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REVIEW ARTICLE

Ecology and epidemiology of anthrax in cattle and humans in Zambia

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Abstract

Anthrax is endemic in Western and North-western Provinces of Zambia. The disease occurs throughout the year and impacts negatively on the economy of the livestock industry and public health in Zambia. During 1989-1995, there were 1,626 suspected cases of anthrax in cattle in Western province and of these 51 were confirmed. There were 220 cases of human anthrax cases in 1990 alone and 248 cases during 1991-1998 with 19.1% and 7.7% case fatality rates, respectively. Interplay of the ecology of affected areas and anthropogenic factors seem to trigger anthrax epidemics. Anthrax has drawn considerable attention in recent years due to its potential use as a biological weapon. In this paper, the history, current status and approaches towards the control of the disease in Zambia are discussed. Quarantine measures restrict trade of livestock and exchange of animals for draught power resulting in poor food security at household levels. Challenges of anthrax control are complex and comprise of socio-political, economical, environmental and cultural factors. Inadequate funding, lack of innovative disease control strategies and lack of cooperation from stakeholders are the major constraints to the control of the dis-

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ease. It is hoped that the information provided here will stimulate continued awareness for the veterinary and medical authorities to maintain their surveillance and capabilities against the disease. This may lead to a culminating positive impact on livestock and human health in the southern African region.

Key Words : Anthrax, Disease Control, Livestock, Socio-economic impact, Zambia

Introduction

Infectious diseases in animals confer considerable economic losses on the livestock industry in Zambia[24,25]. Anthrax is endemic in Western and North-western Provinces of Zambia[27,28]. Zambia is a landlocked country in Central Africa with an area of approximately 725,600 km^2. The country is administratively divided into nine provinces[24]. Land use is divided into four general types as follows : i) communal areas with small scale and peasant agriculture ; ii) commercial farmland ; iii) urban areas ; and iv) wildlife and forest areas. Zambia has an estimated population of 10.3 million[1] with 1,596,271 cattle, 24,019 sheep, 498,173 goats, 135,045 pigs, 3,293,730 poultry, 2,648 donkeys and 27 horses[6].

Anthrax, an infectious bacterial and usually fatal zoonotic disease[11,16,20] is caused by a gram-positive endospore-forming bacterium called *Bacillus anthracis (B. anthracis)* and has an almost worldwide distribution[8,16,22]. Anthrax is a re-emerging infection and consequently, endemic areas may provide additional sources of alternative strains of *B. anthracis* for bioterrorism placing global security at renewed risk. All mammals appear to be susceptible to anthrax to some degree, but ruminants such as cattle, sheep, and goats are the most susceptible and commonly affected, followed by horses, and then swine. There are three forms of anthrax, these being cutaneous, gastrointestinal and inhalational[23]. Inhalational anthrax resulting from exposure to aerosolized *B. anthracis* is the most deadly form of the disease in humans with a mortality rate approaching 100%[21] even with appropriate treatment especially if initiated after clinical symptoms have already progressed. It has been used widely in biological warfare including bioterrorism for decades[3,9,19]. The resilience of the *B. anthracis* endospore combined with the potentially lethal nature of the disease and the efficiency with which it infects via an aerosol route make it an ideal biological weapon and consequently issues about anthrax have drawn considerable attention in recent years[13,14]. The incidences of the anthrax-laced letters that were sent in the wake of the 11 September 2001 terrorist attacks on the World Trade Center and the Pentagon that caused 5 American deaths have shown renewed potential use of this bacterium as a biological weapon[15].

Despite its long history in the country, epidemiological and socio-economic data on anthrax is still less valuable in terms of disease emergency preparedness and understanding the disease in the overall context of existing land use practices in endemic areas. The information discussed in this study may increase public awareness of the risk factors and may subsequently help in the formulation of disease management options for the ultimate goal of implementation of regional rather than local disease control programs.

Materials and Methods

The study involved a review of literature and reports (including scientific publications) on anthrax in livestock and humans at the Department of Veterinary and Livestock Development, National Archives and the Central Veterinary Research Institute in Zambia. The data was also obtained from discussions with local communities and various veterinary professionals in the country.

Anthrax in Livestock

Historical Perspective

In Zambia, anthrax was first reported in 1914 in Luambe National Park[28]. The origin of the disease is unknown. During 1989-1995, there were 1,626 suspected cases of anthrax in cattle in Western Province and of these 51 were confirmed. It remains speculative that movement of cattle from Southern Africa introduced the disease into the country. Livestock entering the country in early 1900 at Livingstone Border were never quarantined. Mandatory quarantine of livestock entering the country was only introduced in 1931. During the pre-colonial period, anthrax was brought under control with epizootic and sporadic cases limited to Southern and Western Provinces among the traditional farming sector and was virtually absent in the commercial farming community as they vaccinated their animals. The disease was not uncommon in Namwala, Mazabuka, Monze and Choma Districts of Southern Province and, Mongu and Senanga Districts of Western Province. The last outbreak of anthrax in Southern Province was in 1987 in Mazabuka District. The disease has been rare in Central and Copperbelt Provinces. Anthrax was reported only once in Kafue District of Lusaka Province and Kitwe District of Copperbelt Province in 1928 and 1971, respectively (Figure 1).

Figure 1. Map of Zambia showing areas where anthrax has been reported as well other major towns.

Current Situation

Initially, confined to Mongu and Senanga Districts in Western Province, anthrax has spread to other districts (i.e. Lukulu, Kalabo, Sesheke and Kaoma) in the Province and adjacent North-western Province (Kabompo and Zambezi Districts). In both provinces the disease is generally confined to the Zambezi plain and is rarely seen in upland areas. Anthrax epidemics are frequent in the dry season and are generally associated with onset of the first rains in October/November[17,18] when grazing pasture is limited to the Zambezi plains. The plains are generally low lying and flood during the rain season. The floods usually leave behind deposits of organic materials along the riverbanks resulting in the ecological conditions described by Van Ness[32] that trigger anthrax epidemics. During the dry season, the grass is short and animals are, thereby, forced to graze very close to the ground. This increases chances of animals picking up anthrax spores in areas whose soils and pastures are contaminated with the

spores.

Anthrax epidemics are also common in areas with inadequate vaccinations. Vaccinating cattle whilst in the flood plains is difficult as animals scatter over large areas with difficult terrain. Subsequently, vaccination coverage is insufficient resulting in the mushrooming of cases of anthrax. This phenomenon has led the local communities to believe that the disease is introduced and spread through vaccinations. Consequently, people resist vaccination campaigns against anthrax. A large-scale anthrax epidemic ravaged almost the entire Western Province in 1990. The disease was first reported in November 1990 in Lukulu District and quickly spread from these initial foci to other areas along the Zambezi Plains reaching Mongu, Kalabo and Senanga Districts and by December of the same year a total of 511 cases were recorded.

Disease Diagnosis

All districts in Zambia submit monthly livestock disease cases to the headquarters of the Department of Veterinary and Livestock Development of the Ministry of Agriculture Food and Fisheries. Field diagnosis of anthrax cases reported in this study was based on clinical signs as described by De Vos[7]. Anthrax was suspected in all cases of sudden death with the presence of bloody discharges from all natural orifices of the carcasses. A definitive diagnosis was based on laboratory investigation of *B. anthracis* in stained blood smears from infected carcasses and bacterial culture as described by Ebedes[10]. During the period 1989-1995, a total of 1,626 suspected cases of anthrax were reported throughout Western Province. The isolation of *B. anthracis* from suspected cases and environmental samples are given in Tables 1 and 2, respectively.

Anthrax Control

Historically, control measures of anthrax in Zambia comprise annual vaccination of cattle and public awareness of the disease. The vaccine is produced locally by the Central Veterinary Laboratory, Department of Veterinary and Livestock Development, Ministry of Agriculture, Food and Fisheries. The vaccine has high potency and has no side effects. Emer-

Table 1. Diagnosis of anthrax in cattle in Western Province of Zambia during 1989-1995

	Year							
Cases	1989	1990	1991	1992	1993	1994	1995	Total
Suspected	45	747	511	111	208	4	–	1,626
Investigated	–	–	27	11	44	–	64	146
Confirmed	2	9	7	8	10	–	15	51
% Investigated/Suspected	–	–	5.3	10.0	21.2	–	–	9.0
% Confirmed/Investigated	–	–	25.9	72.7	22.7	–	23.4	34.9

Table 2. Isolation of *Bacillus anthracis* from environmental samples in Western Province-1996

	Samples			
	Soil	Meat/skin	Bone	Total
Sample number	1	15	1	17
Positive	1	12	0	13
% Positive	100.0	80.0	0.0	76.5

gency vaccinations of animals at risk are carried out during epidemics whilst the general public is advised against salvaging anthrax carcasses for meat. Inadequate vaccination coverage along the Zambezi plains resulting in cases of anthrax has forced local farmers to oppose vaccination campaigns since they believe that the disease is introduced and spread through these vaccinations. Resistance to anthrax vaccinations was also reported among indigenous people, particularly in Southern Province, during the colonial period. The local people were suspicious of the colonial government and considered vaccination campaigns as an attempt to kill cattle in order to create more land for the commercial white settlers. Extensive anthrax vaccinations were only enforced when the Good Cattle Production Bounty Scheme came into operation in 1949. Even then, the farmers were still reluctant to accept the vaccinations until 1960 when the increasing incidence of the disease compelled them to have their animals vaccinated.

In other areas, anthrax received little attention from farmers compared to other diseases such as contagious bovine pleuropneumonia, rabies, tuberculosis, East Coast fever and trypanosomosis. In 1935, Native Authorities in Barotseland (now Western Province) did not oppose the free anthrax vaccinations but rather requested government to give priority to the control of contagious bovine pleuropneumonia that was difficult to control due to its sprawling expansion into neighbouring Angola.

Quarantine of livestock during anthrax epidemics is difficult to enforce due to the existence of numerous illegal routes. Incineration of carcasses is constrained by inadequate sources of firewood in the flood plains where anthrax cases frequently occur. Disease epidemics usually coincide with the farming season (July-December) and the traditional farmers have little or no time to spend on other activities such as burning of carcasses. During this time the farming community is opposed to vaccination campaigns, as they prefer to continue using the animals for ox-draught power and milk production than resting the animals to avoid stress-related immunosuppression.

Anthrax in Humans

Human cases are a sequel of salvaging of anthrax carcasses by rural local communities to supplement animal protein in their diet. Human cases of anthrax have been reported in Senanga, Kaoma, Mongu, Kalabo and Lukulu Districts in Western Province and Zambezi District in North-western Province.

The highest incidence of human cases was in 1990 when about 220 cases were reported to the veterinary and health officials. The fatality rate among the reported cases was 19.1%. The severely affected Districts were Mongu, Kalabo, Lukulu and Senanga. At least 248 cases were reported in Senanga, Mongu, Kaoma, Lukulu, Kalabo and Sesheke Districts in Western Province and Kabompo and Zambezi Districts in North-western Province between 1991 and 1998. The case fatality rate among the cases was 7.7% while the average annual case fatality rate was 7.2% (Table 3). The majority of the reported cases were intestinal anthrax with only 33 cases of cutaneous anthrax. The presenting clinical signs in intestinal anthrax were acute gastroenteritis, diarrhoea, vomiting and abdominal pain while oedema of the face, enlarged parotid lymph nodes and fever were the presenting clinical signs in cutaneous anthrax.

Diagnosis of the disease in the affected areas was based on the history and clinical examination of the patient. Diagnosis of the disease using standard laboratory methods

Table 3. Cases of human anthrax in Western and North-western provinces during 1991-1998

Area	Year								Total	Cumulative Total
	1991	1992	1993	1994	1995	1996	1997	1998		
Mongu	20	4(4)	–	–	–	–	–	31(2)	55(6)	55(6)
Senanga	20	9	–	–	15	19(3)	–	6	69(3)	124(9)
Lukulu	–	–	–	11	–	28	–	–	39	163(9)
Kalabo	5	–	–	–	–	5(1)	–	16(3)	26(4)	189(13)
Kaoma	20(2)	–	–	3(1)	–	3	–	21(1)	47(4)	236(17)
Sesheke	1	–	–	–	–	–	–	–	1	237(17)
Zambezi	–	–	1	–	–	–	–	–	1	238(17)
Kabompo	–	–	–	–	–	–	–	10(2)	10(2)	248(19)
Total	66(2)	13(4)	1	14(1)	15	55(4)	–	84(8)	248(19)	
Case fatality Rate	3.0	30.8	–	7.1	–	7.3	–	9.5	7.7	

Values in parenthesis indicate fatal cases.

based on blood smears and culture isolation[12] was not done due to lack of laboratory facilities at the rural health centres in the affected areas. In such circumstances prior experience on the understanding of the pathogenesis, diagnosis, prevention and treatment of anthrax were essential among health personnel. However, lack of skilled manpower consequently lead to failure of differential diagnosis of clinical manifestations of anthrax.

Treatment of anthrax cases at health centres is the major control method of human cases. Members of the public generally disregard veterinary warnings and salvage anthrax carcasses for animal protein resulting in human cases. Prompt diagnosis and treatment of human cases as recommended by Choquette & Broughton[2] is not feasible in the affected areas in Zambia as rural local communities only report of the disease when people become ill and subsequently die of the infection. The whole problem is exacerbated by the long distances travelled, mostly on foot, by patients to health centres resulting in delayed treatment with ensuing mortalities.

Discussion

Historically, the disease in Zambia has always affected cattle in the traditional farming sector. In 1990 the former Veterinary Public Health Unit, now the Zoonotic Diseases Unit of the Division of Emerging and Other Communicable Diseases Surveillance and Control, established a World Health Organisation (WHO) Working Group on Anthrax Control and Research. The group initiated a long-term three-phase model country programme to formulate the design and method of practical implementation of a surveillance and control programme in certain 'model countries' and then to put this programme forward as a template to assist other countries in the formulation of their own national anthrax surveillance and control policies. This is now included in the WHO Anthrax Guidelines and was made possible by the active participation of the Department of Animal Production and Health, Ministry of Agriculture, Food and Fisheries, Zambia and the Livestock Development Programme, Mongu, Western Province,

Zambia, in a model country programme designed by the Working Group for the purpose[29,30,31].

Widely accepted control measures of anthrax such as vaccinations, public awareness campaigns, quarantine and burning or burying of carcasses seem impractical to enforce in the endemic areas in Zambia. Inadequate cooperation from rural farming communities expressed in form of maximized usage of animals (draught power and milk production), reluctance to bury or burn carcasses and lack of fuel wood to burn carcasses are the major constraints to anthrax control. Inadequate technical and administrative support is the major weakness of the government driven anthrax control programme. Funding and supply of logistics (human resource, transport and cold chain system) are erratic and highly centralized and based at the National Veterinary Office in Lusaka resulting in wastage of valuable time completing administrative procedures.

Government has now opted to subcontract private veterinary practitioners to vaccinate livestock against the disease although success from this strategy may be minimal given the lack of systematic quality control measures to evaluate the performance of the private sector. Alternative and innovative approaches are required to bring anthrax under control. It is recommended that government should adopt a strict and systematic quality control programme of anthrax vaccination campaigns, decentralize management of veterinary resources to operational centers with timely disbursement of resources thereof, introduce an effective cold-chain system and conduct vaccination campaigns at regular intervals when climatic and anthropogenic factors favour their implementation. Work is underway to determine the current prevalence of anthrax in wildlife. Studies on molecular epidemiology of the disease should be conducted for strain identification and differentiation which are an essential prerequisite for proper epidemiological investigations and understanding of anthrax. This effort could subsequently lead to practical implementation of surveillance and control programmes not only in Zambia but also in the whole of southern Africa.

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