parasitic diseases are responsible for most condemnation of offal in slaughter facilities and therefore the main cause of related economic losses (Addis, 2017). Parasitic diseases also contribute to limiting factors for the full development of livestock export trade hence resulting in great financial losses to exporters (Mohamed et al., 2012). In addition to diseases, lack of appropriate slaughtering facilities and inappropriate slaughtering techniques cause unnecessary losses of meat as well as invaluable by-product from animal carcass, which may include offal. Cattle are affected by a variety of internal parasites, and among these are roundworms (nematodes), which are primarily parasites of the gastrointestinal tract with lung included and the liver fluke (trematodes) (Williams and Barker, 2001; Yimam, 2003). Periods of great infection risk occur from late winter through spring, and considerable infection may also occur during milder winters and during summers that are very wet and not overly hot (Williams and Barker, 2001). Under pasture conditions, it is common to encounter mixed infections with several types of roundworms as well as with other parasites as reported by Williams and Barker (2001). Additionally, animals grazing in swamps, marshy or flooded regions or close to water places are exposed to high risk of becoming infected with the tropical liver and also to an array of other parasites (Mesele et al., 2012). Previous studies have indicated a higher loss resulting from condemnations of edible organs and carcasses due to parasitic causes leading to offal condemnations (Negategize et al., 1993; Jembere, 2002; Aseffa 2005; Jibat, 2006). Parasitism is one of the major bottlenecks to livestock development in the tropics (Kassai 1999; Hansen and Perry, 1994; Keyyu et al., 2003; Max et al., 2006), Parasites often leads to abnormal conditions such as fascioliasis, peritonitis, hydatidosis and emphysema in livetsock. Fascioliasis has been found to lead to direct and indirect economic

impacts on livestock production in sheep and cattle resulting into death, loss of carcass weight, reduction in milk yield, condemnation of affected livers, and decline in production (reproductive production) performance, predisposition of other diseases and cost of treatment among others (Kassuku et al., 1986; Hammond and Sewell 1990; Wamae and Ihiga 1991; Menkir et al., 2007; Mungube et al., 2006). It is necessary to have clear information on major causes of organ/offal and carcass condemnations at slaughter facilities. This is important in providing information on where and how to reduce the product and financial losses, caused by the various abnormalities and or diseases in the livestock and meat industry (Jembere, 2002; Yimam, 2003; Aseffa, 2005; Getachew, 2008; Regessa et al., 2013). The main objective of this study was to evaluate condemnations records of beef edible red offals due to major pathological conditions in the Kgatleng Veterinary district, South Eastern Botswana. The study also aimed to investigate the influence of seasonality on the condemnations and financial losses relating to condemnation of red beef offals in the slaughter facilities.

MATERIALS AND METHODS

Study area

Kgatleng Veterinary area falls within the Kgatleng district, south Eastern Botswana. The area is 1014 m above sea level, and located between 24° South and 26° East latitude and longitude, respectively. The District has six slaughter facilities, namely; Mapole, Monakgomo, Mmadipinose, Lorato, Wataola and Kamo. Cattle slaughtered at these slaughter facilities are sourced from different extension areas within the district with various crush facilities used for their collection. Farmers are mainly of resource poor type, on communal grazing lands with relatively poor herd health management.

Study design

The study reviewed veterinary post-mortem slaughter records from the six slaughter facilities in the area. Major pathological conditions leading to red edible offals were identified as data entries over a total of eight months. The data was segregated into two seasons (four months each), being dry (winter; May to August 2015) and wet (summer; December, 2015 to March, 2016). Cattle slaughtered in these facilities are inspected by Government Meat Inspectors, following the standardized veterinary guidelines for ante-mortem and post-mortem inspection as per the Meat Industries Act (Botswana Government Printers, 2011), and such data is stored and available at District Veterinary Offices, Mochudi Veterinary Office in this case.

Data collection and analysis

Data collected was cleaned and verified. It was thereafter processed into spreadsheets and analysed using percentages to determine condemnation rates of the offals. Data evaluated was on beef edible red offals, being the lungs, livers, spleen and kidneys. Pathological conditions were identified that led to condemnations of each offal, and an estimate price per kg was used to calculate

Table 1. Wet season versus Dry season overall condemnations per offal (%).

Organ	Wet season	Dry season
Lungs	26.2	32.7
Livers	16.2	18.4
Spleen	2.3	2.1
Kidney	0.3	2
Total carcasses affected	1531	2209
Percentages	45	55.2

NB: Total cattle slaughtered for wet season (n = 3400) and dry season (n= 4005).

losses, using averaged prices in a major retail shop selling the same offals. Over the two seasons, a total of 7405 cattle were slaughtered across the six slaughter facilities. The number consisted of 4005 cattle slaughtered during the dry (winter) season and 3400 slaughtered during the wet (summer) season.

RESULTS AND DISCUSSION

Post-mortem data obtained from the Kgatleng Veterinary Office at Mochudi showed that a total of 7405 cattle were processed in the district's slaughter facilities in the two periods reviewed (May 2015 to March 2016). During the dry season, a total of 4005 were slaughtered, with a total of 3400 cattle slaughtered during the wet season. Of the slaughtered cattle, 55.2% (2209) in the dry season and 45% (1531) in the wet season suffered major pathological conditions that led to condemnations of the edible red offals extracted from them (Table 1). Ideally, as meat is the main source of protein to humans, it should be clean and free from diseases of particular importance to public health such as tuberculosis, hydatidosis, fascioliasis among others (Williams, 2001). Meat inspection, in the Kgatleng slaughter facilities comprises of ante mortem and post mortem examination, to remove gross abnormalities from meat and its products, prevention of distribution of contaminated meat that could result to disease risk in man and animals and assisting in detecting and eradication of certain diseases of livestock (Van, 1993; Herenda et al., 1994; Teka, 1997; Gracey et al., 1999). The existence of conditions leading to offal condemnations in the Kgatleng slaughter facilities indicates poor herd health by farmers. Farmers in the district are mainly subsistent and on communal areas. In such areas livestock mix across herds in grazing areas and are usually overstocked, making them prone to parasitism and poor health. To control these conditions and improve livestock production efficiencies, farmers should put in place management strategies that control gastrointestinal tract nematodes, and lung worm with a planned and systematic effort to simultaneously control liver fluke and ectoparasites, such as flies, lice and grubs. This further depends on prevalence in a given geographical area. However, good control of all parasites along with good overall herd health is the best guarantee

of increased productivity (Williams, 2001). The current study shows that beef edible red offals in Botswana, just like in other countries like Egypt, Ethiopia and Tanzania, go to waste in the slaughter facilities (Mellau et al., 2010; Ahmed et al., 2013; Mesfin et al., 2015). This situation leads to a threat to food security and financial losses in the country. Further, conditions leading to these condemnations pose a health hazard to meat consumers, farmers and the general public (Table 1).

Lungs

Lungs were highly condemned in both seasons due to conditions emphysema, hemorrhages and hydatidosis (Table 2). The emphysema condition led to a higher condemnation rate in this offal class at 20.6% and 17% for the dry and wet seasons, respectively. The hemorrhage condition contribution was comparable between the seasons at about 4% across the two seasons. Hydatidosis led to an 8.7 and 4.8% lungs condemnation in the dry and wet season, respectively. The emphysema condition that led to higher condemnation rates of lungs is an abnormal permanent enlargement of air spaces distal to the terminal bronchiole and destruction of alveolar septal walls without apparent fibrosis as was earlier explained by Mesfin et al. (2015) and Opara (2005). Mesfin et al. (2015) found hydatidosis condition as a major contributor to condemnation of lungs in the Dessie Municipal abattoir in North east of Ethiopia in a dry season period. This condition's contribution was much lower at 8.7% compared to the current study at 20.6% during the dry season and 17% during the winter season. It should be noted though that, the dry season period in Ethiopia is November - April compared to May - August in Botswana. Similar results on high lung condemnations due to the Emphysema condition during post-mortem were found by Mellau et al. (2010), who reported a 13.1% contribution rate at Arusha Abattoir in Tanzania.

In Ismailia, Egypt, Ahmed et al. (2013) reported higher lungs condemnation rate of up to 44.6% of all condemned organs. This report showed a high condemnation rate of lungs compared to the Kgatleng District data of south

Table 2. Edible red offal's condemnations due to major pathological conditions at Kgatleng slaughter slabs during the dry season (May 2015 to August 2015, Total carcasses affected n = 2209) and wet season (December 2015 to March 2016, Total carcasses affected n = 1531).

Red Offal	Condition	Dry Season		Wet Season	
		Offals affected	(%)	Offals affected	(%)
Lungs	Emphysema	824	20.6	578	17
	Hemorrhages	135	3.4	150	4.4
	Hydatidosis	347	8.7	162	4.8
Liver	Peritonitis	294	7.7	215	6.3
	Abscess	236	5.9	178	5.2
	Stelecia hepatica	209	5.2	159	4.8
Spleen	Peritonitis	63	1.6	62	1.8
	Mutilation	9	0.2	8	0.2
	Congestion	12	0.3	9	0.3
Kidney	Infarcts	15	0.4	1	0.02
	Congenital cyst	25	0.6	2	0.1
	Anemia	12	0.3	0	-
	Hydronephrosis	28	0.7	7	0.2

NB: Total cattle slaughtered for the dry season, n = 4005 and total cattle slaughtered for the wet season, n = 3400.

eastern Botswana. High Egyptian condemnation rate may be linked to the dry, windy and sandy ecosystem compared to that of Botswana. Exposure of animals to stress factors like dust, overcrowding and exhaustion from long treks in search of pasture and water during the dry season may also contribute to respiratory conditions (Kusiluka and Kambarage, 1996). Because of their anatomical and histological characteristics, lungs are perhaps the most exposed to physical, chemical and biological injuries. This is supported by the findings of this study which revealed higher levels of condemnations at 32% and 26.2% in the dry and wet seasons, respectively. Under poor herd health, livestock is also predisposed to parasitism, mainly endoparasites due to deficiencies during the dry period. It is during the dry season that livestock tend to nibble on foreign material due to deficiency cravings, risking infestation. Ruminants particularly cattle, have well developed interlobular septa and lack of collateral ventilation, making them more susceptible to interstitial emphysema (Mellau et al., 2010). Pulmonary emphysema is also caused by obstruction of airflow or by extensive gasping respiration during the slaughter process (FAO, 1994). More conditions leading to lung condemnations are reported by Ahmednur et al. (2015) for Dire Dawa Municipal Abattoir, Eastern Ethiopia. Lung condemnations of hemorrhage, emphysema, hydatid cyst, pneumonia and abscessation at 59, 17, 13, 6 and 5%, respectively were found.

Livers

Livers were second in condemnation rate due to

conditions peritonitis, abscesses and stelecia hepatica in the Kgatleng District slaughter facilities. All the three conditions recorded as having led to liver condemnations in the district were comparable, and lower than 10% across the two seasons. The peritonitis condition led to a condemnation rate of 7.7% during the dry (winter) season and 6.3% in the wet season (Table 2). Bovine liver is one of the largest visceral organs in the animal body, which performs numerous functions and a very rich source of vitamins and minerals (Ibironke and Fasina, 2010). This offal is much sought by consumers and food traders both locally, and in other countries like Nigeria due to its palatability and ease of consumption (Ibironke and Fasina, 2010). However, it is one of the most commonly condemned visceral organs during routine meat inspection (Ibironke and Fasina, 2010). Compared to the current study, Ethiopian studies showed higher condemnations rates for livers. Abunna et al. (2013) reported total condemnation rate of up to 39.7% out of 953 slaughtered in Southern Ethiopia from gross abnormalities. The authors noticed that livers were the most condemned organ in the Dire Dawa municipal abattoir in the period of five months from November 2014 to March 2015, a dry season in Ethiopia. In the current study, liver condemnations were much lower in a similar season, at 18.4%. The main difference between the dry seasons of Botswana and Ethiopia is that, for Botswana, the season is both dry and cold (winter), whereas in Ethiopia the season is relatively warm. The warm weather during this period in Ethiopia may be conducive to disease causing organisms that lead to abnormalities in livers. Still in Ethiopia, Ahmednur et al. (2015) reported a high percentage of liver condemnation at 73.8% out of

a total 17.3% of examined organs post-mortem. Mesfin et al. (2015) also reported high rate of 40.5% in the same region of north eastern Ethiopia for the dry season. Another study by Bogale et al. (2012) reported higher condemnation rates for the liver in northwestern part of Ethiopia, at 34.3% for the dry season, compared to the current study in Botswana. The temperature difference of the dry season in Botswana and Ethiopia, may be having an effect on the vulnerability of organisms leading to liver abnormalities, thus bringing these differences in condemnation rates in the two countries.

Stelecia hepatica condemnation contribution for both seasons in this study is comparable to 8.6% reported by Mellau et al. (2010) at an abattoir at Dodoma, Tanzania. A much higher condemnation rate due to *Stelecia Hepatica* at 30%, was reported by Kamwela et al. (2013) still in Tanzania, at an abattoir in Kigoma. Studies conducted in Ethiopia have also reported higher contributions to liver condemnations by *Stelecia hepatica* (Mohammed et al., 2012). This shows that *Stelecia hepatica* is a large burden in cattle in other African countries compared to Kgatleng District in Botswana. Although *Stelecia hepatica* rarely causes mortalities in cattle, its effects result in reduced production and condemnation of livers during meat inspection in abattoirs (Abunna et al., 2013, Addis, 2017). Such livers are usually declared unfit for human consumption and disposed off, leading to abattoir losses financially and a loss to human nutrition of a cheaper protein source. Abunna et al. (2013) in Wolaita Soddo Municipality Abattoir, Southern Ethiopia reported that the liver is the most often condemned organ. Conditions leading to liver condemnations mostly encountered in abattoirs during post-mortem inspection are macroscopic lesions, due to parasitic infections, resulting in fasciolosis, hydatid cyst, abscess, lesions, calcification and cirrhosis (Abunna et al., 2013). These conditions were observed even in the current study, contributing to liver condemnations. Of the condemned livers in Gondar abattoir at Northwest Ethiopia November 2011 to April 2012 reported by Bogale et al. (2012), fasciolosis was responsible for 48.5%, hydatidosis for 17.9% and cirrhosis for 15.4%. These conditions indicates poor herd health in Botswana just like in Ethiopia. In communal systems of Botswana, deworming strategies are very minimal if not none existent. Fasciolosis is caused by by *Fasciola hepatica*, a trematode (fluke) parasite that infests humans and many species of animals (Mesfin et al., 2015, Addis, 2017).

Spleen

This red offal had a low condemnation rate compared to lungs and the liver, and this was due to conditions peritonitis, congestion and mutilation.

The peritonitis condition had a relatively higher contribution to condemnations of this offal class, at

around 2% for both seasons. Other conditions led to condemnation rates lower than 1% (Table 2). This offal class tended to have an overall low condemnation rate, even in the study by Tembo and Nonga (2015) in Dodoma, Tanzania where a condemnation rate lower than 1% was reported for both dry/winter and wet/summer. Further, the study reported a much higher rate due to peritonitis condition at 23.3%. Compared to Botswana which has cold and warm seasons, Tanzania is always much warmer, which might explain the reported high condemnation rate in Dodoma abattoir. High temperature and moist ecosystems are ideal for microbial proliferation, leading to diseased organs of livestock.

Kidneys

Kidneys just like the spleen had a low condemnation rate in the Kgatleng Veterinary district during the two seasons. Conditions recorded for this offal class condemnations were infarcts, congenital cysts, anaemia and hydronephrosis (Table 2). These conditions led to condemnation rates lower than 1% across the two seasons. Ahmednur et al. (2015) in Ethiopia, reported that out of the 6442 cattle which were slaughtered at Dire Dawa municipal abattoir in a period of five months, from November 2014 to March 2015 which is a dry season too, condemnation rate was at 1.3% for kidneys. The results were comparable with those of the current study. Abunna et al. (2013) and Mesfin et al. (2015) in Ethiopia, reported liver condemnation rates of 3.2% and 5.1%, at Wolaita Soddo and Dessie municipal abattoirs, respectively. These figures are relatively higher compared to those obtained by the study. The differences may be accounted to the different temperatures during the dry season between Botswana and Ethiopia. Botswana's dry season is much cold, whereas the Ethiopian dry season is much warmer.

In the current study, congenital cysts and hydronephrosis tended to contribute more to kidney condemnation at 0.6 and 0.7%, respectively, during the dry season. For hydronephrosis, Mellau et al. (2011) in Arusha and Tembo and Nonga (2015) in Dodoma, both in Tanzania reported condemnation rate of about 1.9%. Both hydronephrosis and congenital cysts were observed more often in the dry season in these studies, an observation similar to the current study. Water scarcity for animals which is common during the dry season in countries like Botswana and Ethiopia, has been associated with predisposing livestock to renal conditions (Mellau et al., 2010; Tembo and Nonga, 2015). Both Botswana and Tanzania always experience dry seasons, accompanied by low rains, leading to lack of water for livestock. Water scarcity is common in rural poor communities, affecting both humans and livestock watering, with grazing resources also negatively affected by lack of rains. Other high condemnations were reported

Table 3. Overall estimated financial losses over the two seasons due to condemnations of the edible red offals.

Offal	Price/kg ^a	Dry season		Wet season	
		Total offals	Total Money	Total offals	Total Money
Lungs	23.95	1306	31278.70	890	21315.50
Liver	36.95	739	27306.05	552	20396.40
Spleen	23.45	84	1969.80	79	1852.55
Kidney	29.95	80	2396.00	10	299.50
Total			62950.55		43863.95

^aUSD1.00 ~ BWP11.00 (Exchange rate: USD to Botswana Pula).

in Morocco, Ethiopia and Kenya (Njoroge et al., 2002; Azlaf and Dakkak, 2006; Berhe, 2009), countries that always experience frequent droughts just like Botswana. Variations in prevalence of hydatidosis in cattle may be as a result of differences in the ecosystems, grazing patterns and status of Echinococcosis in stray dogs, which are the definitive hosts (Njoroge et al., 2002). In a study conducted in Wolaita Soddo Municipality Abattoir of Southern Ethiopia, Abunna et al. (2013) reported that kidneys were condemned mainly for unidentified causes (26.7%) and hydatid cysts (64.3%). These were relatively higher condemnations rates for livers compared to the current study. Variations in these findings further points to differences in ecosystems, grazing patterns, herd health strategies and status of Echinococcosis in stray dogs between Botswana and these other countries. In a study conducted by Bogale et al. (2012) at Gondar, Northwest Ethiopia conducted from November 2011 to April 2012 reports show that nephritis and hydatidosis were found to be the major principal causes for kidney condemnation, accounting for 29.4%. Mesfin et al. (2015) reported that in Dessie municipal abattoir North Eastern of Ethiopia that hydro nephrosis was identified as cause for kidneys condemnation at 11(1.4%) followed by hydatidosis 10 (1.3%), Nephritis 8 (1.0%), Calculi 5 (0.7%) and cyst 5 (0.7%).

Estimated financial losses

The condemnation of edible red offals in slaughter facilities leads to financial losses by meat processing industries and loss of animal protein at household level, negatively affecting food security. The current study observed that overall, the slaughter facilities lost revenue amounting to BWP106 814.50 (~9 710.40 USD), between May 2015 and March 2016 (Table 3). The dry season losses were higher at P62 950.55 compared to the wet season at BWP43 863.95. Larger losses were due to condemnations of lungs and livers at BWP52 594.20 and BWP47 702.45 for the dry and wet seasons, respectively. The spleen and kidneys losses were lower than BWP7000.00 collectively (Table 3). Losses of offals due to these condemnations leads to reduced availability of

human nutrients (proteins, vitamins and minerals), and deprives farmers and slaughter facilities valuable income. Estimated financial losses in the current study over a total of eight months, were relatively lower than losses reported by Ahmednur et al. (2015) at Dire Dawa Municipal Abattoir, Eastern Ethiopia, where losses associated with condemnation of edible organs were estimated at 109,492,728 Ethiopian Birr (ETB) (~547, 463,60 USD), and those reported by Bogale et al. (2012) at 21,565,849 ETB (1268579 USD) per year at Gondar, Northwest Ethiopia.

In another study by Mesfin et al. (2015), losses were lower and comparable to those of the current study. They reported financial losses of 122,617.70 Ethiopian birr (6,288.08 USD) at Dessie municipal abattoir, North Eastern Ethiopia, losses that were associated to condemnation of edible organs. The differences in financial losses in these studies may be due to the value and pricing of individual organs/offals, and currency strengths between the Botswana pula (BWP) and Ethiopian Birr (ETB). Further, ecological factors, farming practices and herd health efficiencies between Botswana and Ethiopia may be different. Nonetheless, these revenue losses negatively affect the livestock value chain; farmers, meat traders and the livestock industry, retarding socio-economic progress in such communities.

Conclusion

The study has revealed the level of condemnations of red beef offal and related revenue losses in the Kgatleng district of Botswana, just like in other African countries. Dry season had a higher percentage of carcasses with condemned offals compared to the wet season respectively. Of the condemned edible red offals in the two seasons, the dry season had a higher percentage of condemnations of lungs versus the wet season for lungs and livers, respectively. The condemnations rates of both the spleen and kidneys were relatively low and comparable across the two seasons. This study shows that for the lung, the emphysema condition contributed heavily to condemnations in both the dry and wet seasons. Peritonitis condition was the main contributor to

liver offal condemnations in the two seasons. Financially, the dry season losses were relatively higher compared to the wet season. Therefore, farmers in the Kgatlang district should put in place proper management and herd health strategies to reduce occurrence of these conditions in carcasses, so as to avail offal products to the market. This will assist abattoirs generate more income from offal products, and cut on financial losses. Furthermore, existence of some of these zoonotic conditions such as tuberculosis, hydatidosis, fasciolosis and cysticercosis in beef herds pose a health hazard to farmers, meat handlers, meat consumers and the public in general under poor herd health farming systems. Thus, livestock extension and public health education need to be strengthened to reduce the disease burden in the Kgatlang veterinary district.

CONFLICT OF INTERESTS

The authors declare no conflict of interest in this study.

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