P-ISSN: 2304-3075; E-ISSN: 2305-4360
International Journal of Veterinary Science
www.ijvets.com; editor@ijvets.com

Research Article

Pig Husbandry and Health Practices of Farmers in Selected *Taenia solium* Endemic Rural Villages of Two Districts in the Eastern Cape Province of South Africa

Msawenkosi I Sithole[1*] , Johan L Bekker[1] and Samson Mukaratirwa[2]

[1]Department of Environmental Health, Tshwane University of Technology, Pretoria, South Africa, 0001
[2]School of Life Sciences, University of KwaZulu-Natal, Westville Campus, Durban, South Africa
***Corresponding author:** msawenkosiS@daff.gov.za

Article History: Received: January 26, 2019 Revised: June 03, 2019 Accepted: June 15, 2019

ABSTRACT

Taenia solium, the causative agent of porcine and human cysticercosis is known to occur at high prevalence in the Alfred Nzo and OR Tambo Districts. Despite the high prevalence of the parasite in the province, no concerted efforts have been made to control and prevent this zoonotic disease despite being eradicable. A cross-sectional study was conducted in selected *T. solium*-endemic villages of the study areas to determine the pig husbandry and animal health management practices of small holder pig farmers. Interviews were done with pig farmers of Alfred Nzo (n=83) and OR Tambo (n=95) Districts using a structured questionnaire. Information collected on husbandry and health management practices were mainly those related to occurrence, awareness and transmission of *T. solium* in pigs and humans which included pig husbandry, marketing, slaughter, disease control and prevention. From the 178 farmers interviewed, 68% were females and 32% were males. Although most households had latrines in Alfred Nzo (96.4%) and OR Tambo (92.2%) Districts, they were not regularly used during night times (12.9%), rainy days (3.0%) and by small children (14.9%). There was a lack of routine pig health inspection (94.0%) and disease preventive interventions. Most pigs were slaughtered at home (97.1%) for both local commercial (80.7%) and own consumption (95.9%). The study confirms that the pig husbandry and health management practices of small-holder pig farmers in the study areas are conducive for the occurrence and transmission of *T. solium* cysticercosis and explains the high endemicity thereof in the two districts. We advocate for a "One Health" approach to control and prevent transmission of the parasite by relevant authorities and stakeholders, such as veterinary services, animal husbandry, farmer organisations, non-governmental organisations and other relevant stake-holders complemented by farmers' education in pig husbandry and health.

Key words: Pig husbandry, *Taenia solium* cysticercosis, Subsistence farming, Smallholder faming, Eastern cape province, South Africa

INTRODUCTION

In developing countries, livestock play a significant role in rural livelihoods and the economies (Herrero *et al.*, 2013). Although the number of pigs in Africa account for only 3.1% of the world's pig population and 2% of global pork production, pigs in the majority of sub-Saharan Africa countries are reared following traditional systems where pigs are left free-ranging or at most confined at night and/or seasonally to protect crops (Penrith *et al.*, 2013). Likewise, South Africa has the largest number of pigs in sub-Saharan Africa of which approximately 25% of the pigs are free-ranging and owned by emerging pig producers in resource-poor areas of the country (Krecek *et al.*, 2008; Krecek *et al.*, 2012). Pigs left to free-range are exposed to infection with parasites such as *T. solium* which negatively affects production output through condemnation of infected carcasses and the zoonotic risk of the parasite to local communities (Roesel *et al.*, 2017). An increase in the prevalence of porcine cysticercosis in the eastern and southern African (ESA) region has been linked with the increase in rural smallholder pig farming and pork consumption (Phiri *et al.*, 2003).

South Africa has the highest reported prevalence of cysticercosis as a result of its large number of rural pigs (Phiri *et al.*, 2003; Krecek, 2005) . Furthermore, *T. solium* cysticercosis has been known to cause serious infection such as neurocysticercosis causing significant losses in agricultural and human productivity, especially in many developing and transitional countries, resulting in a major hindrance to their development goals (Eddi *et al.*, 2006).

Cite This Article as: Sithole MI, JL Bekker and S Mukaratirwa, 2019. Pig husbandry and health practices of farmers in selected *Taenia solium*-endemic rural villages of two districts in the eastern cape province of South Africa. Inter J Vet Sci, 8(4): 235-242. www.ijvets.com

Due to free-range pig farming and poor sanitation in most villages of the Eastern Cape Province of South Africa, the Xhosa-speaking people of the Eastern Cape Province have been reported to have high prevalence of *T. solium* cysticercosis (Mafojane *et al.,* 2003). A community based study of pigs owned by resource-poor, rural pig farmers conducted in 21 villages of the Eastern Cape Province, indicated an average prevalence of 64.6% (Krecek *et al.,* 2008).

Though in 1993, *T. solium* taeniasis/cysticercosis was declared eradicable in sub-Saharan Africa by the International Task Force on Disease Eradication (ITFDE) of the World Health Organisation (WHO, 1993), Food and Agriculture Organisation (FAO) and World Organisation for Animal Health (OIE), limited national-scale control programmes have been implemented (Braae *et al.,* 2016). Smallholder farming (including subsistence farming) has always been perceived as a 'developing country problem' with low levels of commercial market engagement that contribute to rural poverty (Fredriksson *et al.,* 2017). Comparable to what was described by Fredriksson *et al.* (2017), that these small yet numerous are both producers and consumers of their own agricultural output (in this case pigs) and have largely been excluded from many official farming surveys as they are not really regarded as "farmers". However, specific veterinary public health rules (laws and standards) needs to be followed for them to participate in the food supply chain. For example, Food Safety management Systems such as ISO 22000 (ISO, 2018), require that suppliers of raw materials (including live animals sent for slaughter) must provide information such as origin (provenance), to an extent that it will allow the next entity in the supply chain to conduct a hazard analysis.

Against this background, the purpose of this study was to determine the pig husbandry and health management practices of rural farmers in two districts of the Eastern Cape Province of South Africa where *T. solium* cysticercosis/taeniasis is endemic to inform future control and prevention programmes.

MATERIALS AND METHODS

Ethical approval

Written approval for the study was obtained from the Tshwane University of Technology with ethics clearance from the Faculty of Science Committees for Research Ethics (Reference number FCRE2016/06/001SCI) and Animal Research Ethics Committee (Reference number AREC2016/05/001) and the House of Traditional Leaders to conduct the study in their areas of jurisdiction. The latter required two presentations which emphasised their roles in guiding communities regarding their customs and traditions and their consent to administer questionnaire to the community and use of their animals in the study. Participation was voluntary and study subjects were given an option to withdraw from the study at any time should they wish to do so.

The study was conducted in the rural areas of the Alfred Nzo and OR Tambo Districts (within the former Transkei) of the Eastern Cape Province of South Africa. The main economic activity of the rural communities in the two districts is mixed farming (crops and livestock which include pig rearing). These two areas were chosen because previous studies conducted in the same areas, indicated a high prevalence of *T. solium* taeniosis/ cysticercosis in human and pigs (Krecek *et al.,* 2008; Krecek *et al.,* 2012).

Study areas

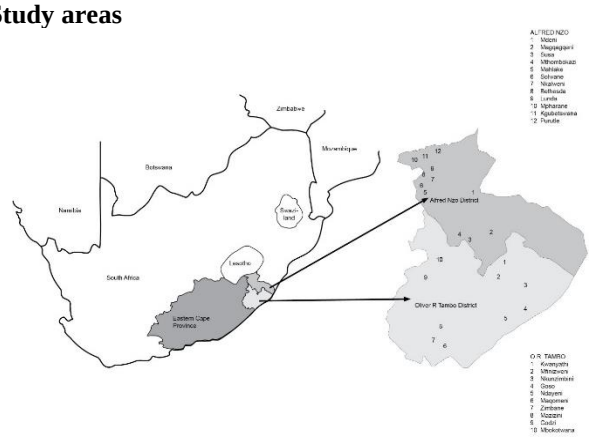

Fig. 1: Location of the two study districts and villages where study pigs were purchased from in the Eastern Cape Province of South Africa.

The Alfred Nzo District is situated within the South latitudes 30° 54' and 83° and East longitudes 28°85' and 97° (Google maps) with a population of about 801, 344 and covers 10 731km² (South Africa, 2011) . The district is regarded as the poorest in the province and is characterised by high unemployment figures. It has an average minimum temperature ranges from 7 to 10ºC in winter and 18 to 24ºC in summer. Its rainfall season occurs in summer from October to March, although approximately 30% of the annual rainfall occurs in the winter months (Kekana, 2017). The district comprise of the Matatiele, Ntabankulu, Mbizana and Umzimvubu Local Municipalities.

The OR Tambo district has a population of about 1,364,943 people and is situated within the South latitudes 30° 00' and 34° 15' and East longitudes 22°45' and 30°15' (Bisi-Johnson *et al.,* 2010). Rainfall in the area is moderate to high and covers 12 096 km² on the coastline (South Africa, 2011) . Ninety three percent of the OR Tambo population resides in rural areas with an estimated 77% of the population unemployed. The district municipality is made up of King Sabata Dalindyebo, Nyandeni, Mhlontlo, Port St Johns and Ingquza Hill Local Municipalities.

Both districts are mainly communal land with rural villages and traditional homesteads scattered all over the land and far apart from each other with most households practising small-scale subsistence farming (van Tol *et al.,* 2016). The majority of households cultivate crops such as maize and small grains on small areas of land around the homes and/or together with extensive livestock rearing including cattle, goats, sheep, pigs and chickens on communal grazing areas. Pigs are owned in varying numbers by each household and are mostly free-roaming.

Study design and data collection

This study forms part of a larger study related to the occurrence and detection of *T. solium* in the Eastern Cape Province of South Africa. A cross-sectional study was

conducted between August and October 2016 in the OR Tambo and Alfred Nzo Districts of the Eastern Cape Province of South Africa to determine the pig husbandry and health management practices of farmers related to the occurrence and transmission of *T. solium* cysticercosis. There were about 25 772 pigs for Alfred Nzo District and 30 151 pigs for OR Tambo District (South Africa, 2016). Prior to commencement of the survey, an inception meeting was held with the representatives of the Local/ House of Traditional Leaders to explain the purpose of the study. This was followed by another meeting with the communities in the study area where Traditional Leaders introduced the study to pig farmers on our behalf. One-hundred-and-seventy-eight farmers were randomly selected from 22 villages of the two districts depending on the owner willingness to sell his/her pigs; Alfred Nzo (n=12 villages; 83 farmers) and OR Tambo (n=10 villages; 95 farmers), where only farmers who were willing to sell pigs were included. A structured questionnaire was used to collect information from farmers on husbandry and health management practices mainly those related to the occurrence, awareness and transmission of *T. solium* in pigs and humans which included pig husbandry, marketing, slaughter, disease control and prevention.

Data analysis

Due to the nature of the questionnaire, not all questions were always answered by all respondents and therefore the n-values of the variables differed. Frequencies observed within the categories of each question were tested for normality by a 1:1 ratio using a Chi-square (χ^2) test. Furthermore, Row x Column frequency tables were constructed of meaningful associations and a χ^2 test for independence (association) was performed (Snedecor & Cochran, 1989). All data analyses were done using SAS Statistical software (SAS, 1999).

RESULTS

The number of questionnaires completed were 46.6% (n=83) for Alfred Nzo and 53.4% (n=95) for OR Tambo (p=0.3684). The socio-demographic information of the two study areas and aspects of pig husbandry and health management practices that could be contributing to the transmission and high prevalence of *T. solium* cysticercosis in pigs and humans are shown in Table 1, 2a-b respectively.

Socio-demographic information

Table 1 provides a summary of the socio demographics information. More females (68%; 121/178) than men (32%; 57/178) were involved in pig farming in the two districts although the difference was not significant (P=0.8522). The average age of farmers interviewed were 53 years and 51 years in Alfred Nzo and OR Tambo Districts respectively. Although the source of income was diverse in the two districts (P=0.0135), the majority of farmers were unemployed (41.0%; 71/173). There was a significant variation in the level of education between the two districts (P=0.0226) with the majority of farmers having education below grade 9. Although there was no significant difference in the number of members per household between the two districts, the most numbers ranged from 3-5 per household. Although most households had latrines in Alfred Nzo (96.4%; 80/83) and OR Tambo (92.2%; 83/90) Districts, they were not regularly used during night times (12.9%; 13/101), rainy days (3.0%; 3/101) and small children (14.9%; 15/101). Few respondents (7.7%; 13/168) from the two districts were members of a farming organisation.

Pig husbandry practices

Tables 2a and 2b shows the responses by pig farmers on pig husbandry practices in the two districts. Surprisingly, a high percentage of respondents in the Alfred Nzo District (63.9%; 53/83) were of the opinion that they were smallholder farmers by virtue of keeping their pigs indoors in relation to those of OR Tambo (62.1%; 59/95) who considered themselves as subsistence farmers (p=0.0005) as their pigs were mainly kept free-ranging. The majority of farmers in both districts responded that mixed animal farming with pigs (90.8%; 154/173), cattle (87.0%; 140/161), goats (88.3%; 143/162) and chickens (87.6%; 148/169) formed part of their cultural tradition ($p > 0.05$ for all four species). In Alfred Nzo, pigs were free-range (63.4%; 52/82), confined (24.4%; 20/82) and tethered (12.2%; 10/82) whereas with OR Tambo 93.3% were free-range (84/90), 5.6% were confined (5/90) and 1.1% were tethered (1/90). There was almost no control of pig movement (80.1%; 140/174) in the study areas, however at some instances shepherd (2.9%; 5/174) and improperly full covered fence (16.1%; 28/174) were used for the purpose. Pigs were allowed to roam with cattle (93.2%; 124/133), sheep/goats (94.0%; 125/133), chickens (94.0%; 125/133), stray dogs (92.4%; 122/132) and game animals (6.1%; 8/131) (Table 2b).

Pig health management

Responses by farmers on pig health management are shown in Table 2b. Most farmers (91.6%; 141/154) indicated that there were no veterinary services rendered to them; neither by government nor private entities, however there was a significant difference (p=0.0477) from those who said they did receive veterinary service between both Alfred Nzo (4.0%; 3/76) and OR Tambo (12.8%; 10/78) Districts. A significant majority of farmers did not deworm their animals (85.5%; 147/172) (p=0.0386) compared to a few who claimed to use manganese (Mn) for both Alfred Nzo (9.0%; 7/81) and OR Tambo (19.8%; 18/91). Our study has also revealed that there was minimal routine animal health inspection (94.0%; 154/168), and most farmers where ignorant about zoonotic (91.0%; 151/166), controlled (96.8%; 149/154) and notifiable (98.7%; 147/149) diseases and were not aware of the notifiable diseases and the procedure to report to veterinary services (96.3%; 157/163). Most farmers (98.7%; 154/156) did not keep records of the medicines purchased, stored and administered, however more respondents in Alfred Nzo (16.5%; 13/79) showed a better understanding of medicine withdrawal period as compared to OR Tambo (5.5%; 5/91) (p=0.0205), but generally the knowledge on medicine withdrawal periods was low (10.6%; 18/170).

Table 1: Demographic characteristics of the study population of Alfred Nzo and OR Tambo Districts of the Eastern Cape Province of South Africa

Factor	No of respondents	Alfred Nzo district	OR Tambo district	$\chi^2_{(df=1)}$	P
Gender	178			0.0347	0.8522
Male		26 (31.3%)	31 (32.6%)		
Female		57 (68.7%)	64 (67.4%)		
Age Group	178			7.7182	0.1025
<35		20 (24.1%)	15 (15.8%)		
35-44		16 (19.3%)	9 (9.5%)		
45-54		18 (21.7%)	21 (22.1%)		
55-64		16 (19.3%)	28 (29.5%)S		
>64		13 (15.7%)	22 (23.2%)		
Average		53 years	51 years		
Source of income	173			14.3585	0.0135
Work		7 (8.6%)	5 (5.4%)		
Self-employed		11 (13.6%)	6 (6.5%)		
Grants		4 (4.9 %)	18 (19.6%)		
Pension		20 (24.7%)	31 (33.7%)		
Unemployed		39 (48.2%)	32 (34.8%)		
*Level of education	178			9.5725	0.0226
No education		2 (2.4 %)	14 (14.7%)		
Grades 1-9		59 (71.1%)	65 (68.4%)		
Grades 10-12		20 (24.1%)	15 (15.8%)		
Tertiary level		2 (2.4%)	1 (1.1%)		
Members in a household	178			3.8050	0.4330
≤2		32 (38.6%)	26 (27.4%)		
3-5		40 (48.2%)	49 (51.6%)		
6-8		5 (6.0%)	9 (9.5%)		
9-11		4 (4.8%)	9 (9.5%)		
>11		2 (2.1%)	2 (2.1%)		
*Presence of latrines	173			2.2757	0.3205
Pit latrines		80 (96.4%)	83 (92.2%)		
Sewerage toilets		3 (3.6%)	5 (5.6%)		
*Latrine/toilets non-usage	101			4.9217	0.1776
Night times		3 (5.9%)	10 (20.0%)		
Rainy days		2 (3.9%)	1 (2.0%)		
Small children		9 (17.7%)	6 (12.0%)		
Use latrines		37 (72.6%)	33 (66.0%)		
Member of farming organization	168			0.0121	0.9123
Yes		6 (7.5%)	7 (8.0%)		
No		74 (92.5%)	81 (92.0%)		

Asterisk (*) denotes factors which influence *Taenia solium* occurrence and transmission in pigs and humans.

Table 2a: Pig husbandry practices, health, disease control and prevention of farmers from Alfred Nzo and OR Tambo districts of the Eastern Cape Province of South Africa

Factor	No of respondents	Alfred Nzo	OR Tambo	$\chi^2_{(df=1)}$	P
Pig husbandry					
*Type of farming	178			11.9419	0.0005
Smallholder		53 (63.9%)	36 (37.9%)		
Subsistence		30 (36.1%)	59 (62.1%)		
Farming is a cultural tradition					
Pigs	173	75 (92.6%)	82 (89.1%)	0.6821	0.7110
Cattle	161	69 (86.3%)	71 (87.7%)	1.5518	0.4603
Goats	162	71 (88.8%)	72 (87.8%)	4.5830	0.1011
Chicken	169	69 (86.3%)	79 (88.8%)	2.6324	0.2681
*Method of rearing pigs	172			28.1481	0.0001
Free-range		52 (63.4%)	84 (93.3%)		
Confined		20 (24.4%)	5 (5.6%)		
Tethering		10 (12.2%)	1 (1.1%)		
*Control of pig movement	174			3.1209	0.3734
No control		69 (84.2%)	71 (76.3%)		
Use shepherd		3 (3.7%)	2 (2.2%)		
Use fence		9 (11.0%)	19 (20.4%)		
Pig health management					
*Veterinary services	154			3.9212	0.0477
Government		3 (4.0%)	10 (12.8%)		
No services		73 (96.1%)	68 (87.2%)		
Internal parasite control	172			4.2799	0.0386
No control		74 (91.4%)	73 (80.2%)		
Manganese		7 (8.6%)	18 (19.8%)		

Asterisk (*) denotes factors which influence *Taenia solium* occurrence and transmission in pigs and humans.

Table 2b: Pig husbandry practices, health, disease control and prevention of farmers from Alfred Nzo and OR Tambo districts of the Eastern Cape Province of South Africa

Factor	No of respondents	Alfred Nzo		OR Tambo		Total		$\chi^2_{(df=1)}$	P
		Yes	No	Yes	No	Yes%	No%		
Pigs roaming with cattle	133	45	5	79	4	93.2	6.8	1.3274	0.2493
Pigs roaming with sheep/goats	133	45	5	80	3	94.0	6.0	2.2506	0.1336
Pigs roaming with chickens	133	45	5	80	3	94.0	6.0	2.2506	0.1336
Pigs roaming with stray dogs	132	43	6	79	4	92.4	7.6	2.4264	0.1193
Pigs roaming with game	131	1	47	7	76	6.1	93.9	2.1389	0.1436
*Routine animal/pig health inspection	164	3	74	7	80	6.1	94.0	1.2286	0.2677
*Knowledge on zoonotic diseases	166	6	73	9	78	9.0	91.0	1.3242	0.5158
*Knowledge on controlled diseases	154	2	70	3	79	2.6	96.8	0.0947	0.7583
*Knowledge on notifiable diseases	149	1	69	1	78	1.3	98.7	0.0074	0.9313
*Report on outbreaks of notifiable diseases	163	1	78	5	79	3.7	96.3	2.5220	0.1123
Records of medicines purchased, stored and administered	156	2	71	0	83	1.3	98.8	2.3035	0.1291
Knowledge of medicine withdrawal period	170	13	66	5	86	10.6	89.4	5.3668	0.0205
Feeding and source of drinking water									
*Pigs given supplementary feed	130	30	17	69	14	76.2	23.9	6.1569	0.0131
*Source of drinking water:									
Dam	161	3	72	13	73	10.0	90.1	5.5312	0.0187
Borehole	163	5	74	9	75	8.6	91.4	2.0184	0.3645
River	167	52	28	61	26	67.7	32.3	0.4984	0.4802
Man-made troughs	162	32	47	26	57	35.9	64.2	2.6983	0.2595

Asterisk (*) denotes factors which influence *Taenia solium* occurrence and transmission in pigs and humans.

Table 3: Pig marketing and slaughtering practices of farmers from Alfred Nzo and OR Tambo districts of the Eastern Cape Province of South Africa

Factor	No of respondents	Alfred Nzo	OR Tambo	$\chi^2_{(df=1)}$	P
Marketing of pigs					
*Buy from other farmers	174			0.0323	0.8575
Yes		76 (91.6%)	84 (92.3%)		
No		7 (8.4%)	7 (7.7%)		
Sell to other farmers	175			0.0003	0.9860
Yes		74 (90.2%)	84 (90.3%)		
No		8 (9.8%)	9 (9.7%)		
*Sell to the public	175			0.0000	0.9956
Yes		74 (89.2%)	82 (89.1%)		
No		9 (10.8%)	10 (10.9%)		
*Buyer obtains health status	171			0.5755	0.4481
Yes		2 (2.4%)	4 (4.5%)		
No		81 (97.6%)	84 (95.4%)		
Seller obtains health status	172			1.0786	0.2990
Yes		1 (1.2%)	0 (0.0%)		
No		82 (98.8%)	89 (100%)		
Record the name of the buyer	170			2.3626	0.1243
Yes		4 (4.9%)	10 (11.4%)		
No		78 (95.1%)	78 (88.6%)		
Record the name of the seller	172			0.1406	0.7077
Yes		2 (2.4%)	3 (3.4%)		
No		81 (97.6%)	86 (96.6%)		
Slaughter of pigs					
*Slaughter pigs at home	174			0.3424	0.5585
Yes		79 (96.3%)	90 (97.8%)		
No		3 (3.7%)	2 (2.2%)		
*Slaughter for commercial	161			3.3370	0.0677
Yes		56 (74.7%)	74 (86.1%)		
No		19 (25.3%)	12 (14.0%)		
*Slaughter for own consumption	170			0.2980	0.5851
Yes		76 (95.0%)	87 (96.7%)		
No		4 (5.0%)	3 (3.3%)		

Asterisk (*) denotes factors which influence *Taenia solium* occurrence and transmission in pigs and humans.

Feeding and source of drinking water

Pigs grazed naturally on grass and were fed with various kitchen household food remnants, however, the most common were mealies and bran for both Alfred Nzo (63.8%; 30/47) and OR Tambo (83.1%; 69/83). Farmers indicated that most pigs used the river/stream as a source of drinking water (67.7%; 113/167), with a significant difference (p=0.0187) from those who had their animals drinking from dam/pond in both Alfred Nzo (4.0%; 3/75) and OR Tambo (15.1%; 13/86).

Marketing and slaughter of pigs

Table 3 shows that most of the farmers bought (92.0%; 160/174) and sold (90.3%; 158/175) pigs from one another. Very few farmers obtained (3.5%; 6/171) and provided (0.6%; 1/172) the health status of the pigs. Most of them did not keep records of buyer (91.8%; 156/170) or seller (97.1%; 167/172). Most of the farmers slaughtered their pigs at home (97.1%; 169/174) for both commercial (80.7%; 130/161) and own consumption (95.9%; 163/170) and almost all of them (94.6%; 158/167) slaughtered their animals without notifying the veterinary services for meat inspection.

Most farmers from the two districts were of the view that meat safety is the responsibility of local government (30.8%; 28/91) followed by the pig owners (18.7%; 17/91) themselves and the rest were for provincial government (17.6%; 16/91), butcheries (15.4%; 14/91), consumers (9.9%; 9/91) and national government (7.7%; 7/91) in that order.

DISCUSSION

Taenia solium cysticercosis/taeniosis is a preventable disease of pigs and humans which often leads to neurocysticercosis in humans. However, there are still challenges with regard to positive change in knowledge, attitude and practices in term of pig husbandry, food safety and pig health management in the affected communities when it comes to control interventions (Sankhyan *et al.*, 2015). This study identified potential risk factors associated with the occurrence and transmission of *T. solium* cysticercosis in pigs in Alfred Nzo and OR Tambo Districts of the Eastern Cape Province of South Africa. The trend that females were more involved with pig farming than men is in line with other studies conducted in South Africa (SAQA, 2007; Banerjee *et al.*, 2008; Modisaotsile, 2012) and elsewhere (Tatwangire, 2013). This might be because farmers in the study areas told us that in the Eastern Cape Province of South Africa, pig farming is regarded as women activity. The reason for a relatively high age range (51-53 years) of respondents from this study could be ascribed to the fact that pig ownership belonged to adults of higher age in a household. Although the majority of the respondents had some kind of source of income (work, self-employed, grants, pension), the majority of farmers were unemployed in both Alfred Nzo (48.2%) and OR Tambo (34.8%). Our results concur with Kekana, (2017) who reported that Alfred Nzo is regarded as poorest district in the province. This study has a high percentage of respondents with an education level below grade 9, which is the minimum legal level for education in South Africa (SAQA, 2007; Banerjee *et al.*, 2008; Modisaotsile, 2012). This might be a hindrance in knowledge-uptake should interventions such as farmers education in pig husbandry or any other related public health education programmes be implemented in the areas of study, on the other hand low level of education should assist in the development of more appropriate education programmes aimed at the population.

Although most households had latrines in the two districts of study, however, at night times and during rainy days, latrines were not used and furthermore young children were prohibited from using the toilets. The non-use of toilets by a proportion translates into open defaecation where pigs are readily exposed to human faeces and thus increasing the chances of transmission of the parasite. Surveys conducted in Tanzania and Zambia have shown that the prevalence of porcine cysticercosis was significantly higher in pigs reared in households without or not using latrines than those with latrines and using them (Pondja *et al.*, 2010).

Similar to resource-poor communities throughout sub-Saharan African countries (Katongole *et al.*, 2012), some farmers in especially Alfred Nzo District regarded themselves as smallholder farmers. This study also showed that pigs were among the most important livestock reared by the farmers in both districts and as part of their cultural tradition and the pigs were mainly kept for household consumption as well as source of income when the need arises. This is in agreement with similar studies elsewhere (Levasseur & Olivier, 2000) where pigs played an important role in the livelihoods of resource-poor rural communities. As it was found in Uganda (Waiswa, 2005), most farmers allowed their pigs to be roaming amongst other domestic animals and households where there was infrequent use of pit-latrines during night times, rainy days and in case of children too small to use pit-latrines (safety measures). This practice may pose a public health risk if pigs can come into contact with other diseased animals and human faeces. The practice of not controlling free roaming pigs from having access to areas where pit-latrines were not frequently used may pose a public health risk.

Majority of farmers indicated that they do not receive veterinary services from the responsible authorities. This should be addressed in order to contribute to the understanding and interpretation of information on disease legislation due to interaction between farmers and authorities (Ellis-Iversen *et al.*, 2010). Although most farmers had no internal parasite control, but few of them claimed to use manganese. Manganese is often added to pigs' diets to strengthen the density of bones, tendons, and joints (Wu *et al.*, 2018) and has no anthelminthic properties.

The absence of meat inspection poses a risk to public health (Sutherst, 2001). For example, *T. solium* cysts and *Echinococcus granulosis* hydatid cysts in pigs, poses a health threat to pork consumers (Eckert *et al.*, 2001; Macpherson *et al.*, 2003). This should be taken into consideration since farmers told us that they slaughter pigs for both commercial and own consumption.

In this study, a significant number of farmers from the two districts confirmed supplementary feeding to their pigs and this is in agreement with Katongole *et al*. (2012) who reported the practice of supplement feeding to pigs using kitchen remnants, grain bran and fodder throughout the year in Kampala, Uganda. The feeding of kitchen remnants may however pose a health risk to diseases such as African swine fever (Ouma *et al.*, 2014) and some zoonotic parasites (Braae *et al.*, 2015). This study revealed that although pigs drank water from man-made troughs, dam and borehole, the main source of drinking water for the study areas was the river (67.7%). This raised a possibility for *T. solium* to be transmitted if water may become contaminated with infected human faeces,

especially if source of water is not protected like in our study areas (Komba *et al.*, 2013; Mwanjali *et al.*, 2013).

This study has also revealed that farmers were buying and selling pigs from one another without obtaining and/or providing health status of the animals. The health status of animals in general other than *T. solium*, assists in declaring whether the animals slaughtered by the farmers are healthy (Madec *et al.*, 2001). This is a concern because most farmers also slaughter their pigs at home for sale and own consumption and as previously stated, they do not have any knowledge regarding diseases. There is a high possibility that pig carcasses with *T. solium* cysts are consumed and hence increasing the chances of transmission of the parasite to individuals when they eat raw or undercooked infected pork. Slaughter at commercial abattoirs will normally control the health status to some extent, but in terms of the Meat Safety Act. 40 of 2000, slaughter of animals for own consumption is exempted from any control (South Africa, 2000).

Farmers assigned the responsibility of meat safety mainly to either government or farmers/butcheries and we consider this as positive in that at least farmers had a certain level of understanding their responsibility, which can contribute significantly in good agricultural practices. The mixed understanding from the farmers can also point to the need for training of farmers in terms of "farm to fork" approach in order to advance their knowledge with regard to meat safety.

The abovementioned shortcomings maybe exacerbated by the fact that the farmers were not members of a farming organisation. Farming organisations may assist with creating bridges between the farmers, government and other relevant stakeholders and may also serve as a hub for information sharing and education (Blay-Palmer *et al.*, 2013).

Conclusions

The study showed that there is a lack of technical livestock health support to prevent and control animal diseases in the areas of the study. Improving pig husbandry practices such as confinement of pigs to avoid access to human faecal matter, improving sanitation and ensuring that facilities are utilised by the community, use of available anthelmintic treatment, improving meat inspection and processing and mass drug administration to the community in the rural settings of the study area will support the principles of good agricultural practices (Thomas & Organization, 2015). Relevant government and provincial authorities are encouraged to initiate integrated intervention strategies on the control and prevention of *T. solium* taeniosis/cysticercosis in the study areas that focuses on pig health education and creating an awareness to farmers on the good farming practices (that are ideal given their circumstances) for the control and prevention of transmission of the parasite. More efforts to improve farming practices, safe slaughter and health education are best addressed by a "One Health" approach, which recognizes that the health of people is connected to the health of animals and the environment.

Funding information

This research was funded through a grant provided by the Agricultural Research Council (ARC) of South Africa on behalf of the Departement of Agriculture, Forestry and Fisheries (DAFF).

Acknowledgements

The authors thank the Department of Agriculture, Forestry and Fisheries (DAFF) of South Africa for financial support. Mr. Maruping Ntsatsi for field support, Veterinary Services staff of the Eastern Cape Province; the House of Traditional Leaders and Community leaders for their support and finally the emerging pig producers who cooperated willingly throughout this study.

REFERENCES

Baiphethi MN, PT Jacobs, 2009. The contribution of subsistence farming to food security in South Africa. Agrekon 48: 459-482.

Banerjee A, S Galiani, J Levinsohn, Z McLaren, I Woolard, 2008. Why has unemployment risen in the new South Africa? Economics of Transition 16: 715-740.

Bisi-Johnson M, C Obi, L Kambizi, M Nkomo, 2010. A survey of indigenous herbal diarrhoeal remedies of OR Tambo district, Eastern Cape Province, South Africa. African Journal of Biotechnology 9.

Blay-Palmer A, K Landman, I Knezevic, R Hayhurst 2013. Constructing resilient, transformative communities through sustainable "food hubs" (Taylor & Francis).

Braae UC, W Harrison, F Lekule, P Magnussen, MV Johansen, 2015. Feedstuff and poor latrines may put pigs at risk of cysticercosis—A case-control study. Veterinary parasitology 214: 187-191.

Braae UC, P Magnussen, W Harrison, B Ndawi, F Lekule, MV Johansen, 2016. Effect of National Schistosomiasis Control Programme on Taenia solium taeniosis and porcine cysticercosis in rural communities of Tanzania. Parasite Epidemiology and Control, 1: 245-251.

Eckert J, M Gemmell, F-X Meslin, Z Pawlowski 2001. WHO-OIE manual on Echinococcosis in humans and animals: a public health problem of global concern (Citeseer).

Eddi C, dB Katalin, L Juan, A William, S Andrew, B Daniela, D Joseph, 2006. Veterinary public health activities at FAO: Cysticercosis and echinococcosis. Parasitology International 55, Supplement, pp: S305-S308.

Ellis-Iversen J, AJC Cook, E Watson, M Nielen, L Larkin, M Wooldridge, H Hogeveen, 2010. Perceptions, circumstances and motivators that influence implementation of zoonotic control programs on cattle farms. Prev Vet Med, 93: 276-285.

FAO I, 2015. WFP (2015) The state of food insecurity in the world 2015. In: Meeting the 2015 international hunger target: taking stock of uneven progress.

Fredriksson L, A Bailey, S Davidova, M Gorton, D Traikova, 2017. The commercialisation of subsistence farms: Evidence from the new member states of the EU. Land Use Policy 60, 37-47.

Herrero M, D Grace, J Njuki, N Johnson, D Enahoro, S Silvestri, MC Rufino, 2013. The roles of livestock in developing countries. Animal 7: 3-18.

Katongole CB, J Nambi-Kasozi, R Lumu, F Bareeba, M Presto, E Ivarsson, JE Lindberg, 2012. Strategies for coping with feed scarcity among urban and peri-urban livestock farmers in Kampala, Uganda. Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS) 113: 165-174.

Kekana MV, 2017. Socio-Economic Factors Influencing Market Participation of Horticultural Smallholder Farmers in the Alfred Nzo District. Tshwane University of Technology.

Komba EV, EC Kimbi, HA Ngowi, SI Kimera, JE Mlangwa, FP Lekule, CS Sikasunge, AL Willingham III, MV Johansen, SM Thamsborg, 2013. Prevalence of porcine cysticercosis and associated risk factors in smallholder pig production systems in Mbeya region, southern highlands of Tanzania. Veterinary parasitology 198: 284-291.

Krecek R, 2005. Third meeting of the Cysticercosis Working Group in Eastern and Southern Africa takes place in Maputo: to the editor. Journal of the South African Veterinary Association 76: 2-3.

Krecek R, L Michael, P Schantz, L Ntanjana, M Smith, P Dorny, L Harrison, F Grimm, N Praet, A Willingham Iii, 2008. Prevalence of Taenia solium cysticercosis in swine from a community-based study in 21 villages of the Eastern Cape Province, South Africa. Veterinary Parasitology 154: 38-47.

Krecek RC, H Mohammed, LM Michael, PM Schantz, L Ntanjana, L Morey, SR Werre, AL Willingham III, 2012. Risk factors of porcine cysticercosis in the Eastern Cape Province, South Africa. PLoS One 7, e37718.

Levasseur V, A Olivier, 2000. The farming system and traditional agroforestry systems in the Maya community of San Jose, Belize. Agroforestry systems 49, 275-288.

Macpherson C, B Bartholomot, B Frider, 2003. Application of ultrasound in diagnosis, treatment, epidemiology, public health and control of Echinococcus granulosus and E. multilocularis. Parasitology 127, S21-S35.

Madec F, R Geers, P Vesseur, N Kjeldsen, T Blaha, 2001. Traceability in the pig production chain. Revue Scientifique et Technique-Office International des Epizooties 20, 523-537.

Mafojane N, C Appleton, R Krecek, L Michael, A Willingham III, 2003. The current status of neurocysticercosis in Eastern and Southern Africa. Acta tropica 87, 25-33.

Modisaotsile BM, 2012. The failing standard of basic education in South Africa. Policy brief 72, 1-7.

Mwanjali G, C Kihamia, DVC Kakoko, F Lekule, H Ngowi, MV Johansen, SM Thamsborg, AL Willingham, III, 2013. Prevalence and Risk Factors Associated with Human Taenia Solium Infections in Mbozi District, Mbeya Region, Tanzania. PLOS Neglected Tropical Diseases 7, e2102.

Ouma E, M Dione, P Lule, K Roesel, D Pezo, 2014. Characterization of smallholder pig production systems in Uganda: constraints and opportunities for engaging with market systems. Livestock Research for Rural Development 26, 56.

Penrith M-L, W Vosloo, F Jori, AD Bastos, 2013. African swine fever virus eradication in Africa. Virus research 173: 228-246.

Phiri IK, H Ngowi, S Afonso, E Matenga, M Boa, S Mukaratirwa, S Githigia, M Saimo, C Sikasunge, N Maingi, 2003. The emergence of Taenia solium cysticercosis in Eastern and Southern Africa as a serious agricultural problem and public health risk. Acta tropica 87: 13-23.

Pondja A, L Neves, J Mlangwa, S Afonso, J Fafetine, AL Willingham III, SM Thamsborg, MV Johansen, 2010. Prevalence and risk factors of porcine cysticercosis in Angonia District, Mozambique. Plos neglected tropical diseases 4: e594.

Roesel K, I Dohoo, M Baumann, M Dione, D Grace, P-H Clausen, 2017. Prevalence and risk factors for gastrointestinal parasites in small-scale pig enterprises in Central and Eastern Uganda. Parasitology research 116: 335-345.

Sankhyan P, S Gupta, G Singh, 2015. Knowledge about, attitudes towards, practices regarding Taenia solium cysticercosis among people attending an epilepsy clinic in India. International Journal of Epilepsy 2: 6-10.

SAQA 2007. South African Qualifications Authority (SAQA).

SAS I 1999. SAS/STAT User's guide, version 9, 1st printing, volume 2. SAS Institute Inc, SAS Campus Drive, Cary, North Carolina 27513.

Snedecor GW, WG Cochran, 1989. Statistical methods,, Eighth Edition Edition. The Iowa State University Press,, AMES, IOWA USA.

South Africa 2011. Census 2011 Provincial Profile: Eastern Cape / Statistics South Africa. Pretoria: Statistics South Africa 2014, Department of Agriculture, F.a.F., ed. (South African Livestock Statistics, government Gazette).

South Africa S 2016. Community Survey 2016 Agricultural Households / Statistics South Africa, Statistics, S.A., ed. (Government Website, SAS).

Sutherst RW, 2001. The vulnerability of animal and human health to parasites under global change. International journal for parasitology 31: 933-948.

Tatwangire A, 2013. Successes and failures of institutional innovations to improve access to services, input and output markets for smallholder pig production systems and value chains in Uganda.

Thomas LF, WH Organization, 2015. Landscape analysis: control of Taenia solium.

van Tol J, W Akpan, G Kanuka, S Ngesi, D Lange, 2016. Soil erosion and dam dividends: science facts and rural 'fiction' around the Ntabelanga dam, Eastern Cape, South Africa. South African Geographical Journal 98: 169-181.

Waiswa C, 2005. Porcine trypanosomiasis in southeastern Uganda: prevalence and assessment of therapeutic effectiveness.

Wu X, L Gao, K Zhou, X Li, X Lin, D Wan, X Xiong, G Liu, Y Yin, 2018. Deposition and transport of trace mineral elements were affected by stocking density in fattening pigs. Journal of Trace Elements in Medicine and Biology 50, 566-571.