Evaluation of knowledge, attitudes and practices regarding neosporosis and toxoplasmosis among farmers and animal health practitioners in Namibia

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Abstract

This study assessed the knowledge, attitudes and practices of livestock farmers in Namibia's Khomas region and animal health practitioners (veterinarians & animal health technicians) in the whole country concerning neosporosis and toxoplasmosis. Structured questionnaires were used, and a total of 63 farmers and 51 animal health practitioners responded out of an estimated 560 farmers in the Khomas region and 300 veterinarians and veterinary technicians in the country. Only 15.9% of the livestock farmers (n=63) had heard about neosporosis or toxoplasmosis or knew how animals get infected ($p<0.0001$). Only 5% of the farmers knew the risks associated with keeping dogs and cats concerning neosporosis and toxoplasmosis, respectively ($p<0.0001$). None of the 51 animal health practitioners routinely requested *Neospora caninum* or *Toxoplasma gondii* laboratory tests in cases of cattle, sheep or goat abortions. Although all animal health practitioners indicated they routinely interacted with

livestock farmers, none regularly discussed neosporosis or toxoplasmosis. Only 3.9% of animal health practitioners (n=51) indicated that they had ever discussed either neosporosis or toxoplasmosis at a farmers' gathering ($p<0.0001$), and only 21.6% had talked to at least one cat owner about toxoplasmosis in the previous 12 months ($p<0.0001$). The authors concluded that farmers in the Khomas region were generally unaware of neosporosis and toxoplasmosis but could change their attitudes and practices if educated. The animal health practitioners lacked a deeper understanding and appreciation of the two diseases, which is required to cultivate enough confidence to educate farmers. Sharing this research and other relevant information on the two diseases at farmers' meetings, veterinary congresses, journals, and newsletters could help educate farmers and animal health practitioners. Such platforms are likely to succeed because both these groups use these forums to get new information.

Keywords: knowledge; attitudes; practices; neosporosis; toxoplasmosis; Khomas; Namibia

Introduction

Approximately 70% of Namibia's population depends directly or indirectly on agriculture, of which livestock production accounts for 80% (Humavindu & Stage 2013; Meat Board of Namibia 2015; Simasiku & Sheefeni 2017). Valued at approximately N$4.6 billion and equating to 4.3% of the gross domestic product (GDP) (Meat Board of Namibia 2019), the livestock sector employs roughly 30% of the nation's total labour force (Humavindu & Stage 2013; Simasiku & Sheefeni 2017). Furthermore, between 2004 and 2009, commercial farming contributed 5-6% of Namibia's GDP; animal products, livestock and crop exports constituted roughly 10.7% of the total Namibian exports (BDO Namibia 2019). Livestock production, therefore, constitutes a significant part of the country's economy. Thus, livestock diseases can cause reduced production and severe economic knock-on effects.

Many infectious causes of abortions have been reported in the country. These include, among others, brucellosis (Madzingira *et al.* 2020), chlamydiosis (Samkange *et al.* 2010), coxiellosis (Bishi *et al.* 2018), Schamellenberg virus (Molini *et al.* 2018), Rift Valley Fever (Cosseddu *et al.* 2020) and bovine virus diarrhoea (Depner *et al.* 1991). Among the pathogens known to cause reproductive losses are *Neospora caninum* and *Toxoplasma gondii*, although they have not been reported in livestock in Namibia. However, *N. caninum* and *T. gondii* have recently been reported in Namibian wildlife species like cheetahs (*Acinonyx jubatus*), African lions (*Panthera leo*), blue wildebeest (*Connochaetes taurinus*), brown hyenas (*Hyaena brunnea*), and black-backed jackals (*Canis mesomelas*) (Seltmann *et al.* 2020). Therefore livestock species like cattle and small ruminants (sheep and goats) could be at risk due to their proximity to wildlife in the commercial farming establishments.

Neosporosis caused by *N. caninum* and toxoplasmosis caused by *T. gondii* are important worldwide protozoal infections that negatively impact livestock productivity through abortions, stillbirths, infertility and birth of weak offspring (Al-Malki 2021; Dubey & Schares 2011; Khan & Noordin 2020; Monney *et al.* 2011). Globally, annual losses due to *N. caninum*-induced abortions have been estimated between US$633.4 million and US$2.380 billion (Reichel *et al.* 2013). Unfortunately, published studies on economic losses attributable to *T. gondii* are scarce and outdated (Stelzer *et al.* 2019); however, in parts of South America, Europe and Australia, these have been estimated between US$1.4 million and US$50 million (Bennett & IJpelaar 2005; Freyre *et al.* 1997; Stelzer *et al.* 2019). These figures clearly illustrate the significant economic impact of neosporosis and toxoplasmosis on the livestock industry worldwide.

To a great extent, livestock neosporosis and toxoplasmosis have generally been overlooked in sub-Saharan Africa, including Namibia. As a result, fewer studies have been conducted on toxoplasmosis and neosporosis, prompting some authors to consider the two diseases as

neglected diseases in sub-Saharan Africa (Gaber *et al.* 2021; Tegegne *et al.* 2016). The neglect of neosporosis and toxoplasmosis could be due to a lack of awareness caused by limited research on these two diseases in Africa.

Despite the evident negative impact of the two infections on livestock production, very little has been done to assess the KAP of key players in the livestock industry. To the authors' knowledge, there is only one KAP study on *N. caninum,* which was done in Egypt (Gaber et al., 2021). Although several toxoplasmosis KAP studies have been done around the world, including in Morocco (Ait Hamou *et al.* 2021; Laboudi *et al.* 2020), Zimbabwe (Chikerema *et al.* 2013), Saudi Arabia (Mahfouz *et al.* 2019), Malaysia (Sadiq *et al.* 2021), the USA (Hill *et al.* 2012) and Senegal (Tebug *et al.* 2015) , these studies were only from a zoonotic perspective with no reference to the livestock industry. In addition, no KAP of the two diseases has been done in southern Africa, including Namibia.

This study aimed to assess the knowledge, attitudes and practices of the livestock farmers in Namibia's Khomas region and the animal health practitioners (veterinarians, animal health technicians & other para-veterinary professionals) in the country concerning neosporosis and toxoplasmosis.

Materials and methods

Study area

The livestock producers enrolled on this study were drawn from the Khomas region of Namibia. The animal health practitioners (veterinarians, animal health technicians & private para-veterinary professionals) were drawn from the whole country. The Khomas region is one of fourteen regions of Namibia and covers approximately 36,964 km^2 (Namibia Statistics

Agency 2011), and has approximately 560 commercial farms (Directorate of Veterinary Services 2018). The region is situated in the central part of the country. It is sandwiched between four other regions: Erongo to the west, Otjozondjupa to the north, Omaheke to the east, and Hardap to the south (Figure 1).

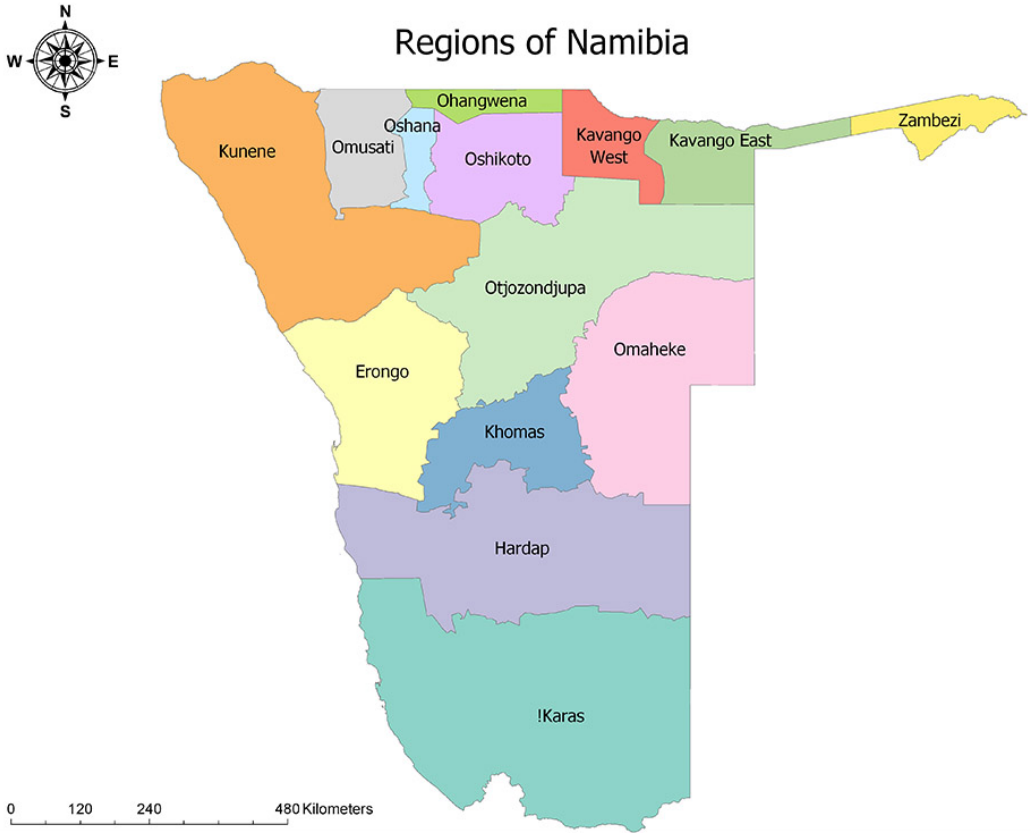

Figure 1: map showing the regions of Namibia with the Khomas region at the centre and surrounded by Erongo, Otjozondjupa, Omaheke and Hardap regions. (Source: https://www.mappr.co/counties/namibia/;used with permission).

Study subjects

The KAP study population included all the 560 livestock producers in the Khomas region and all animal health practitioners (approximately 85 veterinarians and over 200 animal health technicians) in Namibia who are involved in production animal practice. Namibia has more than one million registered livestock producers compared to less than 300 animal health

practitioners. Therefore, sampling the farmers from the whole country would have been very costly and tedious compared to the animal health practitioners.

Data collection

This study was carried out between 1 May and 31 May 2022. Two structured questionnaires, one each for the farmers and another for the animal health practitioners, were used to collect information on livestock farmers' knowledge, attitudes, and practices in the Khomas region and animal health practitioners in Namibia concerning neosporosis and toxoplasmosis. A convenience sampling strategy was employed because the questionnaires were only sent out to farmers and animal health practitioners for whom contact details were accessible or could be met in person. The farmer questionnaires were sent through emails, and the farmers would complete them and email them back. Others were completed during farmers' meetings and through face-to-face and telephonic interviews by the first author; no other interviewers were employed for this. The animal health practitioner questionnaire was sent electronically, either directly or through the Veterinary Association of Namibia, which has direct access to most veterinarians practising in Namibia.

The farmers' questionnaire solicited information on their educational level and experience in farming, their knowledge of causes of abortions, their specific knowledge of neosporosis and toxoplasmosis and the role of cats and dogs in their transmission. Questions on farmers' attitudes centred on their perspectives on livestock abortions, what they would do if neosporosis and toxoplasmosis were diagnosed on their farms, and how important abortions were on their farms. Questions on the farmers' practices gathered information on the vaccines used at the farm, sources of replacement stock, what they would do if abortions occurred on their farm, what they did with aborted animals, and how much livestock production contributed to their livelihoods.

The animal health practitioner questionnaire assessed their knowledge of neosporosis and toxoplasmosis concerning transmission, clinical signs, availability of vaccines and zoonotic implications. In addition, questions on attitudes pertained to whether or not they thought the two diseases occurred in Namibia and whether they thought that the veterinary fraternity in Namibia was well informed concerning *N. caninum* and *T. gondii*. Finally, the questions on practices asked if the animal health practitioners routinely requested laboratory tests for the two diseases in abortion cases and whether they regularly educate their clients on these diseases.

Data analysis

The questionnaire data were captured in Microsoft Excel 2013. The data were first collated, similar questions were grouped, and the responses summarised in a manner easily captured and analyses performed. However, no data was removed as outliers since the data were categorical. Statistical analysis calculations were done using the one-sample z-test for a population proportion calculator (https://epitools.ausvet.com.au/ztestone). The reason was that the farmers and the animal health practitioners were treated as separate populations and had different questionnaires.

Results

The KAP of farmers

The majority of the interviewed farmers [93.7%; n = 63] had high literacy levels and more than ten years of experience [71.3%; n = 63] in livestock production (see Table 1). Sixty-one point nine per cent (61.9%) of the respondents had experienced abortions in their livestock and thought they knew the causes (p=0.0589). Only 1.6% (1/63) of the farmers listed

neosporosis and toxoplasmosis among the causes of abortions they knew, and 4.8% (3/63) were aware that toxoplasmosis was a zoonotic cause of abortions ($p<0.0001$). Fifteen point nine per cent (15.9%; n = 63) of the respondents had heard about neosporosis or toxoplasmosis or knew how animals get infected by these diseases ($p<0.0001$). Only 5% (5/63) of the farmers were aware of the risks associated with keeping dogs and cats concerning neosporosis and toxoplasmosis ($p<0.0001$).

TABLE 1: Summary of the knowledge of farmers regarding neosporosis and toxoplasmosis

KNOWLEDGE	YES	NO	% YES	P value
Secondary school education level or higher	59	4	93.7	<0.0001
At least ten years of farming experience?	45	18	71.4	0.0007
Known causes of abortions include neosporosis & toxoplasmosis	1	62	1.6	<0.0001
Have you ever experienced abortions on the farm & do you know the causes?	39	24	61.9	0.0589
Knowledge of zoonotic causes of livestock abortions includes toxoplasmosis?	3	60	4.8	<0.0001
Knowledge of how animals get infected by abortion-causing agents	23	40	36.5	0.0321
Knowledge of how to prevent livestock abortions	37	26	58.7	0.1673
Have you heard of neosporosis or toxoplasmosis?	10	53	15.9	<0.0001
Know animals affected by neosporosis	9	54	14.3	<0.0001
Know animals affected by toxoplasmosis	10	53	15.9	<0.0001
Knowledge of the risk of keeping dogs	5	58	7.9	<0.0001
Knowledge of the risk of keeping cats	5	58	7.9	<0.0001

Most of the farmers (87.3%) indicated that they would be worried if abortions occurred in their livestock, and 79.4% would take corrective measures ($p<0.0001$) (Table 2). About 69.8% correctly indicated that they would consult their veterinarian if their animals tested positive for neosporosis or toxoplasmosis, and 66.7% indicated that they would not purchase an animal with a history of abortion ($p=0.008$). Less than half of the respondents (41.3%) listed abortion among the causes of livestock losses in their livestock ($p=0.167$). Most respondents (69.8%) indicated that they preferred well-cooked meat ($p=0.0017$), and only 17.5% of the respondents thought that other livestock farmers had ever heard of neosporosis or toxoplasmosis ($p<0.0001$).

TABLE 2: Summary table of the attitudes of farmers concerning neosporosis and toxoplasmosis

ATTITUDES	YES	NO	% YES	P value
They are worried that abortions are occurring.	55	8	87.3	<0.0001
Are abortions taken seriously if they occur?	50	13	79.4	<0.0001
Correct measures in response if animals test positive for neosporosis or toxoplasmosis	44	19	69.8	<0.0001
Appropriate attitude towards purchase of an animal with a history of abortion	42	21	66.7	0.008
Ranking of important causes of livestock losses include abortions?	26	37	41.3	0.1673
Correct attitude about eating undercooked meat	44	19	69.8	0.0017
Whether they think other farmers have heard of neosporosis or toxoplasmosis	11	52	17.5	<0.0001

About 76.2% of the respondents indicated that livestock production contributed at least 50% of their livelihoods ($p<0.0001$) (Table 3). However, most of the farmers sold no more than 30 sheep (23.8%) or goats (14.3%) per year ($p<0.0001$) and 57.1% of them sold more than 20 cattle per year ($p>0.05$). In addition, none of the farmers included *T. gondii* in their vaccination programmes. 49.2% of the farmers indicated that they would cull their animals if they aborted more than once ($p=0.8989$), and only 36.5% gathered animal health information concerning the farm from which they sourced replacement stock ($p=0.0321$). 58.7% of the respondents preferred their grilled meat to be well-done ($p=0.1673$).

TABLE 3: Summary of farmer practices regarding neosporosis and toxoplasmosis

PRACTICES	YES	NO	% YES	P value
Does livestock production contribute at least 50% to livelihood?	48	15	76.2	<0.0001
More than 20 cattle are sold per year	36	27	57.1	0.2597
More than 30 sheep are sold per year	15	48	23.8	<0.0001
More than 30 goats sold per year	9	54	14.3	<0.0001
Vaccines administered include *T. gondii*?	0	63	0.0	<0.0001
Cull animals that abort more than once?	16	47	25.4	<0.0001
Replacement stock sourced elsewhere	31	32	49.2	0.8989
Do you gather information on the farm from which replacement stock is sourced	23	40	36.5	0.0321
Grilled meat preferred well-done?	37	26	58.7	0.1673

The KAP of animal health practitioners

The KAP of animal health practitioners (Table 4) showed that only 9.8% (n=51) of the respondents listed neosporosis and toxoplasmosis among the common causes of livestock

abortions they knew (p<0.0001). However, on most key questions, the respondents showed good knowledge scores of the two parasites, ranging from 60.8% to 90.2% and averaging 68%. Low scores were on questions relating to the zoonotic implications of neosporosis (41.2%; p=0.2088) and the risk of toxoplasmosis posed by veterinary inspected meat (23.5%; p=0.0002).

TABLE 4: Summary of the knowledge of animal health practitioners regarding neosporosis and toxoplasmosis

KNOWLEDGE	YES	NO	% YES	P value
Knowledge of common causes of abortions in cattle includes *N caninum*	5	46	9.8	<0.0001
Knowledge of common causes of abortions in sheep & goats includes *T gondii*	5	46	9.8	<0.0001
Average or higher level of knowledge of *N. caninum*	30	21	58.8	0.2088
Knowledge of *N. caninum* transmission	35	16	68.6	0.0079
Knowledge of final hosts of *N caninum*	34	17	66.7	0.0171
Knowledge of clinical signs of neosporosis in canids	21	30	41.2	0.2088
Ability to name at least one host of *N. caninum*	46	5	90.2	<0.0001
Knowledge of the main problem caused by *N. caninum* in cattle	36	15	70.6	0.0033
Knowledge of zoonotic implications of *N. caninum*	21	30	41.2	0.2088
Knowledge about *N. caninum* vaccination	35	16	68.6	0.0079
Average or higher level of knowledge of *T. gondii*	30	21	58.8	0.2088
Knowledge of *T. gondii* transmission	35	16	68.6	0.0079
Knowledge of *T. gondii* definitive host	31	20	60.8	0.1229
Knowledge of *T. gondii* clinical signs in cats	14	37	27.5	0.0013
Knowledge of animals affected by *T. gondii*	34	17	66.7	0.0079
Knowledge of the main problem caused by *T. gondii* in goats & sheep	36	15	70.6	0.0033
Knowledge of zoonotic implications of *T. gondii*	38	13	74.5	0.0006
Knowledge of how humans get infected by *T. gondii*	34	17	66.7	0.0079
Knowledge about *T. gondii* vaccination	7	44	13.7	<0.0001
Knowledge on whether inspected meat poses the risk of toxoplasmosis	12	39	23.5	0.0002

52.9% of the animal health practitioners thought that neosporosis was present in Namibia (Table 5), and 56.9% thought that this disease was important for the country and that farmers should be worried about it (p>0.05). Furthermore, close to half of the respondents (47.1%) indicated that they would recommend routine vaccination against *N. caninum* and *T. gondii* if effective vaccines were available (p>0.05). On the other hand, only 33.3% and 13.7% of the respondents thought other animal health practitioners were well informed about

toxoplasmosis and neosporosis, respectively ($p<0.05$). Ninety point two per cent (90.2%) felt that it was necessary to educate farmers on these two diseases ($p<0.0001$), and 76.5% believed that *N. caninum* and *T. gondii* should be included in the abortion screening panel used at the central veterinary laboratory in Namibia ($p=0.0002$).

TABLE 5: Summary of the attitudes of the animal health practitioners regarding neosporosis and toxoplasmosis

ATTITUDES	YES	NO	% YES	P value
Do you think N. caninum is present in Namibia?	27	24	52.9	0.6787
Is N. caninum important for Namibia?	29	22	56.9	0.3244
Should farmers be worried about N. caninum?	29	22	56.9	0.3244
Whether they would recommend N. caninum vaccination by farmers if it were available	24	27	47.1	0.6787
If they thought the veterinary fraternity was well informed about toxoplasmosis	17	34	33.3	0.0171
If they thought the veterinary fraternity was well informed about neosporosis	7	44	13.7	<0.0001
Whether they thought it necessary to educate farmers on toxoplasmosis & neosporosis	46	5	90.2	<0.0001
I would recommend routine toxoplasmosis vaccination if it were available	24	27	47.1	0.6787
Would like T gondii & N caninum included in routine lab abortion screening	39	12	76.5	0.0002

The practices of the Namibian animal health practitioners are summarised in Table 6. None of the 51 respondents routinely requested *N. caninum* or *T. gondii* tests in cattle, sheep or goat abortion cases. Only one respondent (2% [n=51]) ever requested laboratory testing for *N. caninum* or *T. gondii* ($p<0.0001$). Although all respondents indicated that they routinely interact with livestock farmers, none of them normally discussed neosporosis or toxoplasmosis with them. However, only 3.9% (2/51) indicated that they had ever discussed either neosporosis or toxoplasmosis at a farmers' meeting ($p<0.0001$), and only 21.6% (11/40) had talked to at least one cat owner about toxoplasmosis in the previous 12 months ($p<0.0001$).

TABLE 6: Summary of the practices of the animal health practitioners regarding neosporosis and toxoplasmosis

PRACTICES	YES	NO	% YES	P value
Lab tests routinely requested in cattle abortion cases include *N. caninum*	0	51	0.0	<0.0001
Lab tests routinely requested for in sheep & goats abortions cases include *T. gondii*	0	51	0.0	<0.0001
Have you ever requested lab tests for N. caninum or *T. gondii*?	1	50	2.0	<0.0001
Do they usually interact with livestock farmers?	51	0	100.0	<0.0001
Whether they usually have farmers' meetings	19	32	37.3	0.0697
Topics generally discussed at farmers' meetings include *N caninum* & *T gondii*	0	51	0.0	<0.0001
Whether neosporosis or toxoplasmosis was ever discussed at any farmer gathering	2	49	3.9	<0.0001
Whether they talked to any cat owner about toxoplasmosis in the previous 12mo	11	40	21.6	<0.0001

Discussion

To the authors' knowledge, this is the first KAP study in southern Africa regarding neosporosis and toxoplasmosis. Although the results showed high literacy levels and many years of experience in livestock farming among most farmers, 84.1% (53/63) of them had never heard of neosporosis or toxoplasmosis and how animals get infected. These findings are similar to one Egyptian study where none of the 41 farmers interviewed knew about neosporosis (Gaber *et al.* 2021). In addition, studies in Saudia Arabia, Malaysia and Ethiopia showed a very low level of toxoplasmosis awareness among farmers, pregnant women and female students, ranging from 5.9% to 20.9% (Desta 2015; Mahfouz *et al.* 2019; Sadiq *et al.* 2021). However, in another study, 84% of Italian women claimed to have heard about toxoplasmosis, although their level of knowledge was deemed superficial and incomplete (Martini *et al.* 2020).

Given that most farmers had never heard of neosporosis or toxoplasmosis, it is not surprising that an even higher proportion (92% [n=63]) were unaware of the risks posed by dogs and cats as definitive hosts of *N. caninum* and *T. gondii*, respectively. The farmers' attitudes concerning these two diseases further reflected this, as most of them (82.5%) thought other farmers were unaware of neosporosis and toxoplasmosis. Also unsurprising was that none of

the respondents routinely vaccinated against *T. gondii*. However, it should be noted that there is only one registered vaccine against *T. gondii* in the world, Toxovax®, which is a live attenuated S48 strain licensed for sheep (Ducournau *et al.* 2020; Monney *et al.* 2011). There is currently no commercial vaccine against *N. caninum* (Marugan-Hernandez 2017). Bovilis Neoguard® was discontinued because it could only protect against horizontal transmission but not against vertical transmission of *N. caninum* (Monney & Hemphill 2014).

It was encouraging, however, that most farmers indicated that they would be worried if abortions occurred in their livestock and were prepared to take remedial measures if neosporosis or toxoplasmosis was diagnosed in their animals. This shows that most farmers might be inclined to change their attitudes and practices concerning the two diseases and adopt preventive measures like vaccination, keeping closed herds, and prior quarantining and testing all replacement stock. However, of concern was that only a small percentage of animal health practitioners (3.9% [n=51]) had ever discussed these two diseases with livestock producers. There is, therefore, a need for animal health practitioners to sensitise livestock producers about neosporosis and toxoplasmosis.

The fact that 76.2% (n=63) of the farmers indicated that livestock production contributed at least 50% of their livelihoods shows a very high reliance on livestock production. This further collaborates with other studies, which estimated that about 70% of Namibia's population depends directly or indirectly on agriculture, of which livestock production accounts for 80% (Humavindu & Stage 2013; Meat Board of Namibia 2015; Simasiku & Sheefeni 2017). This high dependency on livestock production makes this industry sensitive to the effects of epizootics (Heath 2008), including neosporosis or toxoplasmosis, if they are not controlled, which could significantly impact the farmers' livelihoods.

The animal health practitioners generally displayed a fair understanding of neosporosis and toxoplasmosis, as expected. However, only a small percentage (9.8%) listed *N. caninum* and *T. gondii* among the common causes of abortions they were aware of. In addition, many of them were unaware that veterinary inspected meat still poses a risk of toxoplasmosis (Franco-Hernandez *et al.* 2015) if it is not adequately cooked. Furthermore, none of them routinely requested the central veterinary laboratory to test for *N. caninum* or *T. gondii* in abortion cases. This shows a lack of a deeper understanding of these two diseases among the Namibian animal health practitioners. This probably explains why none of the respondents routinely discussed these diseases with farmers. Only a small percentage (3.9%) had ever discussed neosporosis or toxoplasmosis at any farmers' gathering, even though all the respondents routinely interacted with livestock farmers.

This study has demonstrated that the farming community in the Khomas region of Namibia is generally unaware of neosporosis and toxoplasmosis. However, there are indications that they might be willing to change their attitudes and practices if they are educated. On the other hand, animal health practitioners have the basic knowledge of the two diseases. However, they lack a deeper understanding and appreciation required to cultivate enough confidence to educate the livestock farmers. Therefore, the failure of the animal health practitioners to educate livestock producers about neosporosis and toxoplasmosis during their routine interactions with them presents a missed opportunity which should be utilised.

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Declarations

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Ethics approval: This study was approved by the University of Namibia Ethics Committee (Reference number: NEC0007) and the University of Pretoria's Research Ethics Committees (reference numbers REC087-21 and HUM00/0322).

Consent to participate: All participants signed a written consent to participate in this research.

Consent for publication: All participants signed a written consent permitting the publication of this research.

Availability of data and material

The data collected for this research is available upon request.

Code availability: Microsoft Office 2013

Authors' contributions: All authors contributed to the study's conception and design. Material preparation, data collection and analysis were performed by Alaster Samkange. Alaster Samkange wrote the first draft of the manuscript and all authors commented on previous versions. All authors read and approved the final manuscript.

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