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Namibia's demonstration of freedom from bovine tuberculosis

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Summary

Bovine tuberculosis (bTB) is a chronic bacterial zoonotic disease caused by *Mycobacterium bovis* and has been notifiable in Namibia since 1956. Active and passive surveillance for *Mycobacterium bovis* has been implemented in Namibia since 1910 [1]. Active surveillance involves examination of carcasses at export slaughter facilities, which account for 85% of all slaughter in Namibia, routine testing of dairy herds, and testing of cattle and susceptible wildlife before export using World Organisation for Animal Health (OIE) recommended tests. Passive surveillance involves investigation of reported suspect clinical cases through intradermal testing and post-mortem examination, followed by culture. The last confirmed case of bTB in the OIE-approved Foot and Mouth Disease (FMD) Free Zone without vaccination, south of the Veterinary Cordon Fence (VCF), was in 1986, while the last confirmed case in the FMD Protection Zone north of the VCF was in 1995. Namibia exports live weaner cattle to neighbouring South Africa for fattening and eventual slaughter. In 2016, revised conditions for importation of weaner cattle to South Africa from Namibia were introduced, requiring, amongst other stipulations, the testing of the cattle for bTB prior to exportation. In the period of 1 July 2016 to 31 May 2019, a total of 788,773 head of cattle were tested and subsequently exported. A qualitative risk assessment assessed the bTB risk associated with the exportation of weaner cattle from Namibia to feedlots for eventual slaughter in South Africa. The bTB risk associated with that trade was determined to be negligible without pre-exportation bTB testing. Considering the surveillance information gathered, the surveillance systems implemented, the performance of the Veterinary Services and strict import control, Namibia presents this information as a demonstration of freedom from bTB.

Keywords

animal health – bovine tuberculosis – diagnosis – disease freedom – risk assessment – disease surveillance – zoonosis.

Background

Namibia is a semi-arid country with low rainfall and humidity and mainly savannah ecosystems, and covers a land area of 824,292 km². The extensive livestock production system with very limited housing, coupled with the semi-arid climate, low rainfall and humidity and mostly dry weather conditions, is likely to reduce occurrence and transmission of bovine tuberculosis (bTB) in cattle, other domestic livestock and wildlife species in Namibia. In the livestock census conducted by the Directorate of Veterinary Services (DVS) in 2017, Namibia had a cattle population of 2,713,394 [2]. The exportation of weaner cattle to South African feedlots is an important market for the Namibian livestock industry, with subsistence farmers producing approximately 70% of the exports. Bovine tuberculosis has been listed among notifiable diseases since the promulgation of the now repealed Animal Diseases and Parasites Act, 1956 (Act No. 13 of 1956), and in its replacement, the Animal Health Act, 2011 (Act No. 1 of 2011). The DVS of Namibia considers the country free from bTB, with the last cases detected on 28 March 1995.

Bovine tuberculosis is an OIE listed disease caused by infection with *Mycobacterium bovis* (*Mb*) [3]. The disease affects multiple species, and control in endemic countries can be complicated by the presence of wildlife reservoirs [4]. Bovine tuberculosis is an important zoonotic disease with prominent public health implications in low income areas of the world and in areas with a high prevalence of HIV infection [5]. Transmission of *Mb* from an infected to a susceptible host typically occurs by direct contact, via inhalation of contaminated aerosols [3]. The consumption of contaminated animal products is another important route of transmission, and milk pasteurisation schemes in many countries were developed in an effort to reduce the public health impact of bTB. The disease is chronic; clinical signs in affected hosts are typically non-specific and include weight loss, enlarged lymph nodes and generalised weakness. The observed clinical signs will vary depending on the route of infection, with coughing and dyspnoea being common in individuals infected via the respiratory route. Pathological changes include the development of granulomatous lesions in lymph nodes and organs associated with the route of exposure. The incubation period is long, ranging from months to years depending upon the exposure dose, immunological competence of the infected individual and environmental stress. Infected cattle are often subclinically affected, thus complicating ante-mortem diagnosis.

Diagnosis of *Mb* infection can be accomplished by both direct and indirect methods of detection. Indirect measures of the cellular immune response to *Mb* infection are the most common screening tests employed to identify subclinically affected livestock and are applied to live animals, but have imperfect sensitivity and specificity [6]. Confirmatory tests are applied to specimens collected during post-mortem examination, with detection of *Mb* via polymerase chain reaction (PCR) or bacterial culture used to confirm *Mb* infections in cattle. Post-mortem confirmation of bTB is expected to have near perfect specificity (100%) but imperfect sensitivity [7]. The post-mortem examination of carcasses at abattoirs is a common active surveillance procedure used to monitor prevalence in endemic areas or verify freedom from bTB in areas where infection does not occur. Indirect methods of bTB diagnosis in cattle include the single intradermal tuberculin (SIT) test, the comparative intradermal tuberculin (CIT) test and an enzyme-linked immunosorbent assay (ELISA) for the detection of interferon-gamma (INF-γ) release by peripheral blood mononuclear cells. The SIT entails the intradermal injection of 0.1 ml of *Mb* purified protein derivative (PPD, 'tuberculin') into the cervical region or into the caudal fold at the base of the tail; it has been estimated to have a sensitivity and specificity of 92% and

89%, respectively, when screening cattle for bTB [6][7]. Exposure to *Mycobacterium avium* (*Mav*) and other non-tuberculosis species of mycobacteria is a recognised cause of imperfect specificity of the SIT [6]. The CIT includes the intradermal injection of 0.1 ml of *Mav* PPD in addition to the 0.1 ml of *Mb* PPD employed for the SIT and is more specific than the SIT [6], with the sensitivity and specificity in cattle estimated to be 78% and 99.5%, respectively [6][7].

This article is intended to demonstrate Namibia's freedom from bTB by providing information on its surveillance for bTB and the results of a risk assessment performed to assess the bTB risk associated with exportation of weaner cattle to feedlots for eventual slaughter in South Africa.

Surveillance for bovine tuberculosis in Namibia

All the 167 positive diagnoses of bTB which were made in Namibia from 1913 to 1984 were found in dairy animals. The source of infection of all 142 cases recorded from 1930 to 1992 could invariably be traced to the importation of an infected animal from South Africa, while the 25 cases detected in 1913 originated from Germany [1].

Bovine tuberculosis surveillance since 1980 has been mainly based at abattoirs during ante- and post-mortem examination, annual testing of dairy herds, and testing of cattle and wildlife before export. A '*Mycobacterium bovis* Surveillance Protocol' is implemented through active and passive surveillance [8]. Active surveillance involves examination of carcasses at slaughter facilities, routine testing of dairy herds, and testing of cattle and susceptible wildlife before exportation using OIE-recommended tests [3]. Passive surveillance involves investigation of reported suspect clinical cases through intradermal testing, with post-mortem examination and confirmatory testing.

Surveillance at slaughter facilities and during field investigation

Throughout the period of data collection, there were between seven and three export-approved abattoirs and numerous local authority slaughter facilities distributed throughout the country. The DVS provides oversight at the export-approved abattoirs while the local authority slaughter facilities are under the supervision of Local Authorities under the Ministry of Urban and Rural Development, as delegated by the Ministry of Health and Social Services.

Meat inspection at local authority slaughter facilities is conducted by qualified and registered meat inspectors. At the export-approved abattoirs, meat inspection is done by Veterinary Hygiene Inspector Assistants and Veterinary Hygiene Inspectors under the supervision of State Veterinarians, DVS, Namibia.

Ante- and post-mortem inspection at export and local abattoirs is conducted on all animals undergoing slaughter. One case in a bovine animal was confirmed through culture in 1986 [9]. One case in 1991 and two cases in 1992 were suspected at post-mortem examination and were found to be negative on laboratory culture [10][11]. The last cases of bTB were detected on 28 March 1995 at the Oshakati Abattoir in two slaughter cattle that originated from the Mangetti, north of the Veterinary Cordon Fence (VCF) [12]. The disease was suspected at post-mortem examination and confirmed by laboratory culture. No further cases of bTB have been detected. No movement of livestock takes place from areas north of the VCF to the officially recognised FMD Free Zone without vaccination south of the VCF.

A total of 3,321,294 cattle were subjected to ante- and post-mortem inspection by DVS staff at export-approved abattoirs from 1996 to 2017, with negative results for bTB (Table I; Fig. 1). Staff at the export abattoirs are routinely given refresher training in the detection of bTB at abattoirs.

The differential diagnosis for bTB, according to the *Mycobacterium bovis* Surveillance Protocol, includes the following diseases and conditions: contagious bovine pleuropneumonia (CBPP) (with sequestra present), actinobacillosis, lung abscessation, bovine farcy (*Mycobacterium farcinogenes*), bacterial or viral bronchopneumonia, echinococcal hydatid cysts (calcified), pneumonic pasteurellosis and pseudotuberculosis (corynebacteriosis). The aforementioned diseases and conditions have been diagnosed at abattoirs and during field outbreak investigations from 1996 to 2017 according to Disease Report Forms and abattoir high incidence database files.

Table I. Number of cattle slaughtered at seven export approved abattoirs from 1996 to 2017

Year	No. slaughtered
1996	96,159
1997	115,484
1998	158,134
1999	190,776
2000	172,329
2001	173,059
2002	185,491
2003	171,484
2004	166,406
2005	167,993
2006	139,104
2007	141,632
2008	143,506
2009	147,199
2010	145,888
2011	136,856
2012	124,074
2013	141,623
2014	219,024
2015	179,663
2016	111,589
2017	93,821
Total	**3,321,294**

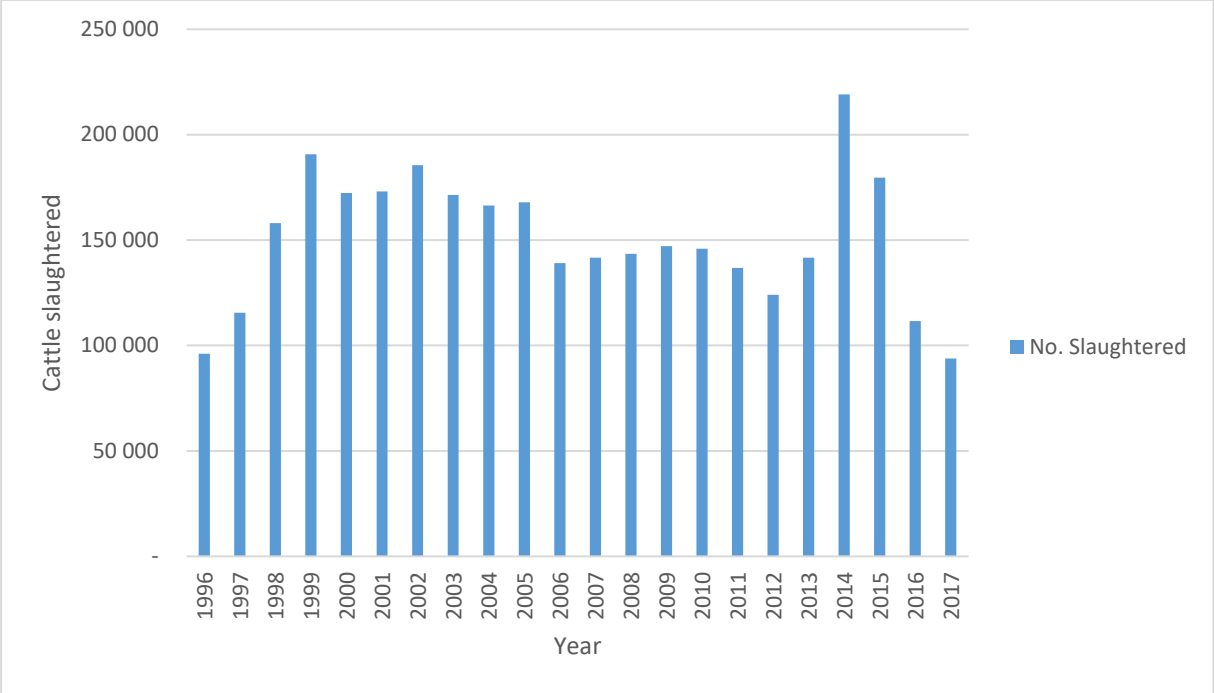

Fig. 1. Trends in cattle slaughter under Directorate of Veterinary Services (DVS) supervision at export abattoirs from 1996 to 2017

State Veterinarians in the field are responsible for investigating suspected outbreaks of diseases. Any *Mb* suspect is investigated through appropriate intradermal tuberculin test or sample collection for bacterial culture or PCR. A total of 3,064 cases of CBPP, 2,043 cases of pneumonia and 28,966 cases of echinococcosis (hydatidosis) were confirmed at abattoirs and during field investigation from 1996 to 2017 (Table II).

Annual testing at dairies

All dairy cattle herds (5,134 animals in 2017) are subjected to annual bTB and brucellosis testing. No positive cases of bTB have been detected in dairy cattle since 1994. The bTB testing using the CIT test is done by trained State Veterinarians and Private Veterinarians according to the Protocol for bTB testing [13].

Testing of game

Testing of game, either routinely or as a prerequisite for exportation, forms part of the surveillance for bTB. A total of 266 buffalo were tested for bTB with negative results from 1995 to 2010 (Table III) using the following tests: cervical CIT and ELISA detection of γ-IFN (Ministry of Environment and Tourism Reports). In 2012, a total of 178 game animals of various species tested negative for bTB (Table IV). In 2013, 17 game animals (6 elephants, 5 white rhinos and 6 black rhinos) were tested for bTB using the *Mb* γ-IFN assay with negative results (Table V) [14]. In 2014, a total of 90 buffalo were tested at Waterberg Plateau Park using the CIT test and all tested negative. In July 2018, six oryx were tested before exportation using the CIT test, and tested negative.

Table II. Cases of contagious bovine pleuropneumonia (CBPP), pneumonia and echinococcosis (hydatidosis) detected at abattoirs and field investigations from 1996 to 2017

Year	Processed	Contagious bovine pleuro-pneumonia	Prevalence (%)	Pneumonia	Prevalence (%)	Echinococcosis (Hydatidosis)	Prevalence (%)
1996	96,159	15	0.02%	388	0.40%	1,440	1.50%
1997	115,484	875	0.76%	5	0.00%	3,227	2.79%
1998	158,134	1,055	0.67%	138	0.09%	2,219	1.40%
1999	190,776	42	0.02%	7	0.00%	6,125	3.21%
2000	172,329	277	0.16%	25	0.01%	10,369	6.02%
2001	173,059	192	0.11%	42	0.02%	160	0.09%
2002	185,491	116	0.06%	66	0.04%	781	0.42%
2003	171,484	261	0.15%	146	0.09%	551	0.32%
2004	166,406	12	0.01%	56	0.03%	224	0.13%
2005	167,993	14	0.01%	53	0.03%	611	0.36%
2006	139,104	0	0.00%	189	0.14%	407	0.29%
2007	141,632	0	0.00%	41	0.03%	121	0.09%
2008	143,506	13	0.01%	14	0.01%	142	0.10%
2009	147,199	27	0.02%	45	0.03%	205	0.14%
2010	145,888	14	0.01%	26	0.02%	98	0.07%
2011	136,856	20	0.01%	114	0.08%	384	0.28%
2012	124,074	24	0.02%	31	0.02%	226	0.18%
2013	141,623	68	0.05%	49	0.03%	816	0.58%
2014	219,024	3	0.00%	332	0.15%	474	0.22%
2015	179,663	20	0.01%	111	0.06%	219	0.12%
2016	111,589	0	0.00%	12	0.01%	105	0.09%
2017	93,821	16	0.02%	153	0.16%	62	0.07%

Table III. Buffalo tested for bovine tuberculosis (bTB) from 1995 to 2010

Place	Date tested	Buffalo tested	ELISA	Gamma interferon	Intradermal skin test
Waterberg	Mar-95	10	10	10	
	Sep-98	7	7	7	
	Jun-04	25			25
	Jul-06	43			43
	Jul-08	42			42
	Jun-10	57			57
Tsumkwe	Sep-96	30	30	30	
Mahango	Sep-97	22	22	22	
Zambezi (W/ Caprivi)	Oct-98	15	15	15	
Mamili	Oct-98	15	15	15	
Total		**266**	**99**	**99**	**167**

Table IV. Results of bovine tuberculosis (bTB) testing using *M. bovis* gamma interferon (Bovigam) in game animals in 2012

Species	Number tested	No. positive
African buffalo	10	0
Roan antelope	16	0
Common impala	16	0
Greater kudu	16	0
Cape eland	16	0
Gemsbok	16	0
Springbok	20	0
Hartebeest	16	0
Spotted hyena	8	0
Brown hyena	4	0
Lion	4	0
Serval	6	0
Leopard	6	0
Black-backed jackal	6	0
Cheetah	6	0
Caracal	4	0
Cape fox	4	0
Bat eared fox	4	0
Total	**178**	**0**

Table V. Results of bovine tuberculosis (bTB) testing using *M. bovis* gamma interferon in game animals in 2013

Species	Number tested	Number positive
Elephants	6	0
White rhino	5	0
Black rhino	6	0
Total	**17**	**0**

Table VI. Summary of cattle tested for bovine tuberculosis (bTB) with negative results and exported to South Africa

Year	2016	2017	2018	2019	Total
Cattle tested for bTB and exported to South Africa	37,885	313,501	306,697	130,690	**788,773**
Cattle census in FMD free zone	1,322,860	1,074,852	991,063	991,063	
Percentage cattle tested for bTB	2.9%	29.2%	30.9%	13.2%	

Testing of livestock for export purposes

The exportation of animals and animal products may occur only under the close supervision of the DVS and in compliance with the Animal Health Act, 2011 (Act No. 1 of 2011). The exportation of weaner cattle to feedlots in South Africa for eventual slaughter is an important market for the Namibian livestock industry, with subsistence farmers producing approximately 70% of the exports. From the introduction of revised importation requirements for cattle, sheep and goats by South Africa on 1 July 2016 until 31 May 2019, a total of 788,773 cattle were tested for bTB using the SIT test with negative results and therefore were exported (Table VI). The percentage of the national cattle herd tested was 12% in 2016, 23% in 2017 and 11% in 2018. The number of cattle tested (788,773) with negative results from 1 July 2016 to 31 May 2019 provides growing evidence of the absence of bTB in Namibia. The revised import requirements including testing against bTB are still in place. The cost for testing 788,773 cattle for bTB is estimated at 47,326,380 Namibian Dollars (NAD).

Testing of imported animals

The importation of animals and animal products may only occur under the close supervision of the DVS and in compliance with the Animal Health Act, 2011 (Act No. 1 of 2011). Given that bTB is deemed not to be present in Namibia, the veterinary import permit requires that cattle and other susceptible species be tested for the disease before they are imported into Namibia by using the CIT test with both avian and mammalian tuberculin during the 30 days prior to importation. Namibia only imports cattle and wildlife from OIE-approved FMD Free Zones without vaccination in South Africa and Botswana. In addition, bovids and their germplasm imported into Namibia must meet relevant OIE guidelines on bTB [15]. Namibia imported 12,405 cattle from South Africa and 13 cattle from Botswana during the period 1996 to 2017. Imported cattle are branded, tagged according to the Namibian Animal Identification Regulations in the Animal Health Act, 2011 (Act No.1 of 2011) with individual identification and registered on the Namibian Livestock Identification and Traceability System (NamLITS). All imported domestic animals are followed up until slaughter or natural death by the local State Veterinarian, with records kept in registers of imported animals at the State Veterinarian Office (SVO).

Bovine tuberculosis risk assessment of Namibian cattle

The application of risk analysis to the international trade in animal products has been addressed within the scientific literature [16]. Chapter 2.1. of the *Terrestrial Animal Health Code* (the *Terrestrial Code*) provides guidance on the implementation of import risk analysis [17]. An independent qualitative risk assessment was performed to assess the bTB risk associated with the exportation of weaner cattle from Namibia to feedlots for eventual slaughter in South Africa [18]. For the period 1 July 2016 to 31 July 2018, a total of 520,470 weaner cattle were exported to South African feedlots for eventual slaughter.

The identified hazard of interest for this assessment was the importation of bTB-affected cattle into South Africa. The specific cattle population of interest was cattle exported to South Africa from Namibia for direct slaughter or for fattening prior to slaughter. The risk assessment therefore considered feeder, stocker and slaughter cattle while excluding the risks associated

with the exportation of cattle for herd expansion and other breeding purposes. The risk assessment included an entry assessment, an exposure assessment and a consequence assessment. The final risk estimation integrated the risk associated with the entirety of the risk pathway from hazard introduction to the development of negative consequences. The assessment further considered disease surveillance in Namibia, the evaluation of Veterinary Services in Namibia, disease reporting history, and animal and animal product import control and disease control.

Disease reporting history

Namibia has completed all OIE-required semester and annual disease reports for the time period from the 2005-semester to 2018 [19]. The last official bTB report of 1995 is consistent with the data available from the World Animal Health Information System (WAHIS) data base.

Disease status (general)

The effectiveness of the Namibian disease control programmes has been recognised by the international community. Namibia has an OIE-certified FMD free zone without vaccination that was first certified in 1997 [20]. Namibia has 'free from CBPP' status for a zone according to the provisions provided within Chapter 11.5 of the *Terrestrial Code*: it is free from infection with *Mycoplasma mycoides* subsp. *mycoides* small colony (SC) (contagious bovine pleuropneumonia) [21]. The same zone is also certified free from peste des petits ruminants (PPR) according to the provisions of Chapter 14.7. of the *Terrestrial Code* [22]. Namibia is the first country in Africa to obtain official bovine spongiform encephalopathy (BSE) status of 'negligible risk in regards to BSE' [23]. NamLITS allows the tracing of both imported and locally produced animals in the country should it become necessary in the event of a disease outbreak. These observations are consistent with a very high standard of disease control.

Risk estimation

The overall risk estimation considers the entire risk pathway from hazard introduction until the resulting negative consequences. The likelihood of the hazard occurring is calculated as a joint probability (multiplication) of the entry and exposure assessments. The strength of Namibia Veterinary Services in conjunction with the negligible expected prevalence of bTB in exported cattle suggests that the overall likelihood of entry of bTB into South Africa is '*negligible*' despite the large number of cattle that are exported and the chronic nature of bTB [18]. The expected pathway for exposure should an *Mb*-infected animal be imported into South Africa is direct contact between the imported animal and local livestock or wildlife. The direct contact expected between imported cattle and cattle from other sources suggests that the likelihood of exposure should be quantified as '*high*' [18]. South Africa is not free of bTB and therefore the identification of a newly affected herd should only have an '*incidental*' impact at provincial and national levels. The interpretation is for an overall '*minor*' consequence related to the introduction of bTB-affected cattle [18].

The entry assessment suggested a '*negligible*' likelihood whereas the exposure assessment suggested a '*high*' likelihood. The joint likelihood is therefore estimated as '*negligible*', as per Table VII. The combination of a '*negligible*' likelihood and a '*minor*' consequence yields an overall determination of '*negligible risk*' (Table VIII). This risk has been determined on the basis of the exportation of cattle without pre-exportation bTB testing, using only the expected prevalence of bTB in the source population.

Table VII. Qualitative risk assessment matrix of the overall likelihood of a negative consequence considering both the likelihood of entry and exposure of susceptible populations within the importing country

Likelihood of exposure		Likelihood of entry				
		Negligible	Very low	Low	Moderate	High
	High	Negligible	Very low	Low	Moderate	High risk
	Moderate	Negligible	Very low	Low	Moderate	Moderate
	Low	Negligible	Negligible	Very low	Low	Low
	Very low	Negligible	Negligible	Negligible	Very low	Very low
	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

Table VIII. Qualitative risk assessment matrix cross-classifying the likelihood of entry and exposure with the expected severity of the negative consequences

Likelihood of event		Negative consequences of event				
		Incidental	Minor	Modest	Major	Catastrophic
	High	Very low risk	Low risk	Moderate risk	High risk	High risk
	Moderate	Very low risk	Low risk	Moderate risk	High risk	High risk
	Low	Very low risk	Low risk	Low risk	Moderate risk	Moderate risk
	Very low	Negligible risk	Very low risk	Low risk	Low risk	Low risk
	Negligible	Negligible risk	Negligible risk	Very low risk	Very low risk	Very low risk

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The investigation of cases that are a differential diagnosis for bTB, in the form of CBPP, pneumonia and echinococcosis, at abattoirs and during field investigations, highlights the strength of the surveillance system being implemented to confirm the absence of bTB.

The negative results of testing of dairy cattle (5,134) and game (557), testing of live cattle for bTB prior to exportation (788,773) and ante- and post-mortem inspection activities involving 3,321,294 cattle at abattoirs demonstrate a robust surveillance system for bTB. The foregoing

provides ample evidence that the sensitivity of the surveillance system is adequate to detect bTB if it were present in Namibia.

Namibia implements import risk analysis in line with international standards as set by the OIE. The country only imports limited numbers of breeding animals, which significantly reduces the risk of importing bTB-affected animals. Import permits are reviewed regularly and there is evaluation and review of risk management measures by DVS.

The exportation of weaner/feeder cattle from Namibia to South Africa is associated with negligible bTB risk even in the absence of pre-movement testing. Namibia has been considered to be free of bTB and was declared a BTB Protection Area before independence by the then South African Government, in terms of Government Notice R471 of 1980. Bovine tuberculosis surveillance since 1980 has been mainly performed at abattoirs during ante- and post-mortem examination, and during annual testing of dairy herds and testing before exportation. The independent risk assessment concluded that 'The export of weaner/feeder cattle from Namibia to South Africa is associated with negligible bTB risk even in absence of pre-movement testing' [18].

Recommendations

In view of the surveillance information gathered, surveillance systems implemented, strict import control and the findings of the independent qualitative risk assessment, it can be demonstrated that Namibia is free from bTB even in the absence of application of the OIE prescribed protocols for self-declared freedom from bTB.

It is against this background that Namibia wishes to present this document as a demonstration of freedom from bTB.

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