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Anthrax in animals and humans in Mongolia

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Summary

Anthrax is endemic throughout Mongolia, except in the semi-desert and desert areas of the south. The prevalence of anthrax in Mongolia had drastically decreased since the 1950s due to the use of anthrax antiserum and vaccines, but the privatisation of the animal husbandry sector and changes in the structures of the veterinary and medical delivery systems in Mongolia over the last decade have resulted in challenges for disease control. Animal and human anthrax has become an increasing problem since the mid-1990s. Human cutaneous anthrax is common in Mongolia as a result of exposure to infected animals. In this paper, the authors identify potential causes for the increase of anthrax in Mongolia. The current prevention efforts may not be adequate. Anthrax surveillance and control must be intensified, particularly in areas of high prevalence.

Keywords

Anthrax – Bacillus anthracis – Diagnosis – Disinfection – Disposal – Epidemiology – Local isolate – Mongolia – Nomadic livestock – Reporting – Vaccination – Zoonosis.

Introduction

Mongolia, with an area of 1.566 million km² and a population of 2.6 million inhabitants, has one of the lowest population densities in the world (6). The country is divided into 21 administrative provinces which are further subdivided into counties known as 'soum'. Livestock production is its most important economic resource. Agricultural production accounts for 21.7% of the Gross Domestic Product, with livestock production constituting 84.7% of the total agricultural output (6). In 2005, 30.6 million domestic animals including 13.3 million goats, 12.9 million sheep, 2 million horses, 2 million cattle, 254,200 camels, 22,700 pigs and 141,700 chickens were raised (6). Mongolian animal husbandry is primarily nomadic and depends on geographic and climatic conditions and flora. Since the 1990s, Mongolia has adopted a market economy system by disbanding state collectives and privatising the animal husbandry sector. Herders comprise approximately 14% of the population (6). Additional agriculture-related occupations include butchers, meat traders and workers at slaughterhouses, wool factories and tanneries; these industries are found mainly in Ulaanbaatar, Darkhan and Erdenet, the largest cities. Anthrax is endemic in many areas of Mongolia, resulting in significant problems for livestock production and zoonotic concerns for humans who are occupationally exposed.

Over the last decade, the structures of the veterinary and medical systems have changed in Mongolia, resulting in challenges for disease control. Local veterinary clinics were privatised in 1999; today, 723 private veterinary clinics provide services (O. Ulambayar, personal communication). The State continues to fund the prevention and diagnosis of some infectious animal diseases, including the cost of vaccines and vaccination services. Since the mid-1990s, the ownership and financing of the medical sector have been diversified, and a health insurance scheme has been introduced and developed. In 1991, Mongolia introduced the current national immunisation programme (3). As of 2005, Mongolia had 27 physicians and 72 hospital beds per population of 10,000 (6). Although this ratio is one of the highest in Asia, financial difficulties remain a major challenge as the country seeks to develop economic self-sufficiency and deliver modern health care to its people (3).

With the privatisation of the domestic animal and animal health service, the implementation of preventive measures against zoonotic diseases must be considered from a new point of view. Epidemiological data on infectious animal diseases in Mongolia are available mainly through personal communications and are rarely published in international peer-reviewed journals. To facilitate the further development of a national strategy for disease control this article reviews anthrax outbreaks in animals and humans that have occurred in Mongolia in recent years, suggests potential causes, and identifies possible weaknesses in prevention strategies.

Anthrax in animals

Bacillus anthracis, the bacterium that causes anthrax, is found primarily in the soil. Ancient Mongolians, who understood this relationship, called this disease the 'soil thing' (8). The disease was also called 'spleen' in apparent reference to the pathological changes that occur (2).

From north to south, Mongolia comprises five geographic zones: forest (taiga), forest-steppe, steppe, semi-desert and desert. According to the research by Maidar (4), between 1921 and 1956, anthrax was prevalent throughout the country, except in Dundgovi, Dornogovi and Umnugovi Provinces, which are semi-desert and desert areas. Most anthrax cases during this period occurred in the Selenge, Bulgan, Arkhangai, Khentii, Zavkhan, Dornod and Sukhbaatar Provinces of Mongolia. For example, in 1930, 2,000 sheep died of anthrax in the provincial centre of Dornod. In the summer of 1944, there was drought in Selenge Province and herders moved to the areas closer to the Selenge river: about 500 horses and many cattle died of anthrax. In July and August 1948, in the Khalkh gol and Khunt soums of Dornod Province there were 2,200 fatalities in sheep, goats and cattle as a result of anthrax (2).

The prevalence of anthrax had been drastically decreasing since the 1950s. This may have been the result of using anthrax antiserum, Tsenkovskii's vaccine (from 1941 onwards) and anthrax vaccine STI (from 1948 onwards) (2).

Batsuuri (2) evaluated the prevalence and risks of fifteen bacterial zoonotic diseases in Mongolia between 1976 and 1995. Anthrax caused 1% of those zoonotic diseases in animals and was responsible for 2% of the mortality from the same diseases in animals. Batsuuri found that 84.8% of all anthrax cases in animals involved cattle, 9.1% occurred in sheep and goats, and 3% were seen in camels and horses, respectively. Of the total animals that died of anthrax, 80.9% were cattle, 11.7% sheep and goats, 4.3% camels and 3.2% horses. Batsuuri divided the country into areas according to the risk of animal anthrax prevalence, as shown in Figure 1. The areas with a high risk contained 91.4% of the animal anthrax cases, while the moderate and low-risk areas contained 6.5% and 2% of these cases, respectively. The prevalence of anthrax is directly and indirectly dependent on the soil types, annual average temperatures, and annual levels of sunlight and precipitation. According to Batsuuri, 77.2% of the soums with anthrax outbreaks had black or dark brown, neutral or weakly acidic soil with a humus content greater than 3%. Of the soums with anthrax outbreaks, 88.8% had annual average temperatures below 0°C, 56.8% had annual sunlight levels below 1,300 kWh/m^2, and 71.6% had an annual average precipitation greater than 250 mm.

The authors examined data on anthrax outbreaks which occurred throughout Mongolia between 1996 and 2005. During this period animal anthrax outbreaks occurred in 16 of the country's 21 provinces (Table I) (7). Most outbreaks were reported in Khuvsgul, Zavkhan, Uvurkhangai and Dornod Provinces. No cases of anthrax were recorded in animals in Umnugovi, Dundgovi, Govisumber, Dornogovi, Sukhbaatar and Darkhan-Uul Provinces. A total of 86 anthrax cases occurred in animals in Ulaanbaatar, the capital city (Tuv Province), in 1997, 1998, 2002 and 2004. Nationwide, 78.3% of all anthrax cases occurred in cattle, 17% in sheep and goats, 4.3% in horses, 0.25% in camels, 0.15% in dogs and 0.1% in pigs. The anthrax cases in dogs and pigs occurred in the

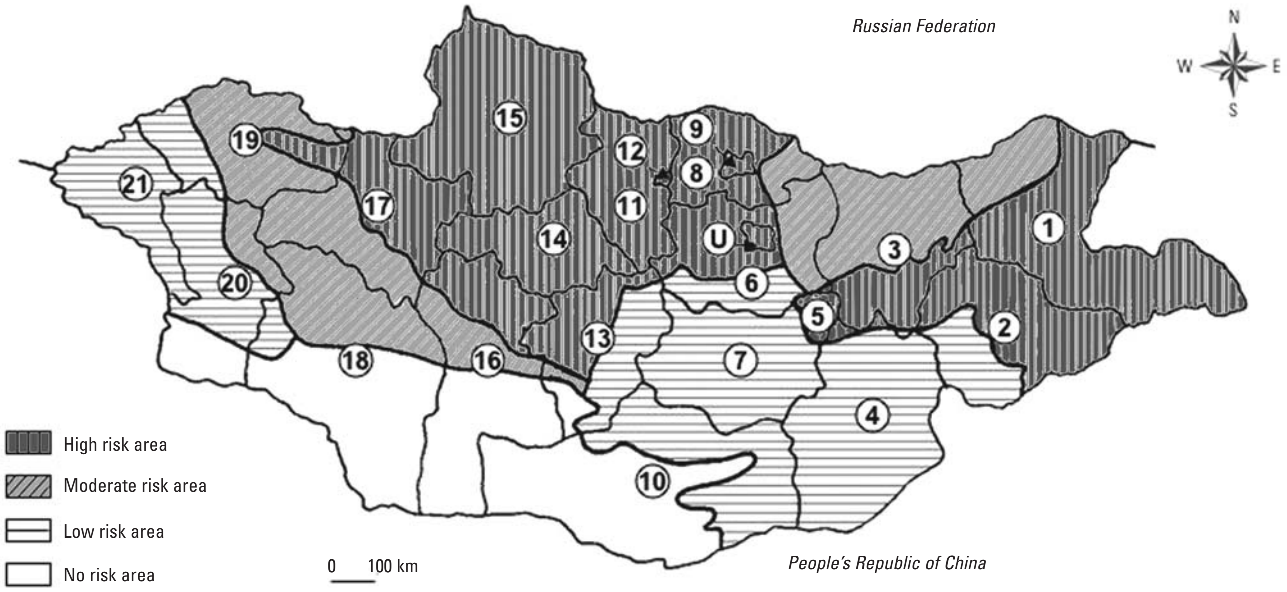

Fig. 1
Territory of Mongolia, divided according to the risk of animal anthrax prevalence, 1976 to 1995 (2)
Provinces: Dornod (1), Sukhbaatar (2), Khentii (3), Dornogovi (4), Govisumber (5), Tuv (6), Dundgovi (7), Selenge (8), Darkhan-Uul (9), Umnugovi (10), Bulgan (11), Orkhon (12), Uvurkhangai (13), Arkhangai (14), Khuvsgul (15), Bayankhongor (16), Zavkhan (17), Govi-Altai (18), Uvs (19), Khovd (20), Bayan-Ulgii (21), Ulaanbaatar, the capital city (U)

Table I
Distribution of animal anthrax cases in provinces of Mongolia, 1996 to 2005

Province	**Number of infected animals** (per one hundred thousand head)										**Total**
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	
Khuvsgul	127 (6.4)	259 (12)	140 (6.1)	27 (1.1)	128 (5.6)	42 (2.4)	51 (2.7)	7 (0.3)	15 (0.7)	37 (1.5)	**833**
Zavkhan	66 (2.7)	46 (1.8)	36 (1.4)	32 (1.3)	38 (2)	29 (2)	8 (0.6)	10 (0.6)	5 (0.3)	10 (0.5)	**280**
Uvurkhangai	25 (1)	23 (0.9)	-	11 (0.4)	122 (5.7)	3 (0.2)	14 (0.8)	7 (0.4)	4 (0.2)	23 (1)	**232**
Dornod	-	-	-	41 (5.1)	51 (6.2)	9 (1.1)	-	-	15 (1.7)	61 (6.2)	**177**
Ulaanbaatar [(a)]	-	42 (14)	6 (2)	-	-	-	36 (15.4)	-	2 (0.9)	-	**86**
Khentii	-	1 (0.1)	5 (0.4)	10 (0.7)	-	-	2 (0.1)	-	26 (1.7)	26 (1.5)	**70**
Tuv	-	33 (1.6)	-	4 (0.2)	4 (0.2)	-	-	-	29 (1.9)	-	**70**
Arkhangai	-	-	47 (2.2)	4 (0.2)	-	14 (0.8)	-	-	-	-	**65**
Bayankhongor	-	4 (0.2)	-	36 (1.5)	2 (0.1)	1 (0.1)	-	5 (0.5)	-	2 (0.1)	**50**
Uvs	-	1 (0.1)	-	-	-	26 (1.7)	-	-	15 (0.8)	3 (0.2)	**45**
Govi-Altai	-	-	-	-	-	-	-	-	31 (2)	2 (0.1)	**33**
Bulgan	-	5 (0.4)	-	-	-	6 (0.4)	-	-	5 (0.4)	15 (1.1)	**31**
Khovd	-	-	-	-	-	-	-	-	-	28 (1.4)	**28**
Orkhon	-	-	-	-	-	-	-	-	-	9 (6.6)	**9**
Selenge	-	-	-	-	-	-	-	-	3 (0.5)	-	**3**
Bayan-Ulgii	-	-	-	-	-	2 (0.2)	-	-	-	-	**2**
Darkhan-Uul	-	-	-	-	-	-	-	-	-	-	**-**
Dornogovi	-	-	-	-	-	-	-	-	-	-	**-**
Dundgovi	-	-	-	-	-	-	-	-	-	-	**-**
Govisumber	-	-	-	-	-	-	-	-	-	-	**-**
Umnugovi	-	-	-	-	-	-	-	-	-	-	**-**
Sukhbaatar	-	-	-	-	-	-	-	-	-	-	**-**
Total	**218**	**414**	**234**	**165**	**345**	**132**	**111**	**29**	**150**	**216**	**2,014**

a) Capital city

provinces with the highest prevalence: three dogs were infected in Chuluunkhoroot soum of Dornod Province in 1999, and two pigs were infected in Erdenebulgan soum of Khuvsgul Province in 2005. Of the total number of animals that died of anthrax between 1996 and 2005, 70.4% were cattle, 23.8% sheep and goats, 5.3% horses, 0.2% camels, and 0.15% dogs and pigs, respectively. During this period, the total percentage of morbidity and mortality of small ruminants among domestic animal species infected with *B. anthracis* was approximately twice as much as it had been between 1976 and 1995. This may indicate that the number of sheep and goats vaccinated against anthrax was lower than the number of cattle, leading to the increase of prevalence among small ruminants. Horses and camels are vaccinated only when there is an outbreak.

In Mongolia, anthrax is a seasonal disease. Between 1996 and 2005, 72.6% of all animal anthrax cases occurred from June to September, with a peak of 23.4% in September. The second peak occurred in December, when 9.5% of the cases were reported.

Diagnosis

Clinical symptoms of natural infection with *B. anthracis* are similar in all animal species (D. Nyamsuren, M. Tuvshinzaya and D. Dashzevge, personal communication). Animals can be found dead in the morning despite showing very few clinical signs (e.g. depression) – or being completely free of clinical signs – the previous evening. Sweating is observed in camels before death. In warmer seasons, the carcass swells very rapidly, especially around the head, neck, thorax and abdomen. The lower fore- and hind legs are swollen but not rigid, but the upper ones are even more swollen. Bloody or dark brown liquid discharges from the nostrils, mouth, anus, vulva or penis. If anthrax is suspected, the carcass is not opened. If it is not known that an animal had anthrax, and a necropsy is carried out, the bloody brown spleen is grossly enlarged. It is common practice for soum veterinarians to diagnose animal diseases by observing clinical signs. Because of the lack of laboratory supplies and simple equipment such as microscopes, slides and stains in soum veterinary clinics, it is impossible to confirm the clinical diagnosis by laboratory tests locally. In some cases, because anthrax resembles other diseases such as pasteurellosis, enterotoxemia, blackleg, strangles or plant poisoning, anthrax cases are misdiagnosed, and disease control measures are not instituted promptly. In cases where definitive diagnosis cannot be made locally, soum veterinarians seek the intervention of the provincial veterinary laboratories for confirmation. The lower ear or a sample from the discharged blood is sent for laboratory diagnosis. Provincial laboratories diagnose anthrax by direct microscopy, isolation, a pathogenicity test in laboratory animals and the Ascoli test. The State Central Veterinary Laboratory is capable of conducting biochemical tests, tests for antibiotic resistance, polymerase chain reaction and an immunofluorescence test for the diagnosis of anthrax.

Control measures

Movement control, disposal and disinfection

In the case of an anthrax outbreak, movement is restricted for 2 weeks. The carcass is buried or, occasionally, incinerated. Limited amounts of disinfectants are supplied from the State to soum veterinary clinics. Formaldehyde, chlorine lime and neutral calcium hypochlorite are the most available and commonly used disinfectants in Mongolia. In the 'General recommendations for veterinary sterilisation and disinfection', approved by the State Veterinary Department (SVD) in 2007, the following substances are included for use as disinfectants for anthrax:

– chlorine lime with 5% to 10% active chlorine
– 10% sodium hydroxide
– 4% to 10% formaldehyde
– 10% iodine monochloride
– 0.5% Omnisept (Bremer Farma, Germany)
– 3% Kristalla 900 (Inter-Sintez, Ukraine)
– 5% phenol
– 1:500 Killsa (Tsagaan Zalaat Agvet, Mongolia)
– 3% hydrogen peroxide.

The veterinary disinfection around the carcass is paid for by local government.

Vaccination

Vaccination is the most effective tool for combating infectious diseases in Mongolia, as animal husbandry is pasture-dependent and herds of different animal species are allowed to mingle freely. Vaccination is essential for all livestock that reside in or migrate through endemic foci (8) and the cost of vaccines and vaccination services continue to be funded by the State. Animal anthrax vaccine using $34F_2$, the international standard strain, has been produced domestically at Biocombinat (the state-owned manufacturer of veterinary biologicals) since the 1970s. This vaccine is considered to be highly effective. Today, between 2,500 and 2,900 litres of the anthrax vaccine is produced per year (Ts. Ulziitogtokh, personal communication). The vaccination period for anthrax is from April to May of each year before the peak outbreaks. In most animals, except horses (see below), the initial dose of vaccine is administered once, in volumes of 1.5 ml to camels, 1.0 ml to cattle, and 0.5 ml to calves and foals up to six months old, as well as sheep, goats and pigs.

Complete immunity is established in two weeks and persists for at least one year. Horses are injected with 1.0 ml of vaccine twice, with an interval of one month between each injection (10). Approximately 300 litres of animal anthrax antiserum is produced per year using local isolates (Ts. Ulziitogtokh, personal communication). The antiserum is used to induce short-term passive immunity of up to 14 days and for treatment. A single dose ranges between 5 ml and 20 ml for prevention and 30 ml and 200 ml for treatment according to the animal species and age. Depending on the progress of recovery of the animal, the treatment dose can be administered several times at intervals of between 8 and 24 hours (11).

Anthrax in humans

Human anthrax outbreaks were reported in 27 separate years between 1964 and 2005 (5), with continuous outbreaks occurring between 1975 and 1981 and from 1996 to 2005. During this latter period, 108 human anthrax cases, including seven fatal infections, were reported. Of these patients, 86.1% were infected by exposure to animals, 2.8% from animal derived products and 6.5% from soil. The source of infection of the rest of the patients (4.6%) was not identified. The vast majority (107) of the affected people had the cutaneous form of the disease; one person had mixed cutaneous and intestinal infections. Adults accounted for 91.7% of all anthrax cases, and 75.9% of the patients were males. In Mongolia, men slaughter animals, the task that exposes them to a higher risk of infection with *B. anthracis*. Most infections were the result of occupational exposure, with 65.7% of all cases occurring in herders.

Human anthrax is closely correlated with outbreaks in animals (Fig. 2) and thus is seasonal in Mongolia. Between 1996 and 2005, 76.9% of all human anthrax cases occurred between June and September, with a peak of 21.3% in September. Slaughtering is not common in winter, thus only one person was infected in December, even though the animal infection rate was comparatively higher during this month. Uvurkhangai and Khentii Provinces reported the highest incidence of human anthrax (Table II). No cases were reported in Umnugovi, Dundgovi, Govisumber, Dornogovi, Sukhbaatar, Govi-Altai and Bayan-Ulgii Provinces. The number of cases in Khuvsgul and Zavkhan Provinces was comparable to the incidence for the rest of the country, even though animal anthrax cases had been high in these two provinces throughout this period (1996-2005). In Mongolia, people over the age of 14 living in endemic foci are vaccinated for anthrax in spring, before the animal outbreaks. The human vaccine uses the live spore suspension of strain STI (Institute of Microbiology, Kirov, Russia). An initial two doses of vaccine are administered 21 days apart, followed by single annual booster doses.

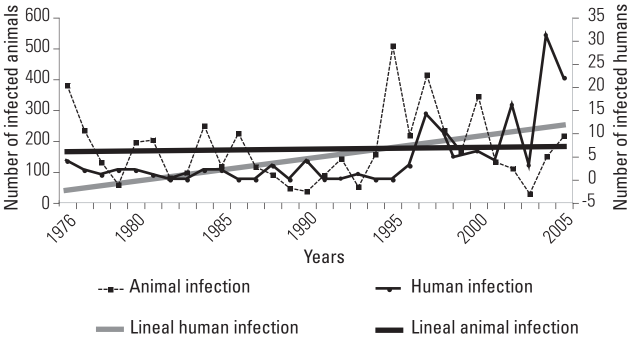

Fig. 2
Number of animals and humans infected with *Bacillus anthracis* in Mongolia, 1976 to 2005

Out of the total of 77 anthrax outbreaks in humans between 1996 and 2005, 19 consisted of 2 to 6 cases each (the rest of the outbreaks had only a single case each). Cattle were the source of infection in 14 of these outbreaks, which affected 37 people. One of the outbreaks was caused by horses and infected four people, one of whom was the only person to suffer from cutaneous and intestinal infections. One possible explanation for these multiple human infections is that several people are involved in slaughtering large animals such as cattle and horses, thus increasing the risk of multiple infections. But it was not identified whether these people were infected from live animals or post-mortem.

The source of exposure for humans appears to be changing. From 1996 to 2000, cattle were the main source of infection, and accounted for 53.1% of the reported human cases. Over the same period, sheep were responsible for only 12.5% of human cases. However, a different pattern emerged from 2001 to 2005. During this period, 39.5% of all human cases were associated with infected small ruminants, while 40.8% resulted from exposure to cattle. This observation might be explained by an increased number of anthrax infections in sheep and goats, as mentioned above.

Local isolates of *Bacillus anthracis*

Tserendorj studied local isolates of *B. anthracis* in Mongolia (8). These isolates were obtained between 1979 and 2004 from Ulaanbaatar and from the provinces of Arkhangai, Bayankhongor, Bulgan, Dornod, Khentii, and Selenge. Ten isolates came from cattle, eight from sheep, two from horses and one each from a camel and a goat. Tserendorj compared the morphology, cultivation, biochemical and molecular biological properties, pathogenicity, and antibiotic and disinfectant resistance of these local isolates with those of the standard vaccine strain, $34F_2$. Local isolates were identical to strain $34F_2$ in

Table II
Distribution of human anthrax cases in provinces of Mongolia, 1996 to 2005

Province	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Uvurkhangai	3	2	-	-	3	-	6	2	2	3	**21**
Khentii	-	3	1	-	-	2	4	-	3	1	**14**
Dornod	-	-	-	3	2	-	-	-	3	2	**10**
Selenge	-	-	-	-	-	-	-	-	9	-	**9**
Khuvsgul	-	3	2	-	-	-	2	-	-	1	**8**
Bayankhongor	-	1	-	1	-	1	-	-	-	4	**7**
Darkhan-Uul	-	-	-	-	-	1	-	-	5	1	**7**
Arkhangai	-	1	1	-	-	-	2	-	1	1	**6**
Uvs	-	2	-	-	-	-	-	-	3	-	**5**
Ulaanbaatar[a]	-	-	-	-	-	-	2	1	1	-	**4**
Bulgan	-	-	-	-	-	-	-	-	3	1	**4**
Orkhon	-	-	-	-	-	-	-	-	-	4	**4**
Zavkhan	-	1	1	-	-	-	-	-	-	2	**4**
Tuv	-	1	-	-	1	-	-	-	1	-	**3**
Khovd	-	-	-	-	-	-	-	-	-	2	**2**
Govi-Altai	-	-	-	-	-	-	-	-	-	-	**-**
Bayan-Ulgii	-	-	-	-	-	-	-	-	-	-	**-**
Dornogovi	-	-	-	-	-	-	-	-	-	-	**-**
Dundgovi	-	-	-	-	-	-	-	-	-	-	**-**
Govisumber	-	-	-	-	-	-	-	-	-	-	**-**
Umnugovi	-	-	-	-	-	-	-	-	-	-	**-**
Sukhbaatar	-	-	-	-	-	-	-	-	-	-	**-**
Total	**3**	**14**	**5**	**4**	**6**	**4**	**16**	**3**	**31**	**22**	**108**
Dead	*1*	*2*	-	-	-	*1*	*1*	-	-	*2*	*7*

a) Capital city

cell morphology, cultivation and biochemical properties, except that the local strains all formed capsules. All local strains contained pXO1 (toxin) and pXO2 (capsule) plasmids, while strain $34F_2$ had only pXO1. In experimental infections in sheep, the local strains caused acute septicaemia and rapid death within 28 h to 36 h. There was absence of rigor mortis and unclotted blood was discharged from the anus. A white foamy or bloody yellowish liquid was discharged from the nostrils and mouth. Haemorrhagic inflammation was seen in the liver, spleen, kidney, lung, lymph nodes and brain. Venous congestion, oedema, haemorrhage, and protein degeneration in the liver occurred. The spleen enlarged to almost twice its normal size and turned dark brown and sticky. The local isolates were 100% sensitive to streptomycin, kanamycin, gentamycin, cefazolin, doxycycline and ciprofloxacin. Some isolates were resistant to other antibiotics: 14.3% were resistant to penicillin and 42.9% to cloxacillin, and all isolates were resistant to levomycitin. Sporulated forms of *B. anthracis* were killed by 0.005% to 1% neutral calcium hypochlorite, 4% formaldehyde, 10% hydrogen peroxide, 0.5% Omnisept (Bremer Farma, Germany), and 0.012% to 0.2% Killsa (Tsagaan Zalaat Agvet, Mongolia) in 15 to 30 min. Supersept (Bremer Farma, Germany) was least effective in disinfecting the sporulated forms. They were killed by 5% Supersept within 2 h.

Surveillance and control of anthrax in Mongolia: current problems

Before the 1990s, domestic animals were state property and there was only a State Veterinary Service. All preventive, prophylactic and disease control services for animals were provided by the State. Preventive measures for animals in endemic foci or moving to slaughter houses were successfully implemented. Meat supply for public consumption was provided by the State under strict disease inspection procedures, and herders were allowed to slaughter animals only if the meat was for consumption by their family. Veterinarians visited herders frequently to check the health status of their animals. Any animal losses or morbidity and mortality cases were checked by veterinarians and registered. Thus, the animal disease information was reliable. Since the 1990s, Mongolia has adopted a market economy system by disbanding state collectives and privatising the animal husbandry sector. In 1999, soum veterinary clinics were privatised. With privatisation, the implementation of measures for animal health has been greatly changed. Animal and human anthrax has become an increasing problem since the mid-1990s.

The objective of anthrax control measures is to break the cycle of infection. Each of the following actions must be rigorously implemented:

– disposal of anthrax carcasses
– disinfection
– decontamination and disposal of contaminated materials
– vaccination of exposed susceptible animals and humans in at-risk occupations (9).

Appropriate carcass disposal is a key step in limiting the spread of anthrax. In Mongolia, where animal husbandry is pasture-dependent, avoiding environmental contamination with *B. anthracis* is difficult. When animals die on pasture, they are readily eaten by wild carnivores, birds or dogs. Consumption of the carcass exposes *B. anthracis* to oxygen, and leads to spore formation and contamination of the soil. In addition, carnivores and birds are resistant to clinical disease and may disseminate the spores to other areas. Herders should protect the carcass from contact with carnivores until the arrival of veterinarians. But carcasses are often left unprotected, probably due to the herders' lack of knowledge about the transmission of the disease. Thus, public education campaigns for anthrax should be intensified in Mongolia. Incineration is usually not performed. Even though the carcass is buried, sometimes fences or warning signs are not put up. It greatly depends on the responsibility of the veterinarians, state veterinary inspectors and governors participating in the combating of the disease.

Inappropriate storage conditions for disinfectants in some soum veterinary clinics and veterinarians' lack of knowledge about disinfection may have adverse effects. It is important that veterinarians follow the specific disinfection instructions for each disease.

The service provided by soum veterinarians has become limited due to the lack of finance. Most of the clinics do not satisfy the minimal standards. As previously stated, the State continues to fund the prevention and diagnosis of some infectious diseases, including the cost of vaccines and vaccination services; soum veterinarians order vaccines from the state on the basis of local long-term disease status, but because of the limited budget for vaccine and vaccination costs, the vaccine orders are not fully supplied, irrespective of the disease prevalence. The lack of vaccines remains a major constraint that may lead to inadequate vaccination coverage. As shown in Figure 3, the highest incidence of animal anthrax occurred in 1995, when nationwide vaccination was at its lowest level (8). Only a tenth as many animals were vaccinated in 1995 compared to the vaccination rate in 1990, and the number of animals with anthrax increased 18-fold. Of the 508 cases of anthrax in 1995, 456 occurred in Khuvsgul Province, where the prevalence of this disease is the highest. This may indicate that the absence of regular vaccination in areas with active anthrax foci could lead to outbreaks. Animal anthrax also re-emerged in Khentii Province in 1997, after a seven-year period during which no outbreaks were recorded. Vaccination for animals against anthrax had decreased six-fold in Khentii Province between 1990 and 1996. This factor may have contributed to or caused the re-emergence of anthrax in 1997. Another factor contributing to the increased disease prevalence might be the quality of the vaccination campaign, for example, veterinarians may not identify the exact disease foci or ensure that all susceptible animals in the area are vaccinated; moreover, since animal certification and movement control is poor in Mongolia, unvaccinated animals can transmit disease to other areas. According to Article 14.2.1 of the Law on Livestock Health and Gene Protection of Mongolia, approved in 2001, legal entities and individuals must involve their livestock in veterinary programmes against infectious diseases. In Article 16.2.3 of the same Law, an individual/official shall pay a fine of up to MNT 50,000 (US$43) and a legal entity shall pay a fine of between MNT 50,000 and MNT 80,000 (US$43-US$69) in case of a breach of Article 14.2.1. A state veterinary inspector imposes these fines on any party who breaks the provisions of this Law. Herders are actively involved in the animal vaccination campaigns against foot and mouth

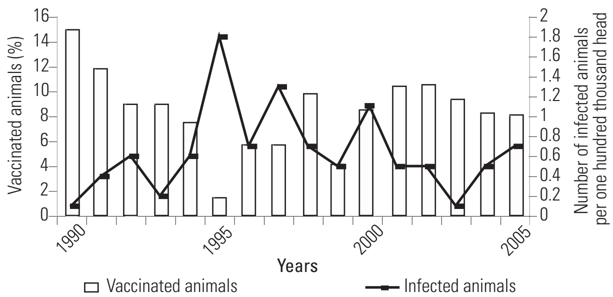

Fig. 3
Correlation between vaccinated animals and animals naturally infected with *Bacillus anthracis* in Mongolia, 1990 to 2005

disease and sheep pox. But some herders will not participate in vaccination programmes if there has been no outbreak of a disease for several years. Veterinarians should explain to herders the importance of animal vaccination in preventing outbreaks of serious infectious diseases in endemic foci.

Human vaccination may reduce the risk to humans in areas where anthrax outbreaks are frequent in animals. In 2003, 5,099 people were vaccinated for anthrax in 6 provinces, 45.7% of them in Khuvsgul Province. The high vaccination rate and correspondingly low incidence of human anthrax in Khuvsgul Province suggest that anthrax awareness is high in this province, and preparedness is relatively effective. In 2004 and 2005, animal and human anthrax outbreaks occurred simultaneously in Selenge, Orkhon and Khovd Provinces, where no cases had been recorded since 1996. This may have been the result of inadequate preparedness and/or knowledge about anthrax prevention in those provinces. Seven human cases occurred in Darkhan-Uul Province during a three-year period when no animal anthrax cases were reported. Darkhan, the center of Darkhan-Uul Province, is the second largest city in Mongolia and a centre for the processing of animal products. Thus, these infections may have resulted from exposure to animals or animal derived products originating in other areas. For example, three of the patients were meat carriers and they were affected by the cutaneous form of anthrax.

A number of factors complicate the assessment of the current status of animal health in Mongolia. There is inadequate cooperation between herders, veterinarians and the SVD in pathogen research or in the development of an epizootiological map of infectious animal diseases (8). Most herders do not inform veterinarians when symptoms of infectious diseases occur in their herds. Instead, they prefer to consume the meat from infected herds, and sell the skin and wool. There is little understanding of the danger, cause and prevention of anthrax among the general population. Of the 47 people infected with anthrax between 1996 and 2005 as a result of exposure to their own animals, 87.2% had not informed a veterinarian that their animal was sick (1). This indicates that herders do not report cases when only a few animals die, and that such cases may only be diagnosed at a later stage if, for example, human outbreaks occur. It is not uncommon for herders to seek the help of veterinarians only when many animals die in a short period. In July and August of 2004, several horses died suddenly in Khukhmorit soum of Govi-Altai Province. Herders did not report these cases to veterinarians. But later, during surveillance of equine diseases that was being undertaken to ascertain if the area would be suitable for raising wild horses, those animals were diagnosed, retrospectively, by isolating *B. anthracis* from the soil (5, 8). According to the Law on Livestock Health and Gene Protection of Mongolia, individuals and legal entities must inform the local veterinary service unit (veterinary clinic) and bag/horoo (subdivision of soums and districts) administration within 12 hours if any animals show clinical signs of an infectious disease and/or rapid loss of mass (Article 14.1.5). As previously stated, Article 16.2.3 of the same Law allows state veterinary inspectors to impose fines on those who break the provisions of the Law; nevertheless, the implementation of Article 14.1.5 is less than satisfactory. The fact that soum veterinarians usually only have access to herders during vaccination periods might also lead to delayed reporting of outbreaks. Mobile communication is becoming popular in Mongolia and this may facilitate animal health reporting in the future.

As has already been said, because of the lack of laboratory supplies and simple equipment such as microscopes, slides and stains in soum veterinary clinics, it is impossible to confirm the clinical diagnosis by laboratory tests locally, so the samples are sent to the provincial laboratories. It is common practice for soum veterinarians to diagnose animal diseases by clinical signs alone (8). This is mostly because of the distance to the provincial centres and the lack of easily available transportation. Thus, the data on infectious disease outbreaks sent to the SVD is confirmed by either clinical or laboratory diagnosis, or a combination of the two. In the data of the SVD, a total of 67 outbreaks and 177 cases of animal anthrax were recorded in Dornod Province between 1996 and 2005 (7). The provincial veterinary laboratory of Dornod received 58 samples from animals suspected to be infected with anthrax from soums during this period and 22 of them were confirmed by the laboratory tests (D. Nyamsuren, personal communication). The soum veterinarians report animal infectious diseases to the SVD both monthly and annually. Anthrax is included in the list of the diseases to be reported urgently to the SVD. Because the disease information exchange between herders and veterinarians is unsatisfactory, the actual number of animal anthrax cases or outbreaks could exceed the number that is reported and registered on the SVD database. Soum veterinarians should be provided with easy-to-use diagnostic kits and appropriate, safe boxes and tubes for the transfer of infective samples.

Soil disturbances could also contribute to the increased number of anthrax outbreaks. Gold mining in Mongolia has increased, resulting in soil disturbances in many areas. Between 1996 and 2005, one gold miner was infected with *B. anthracis* from the soil (5).

Coordination between local administrators, veterinarians and state veterinary inspectors in finding permanent solutions to the above-mentioned problems must improve.

In addition, training in disease control should be made available for local non-veterinarian officials.

Conclusions

The recent increased incidence of anthrax in Mongolia suggests that improved control measures are needed to protect both animal and human health. Mongolia must develop an anthrax control programme that includes improved access to veterinary care and information exchange, enhanced diagnostic capabilities (especially easy-to-use diagnostic kits for field veterinarians), appropriate disposal of carcasses, suitable disinfection and decontamination processes, an improved vaccination strategy, strong controls on animal movement and slaughtering, and increased public awareness. Coordination between local administration, veterinary and public health services, and veterinary inspection is most important if these changes are to take place. Training for epidemiologists in each provincial veterinary service is urgently required, as is an improvement in the information contained in databases on infectious animal diseases. It is hoped that the information provided here will stimulate the veterinary and medical authorities to improve their surveillance and response capabilities against anthrax for the ultimate improvement of livestock and human health in Mongolia.

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Fièvre charbonneuse affectant les animaux et les hommes en Mongolie

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Résumé

La fièvre charbonneuse est endémique en Mongolie, excepté dans les zones désertiques et semi-désertiques du sud du pays. La prévalence de la fièvre charbonneuse en Mongolie avait considérablement diminué depuis les années 1950 grâce à l'utilisation d'antisérum et à la vaccination, mais depuis une dizaine d'années, les changements structurels auxquels ont été soumis les systèmes de prestation de services vétérinaires et médicaux ont rendu plus difficiles les activités de lutte contre la maladie. Depuis le milieu des années 1990, la fièvre charbonneuse pose un problème qui ne cesse de s'aggraver. La forme cutanée de la fièvre charbonneuse chez l'homme est désormais fort répandue dans le pays, en raison de l'exposition aux animaux infectés. Les auteurs tentent d'élucider les causes potentielles de l'augmentation des cas de fièvre charbonneuse en Mongolie. Les efforts de prévention mis en œuvre sont probablement insuffisants. Les activités de surveillance et de lutte contre la maladie devraient être intensifiées, notamment dans les régions où la prévalence est élevée.

Mots-clés

Bacillus anthracis – Bétail nomade – Déclaration – Désinfection – Élimination – Épidémiologie – Fièvre charbonneuse – Mongolie – Vaccination – Zoonose.

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Carbunco bacteridiano en animales y seres humanos en Mongolia

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Resumen
El carbunco bacteridiano es endémico en todo el territorio de Mongolia, excepto en las zonas semidesérticas y desérticas del sur del país. Desde los años 50, gracias a la utilización del antisuero contra el carbunco bacteridiano y la vacunación, la prevalencia de la enfermedad disminuyó de manera espectacular en el país. Pero las modificaciones introducidas en las estructuras de atención de la salud animal y pública de Mongolia en el curso de los últimos diez años menoscabaron el control de la enfermedad. Desde mediados de los años 90, el carbunco animal y humano se ha convertido en una amenaza creciente. El carbunco cutáneo humano es común en Mongolia debido a la exposición a animales infectados. En este artículo, los autores exponen las posibles causas del aumento de la incidencia de la enfermedad en Mongolia. Las medidas preventivas actuales podrían ser inadecuadas. Es preciso intensificar la vigilancia y el control del carbunco, en particular en las zonas de elevada prevalencia.

Palabras clave
Bacillus anthracis – Carbunco bacteridiano – Desinfección – Eliminación – Epidemiología – Ganado nómade – Mongolia – Notificación – Vacunación – Zoonosis.

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