

# The spread of pathogens through trade in small ruminants and their products

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## Summary

While the international trade in small ruminants and small ruminant products is small relative to the trade in bovine, swine and poultry products, it is still economically important. In addition to wool, it includes some unique products (such as goat and sheep milk cheeses, cashmere fibre and karakul pelts) and the sheep/goat meat trade plays a large part in sustaining livelihoods in several regions of the world. The trade in small ruminants and their products also merits consideration because sheep and goats may transmit zoonotic diseases such as Rift Valley fever, Crimean Congo haemorrhagic fever, brucellosis and listeriosis. They also may transmit highly infectious livestock diseases, such as peste des petits ruminants, to naïve populations of small ruminants in other countries. This can have dramatic consequences, particularly for poor people whose livelihood often depends on small ruminants. In addition, sheep and goats can serve as an important source of foot and mouth disease (FMD) for cattle. This has enormous global trade implications and it is important, therefore, that sheep and goats be considered in FMD control programmes aimed at improving access to trade.

## Keywords

Bovine spongiform encephalopathy – Cashmere – Disease – Foot and mouth disease – Goats – International trade – Meat – Milk – Peste des petits ruminants – Rift Valley fever – Scrapie – Sheep – Skins – Wool – Zoonosis.

## Introduction

International trade has grown dramatically since World War II. That growth has been facilitated by international efforts to break down trade barriers and to create a level playing field for all trading partners through free market initiatives formalised through the World Trade Organization (WTO), which was established in 1995. Growth in the trade of livestock and foods of animal origin has been particularly robust as a result of several factors, including:

- elimination or reduction of tariffs associated with free market reforms
- technological advances in containerised and refrigerated shipping
- economic growth and development associated with a steadily increasing global consumer demand for foods of animal origin, particularly in developing countries

– increased migration of people to new countries, creating demand for animal products not traditionally found in those destinations.

Between 1961 and 2006, the contribution of livestock products to global agricultural export value rose from 11% to 17% (8). Between 1980 and 2006, the volume of total meat exports increased more than threefold, while exports of dairy products more than doubled and exports of eggs almost doubled. From 1995 to 2007, the average annual growth rate in the world for meat, milk and egg production was 2.7%, 1.8% and 3.1%, respectively. It is projected that global production and consumption of meat will continue to rise, from 233 million tonnes in 2000 to 300 million in 2020. Milk production and consumption is expected to increase from 568 million to 700 million tonnes over the same period, while egg production is expected to increase by 30% (13).

The increased movement of live animals and animal products in international trade has increased the risks of

spread of transboundary diseases of animals as well as zoonotic diseases, particularly those that are foodborne. Recognising these risks, the WTO has actively promoted the development of international standards to ensure that animal health and food safety are considered and protected as core elements in international trade. The World Organisation for Animal Health (OIE) provides scientific expertise to the WTO for the regulation of trade in livestock while the Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO), through the Codex Alimentarius, provide guidelines for the regulation of food products, including foods of animal origin.

One of the OIE's main missions is to ensure the transparency of the world animal health situation so as to control the spread of disease and facilitate safe trade. To this end, the OIE maintains a list of notifiable diseases (17). The notifiable diseases affecting small ruminants are given in Box 1. Member Countries of the OIE must report confirmed occurrences of these diseases within their borders to the OIE through its World Animal Health Information System (WAHIS). Information from WAHIS (immediate disease notifications, weekly information, six-month summary reports and yearly summary reports) is always available to Member Countries and other

#### Box 1

##### **Diseases affecting sheep and goats included on the list of notifiable diseases of the World Organisation for Animal Health, 2010**

Listed alphabetically, not by importance

##### **Diseases listed specifically for sheep and goats**

Caprine arthritis/encephalitis  
Contagious agalactia  
Contagious caprine pleuropneumonia  
Enzootic abortion of ewes (ovine chlamydiosis)  
Maedi-visna  
Nairobi sheep disease  
Ovine epididymitis (*Brucella ovis*)  
Peste des petits ruminants  
Salmonellosis (*S. abortusovis*)  
Scrapie  
Sheep pox and goat pox

##### **Other significant diseases of sheep and goats listed in the multiple species category**

Anthrax  
Bluetongue  
Brucellosis (*Brucella melitensis*)  
Foot and mouth disease  
Heartwater  
Paratuberculosis  
Q fever  
Rabies  
Rift Valley fever  
Rinderpest

Source: World Organisation for Animal Health (17)

subscribing institutions. The six-month and yearly summary reports are also available to the general public. The OIE information system also includes tools to compare the animal health situation in different countries. Such applications can help determine potential risks from trade in live animals or in animal products between Member Countries.

Furthermore, the OIE publishes and annually updates the *Terrestrial Animal Health Code (Terrestrial Code)*, which recommends health measures to be used by the veterinary authorities of importing and exporting countries to prevent the transfer of agents that are pathogenic for animals or humans, while avoiding unjustified sanitary barriers. The recommended zoosanitary measures for control of each of the small ruminant diseases listed in Box 1 can be found in the *Terrestrial Code* (19). A companion volume, the *Manual of Diagnostic Tests and Vaccines for Terrestrial Animals*, provides internationally agreed diagnostic laboratory methods and requirements for the production and control of vaccines and other biological products, including those for the diagnosis and prevention of the notifiable small ruminant diseases (16).

The intention of this paper is to provide some perspective on the patterns of trade in small ruminants and their products, identify key animal and zoonotic pathogens that can be disseminated by sheep and goats through both regulated and unregulated trade, and provide some specific, current examples of trade issues associated with the movement of small ruminants and their pathogens.

## Distribution and management of small ruminants and patterns of trade

In 2008, there were an estimated 864.4 million goats and 1.09 billion sheep in the world (9). The distribution of these animals by continent or region is given in Table I. Although well adapted to diverse ecological and climatic zones, small ruminants are particularly well represented in semi-arid regions, as they generally show greater adaptability than cattle to dry conditions. This is because they have better water conservation mechanisms and, especially in the case of goats, a wider range of foraging behaviour (browsing and grazing).

Comparatively few of the world's small ruminants are found in the developed countries, although Australia has been and remains a major actor in the global commercial trade in sheep, exporting wool, meat and breeding stock. Even in developed countries where intensive management of other livestock species is widespread, few sheep are

**Table I**  
**Populations of sheep and goats by continent/region, 2008**

Continent/Region	Number of sheep	Number of goats
Africa	289,652,802	294,534,770
Americas	90,360,540	37,292,895
Asia	457,624,391	511,295,158
Europe	134,628,544	17,860,213
Oceania	114,041,181	3,417,841
World total	1,086,307,458	864,400,877

Source: Food and Agriculture Organization (9)

managed under intensive conditions. Rather, they are usually managed extensively on ranches or on public lands. There is, however, some intensive feedlot meat production of sheep in North America and Europe. There are also small numbers of sheep and goats managed intensively for milk and cheese production, again, primarily in Europe and North America.

Livestock production systems in developing countries have been reviewed (14). In general, small ruminants are either integrated into subsistence, smallholder farming systems, herded by landless people around towns and villages, or managed extensively under transhumant or fully nomadic systems. Nomadic herding is common in many parts of Africa and Asia (particularly in the semi-arid regions stretching from the Sahel in West Africa through East Africa, the Middle East and Central Asia to Mongolia in the East, and India to the south) and represents the principal livelihood of tens of millions of people. It is not uncommon for nomadic flocks to cross international borders in their search for grass and water, which has implications for transboundary disease control.

## Trade in small ruminant products

### Trade in meat

Regardless of the management system, most sheep and goats are raised mainly as a source of meat. However, most of this meat is sold or consumed through domestic channels rather than entering international trade. In developing countries, the majority of small ruminants are butchered for local consumption or for sale in nearby towns and cities. Meat from small ruminants accounts for a significant portion of the meat produced in the Near East and North Africa, sub-Saharan Africa and South Asia, but it remains of minor importance at the global level. In fact, international trade in sheep meat has remained relatively static in recent decades, in contrast to the trade in pig and poultry meat, which has increased dramatically, as shown

in Table II. International trade in goat meat is even more limited than that of sheep meat, so much so that, historically, statistics on trade in goat meat were difficult to find; they were often either ignored or rolled into those reported for sheep meat.

In this light, it is worth noting that there has been an increase in goat meat imports to the United States recorded in recent years. Consumption of goat meat in the United States has traditionally been negligible and the country was a net exporter of goat meat up until 1990. However, a growing influx of Hispanic, African and Middle Eastern people in recent years has notably increased demand for goat meat and, in 2007, the United States imported 10,166 tonnes, representing an estimated 718,000 goat carcasses. The main exporters of goat meat to the United States are Australia and New Zealand, with more than 90% coming from Australia. Mexico also contributes a small proportion of the overall quantity (15). Australia is unique in having a large feral goat population that is exploited for goat meat production for export.

The largest international trade in small ruminants for meat involves the Islamic countries, especially those in the Middle East where arid conditions limit the potential for local livestock production. Notably, this trade is often in live animals for slaughter rather than in carcasses. Importation of live animals helps to ensure that the animals will be slaughtered after arrival according to the Islamic religious practice of halal. There is a significant annual rise of animal movements and trade throughout the Muslim world in the weeks preceding the religious holiday of Eid ul-Adha, which occurs at the end of Haj, the annual pilgrimage to Mecca. This is because the Islamic religious tradition calls for the slaughter of an unblemished ram in conjunction with this festival of Eid (which celebrates Muslim belief that Ibrahim accepted God's request to kill his son Ishmael and that God intervened at the moment of slaughter and provided a ram for sacrifice instead). This large-scale movement of small ruminants over a short

**Table II**  
**Changes in global trade in livestock products from 1980 to 2006**

Product	World exports (million tonnes)		Share of total production (%)	
	1980	2006	1980	2006
Total meat	9.6	32.1	7.0	11.7
Pig meat	2.6	10.4	4.9	9.8
Poultry meat	1.5	11.1	5.9	13.0
Bovine meat	4.3	9.2	9.1	14.2
Ovine meat	0.8	1.1	10.6	7.7
Other meat	0.4	0.3	—	—
Dairy	42.8	90.2	8.7	12.7
Eggs	0.8	1.5	3.1	2.2

Source: Food and Agriculture Organization (8)

period of time, and their subsequent halal slaughter, has been associated with several diseases, notably peste des petits ruminants (PPR) and two zoonotic diseases: Rift Valley fever (RVF) and Crimean Congo haemorrhagic fever (CCHF). For example, the movement of large numbers of sheep and goats from rural areas to the cities in the weeks preceding Eid, followed by the mass slaughter and butchering of these animals, has been associated with cases of CCHF in humans in Pakistan (11). Individuals involved in butchering are at high risk for the disease as it can be transmitted from viraemic animals via contact with their blood or by aerosol. The associations of PPR and RVF with movement of animals for Eid are discussed in more detail later in this paper.

### Trade in milk and dairy products

International trade in sheep and goat milk is negligible relative to trade in cow milk, but export of cheeses made from sheep or goat milk is significant for some countries, notably in Western Europe, although it remains a fraction of the trade in cow's milk cheeses. Many traditional cheese recipes call for the use of unpasteurised milk and the use of unpasteurised sheep or goat milk can be associated with the transmission of zoonotic diseases, most notably brucellosis (*B. melitensis*) and listeriosis (*L. monocytogenes*). Where unpasteurised or raw milk cheese is permitted in trade, it has to be aged for at least 60 days. A more complete list of diseases transmissible through unpasteurised milk of small ruminants is given in Table III.

**Table III**  
**Zoonotic diseases potentially transmitted through unpasteurised milk of sheep or goats**

Disease	Method of transmission	
	Aetiologic agent secreted in milk	Introduced by faecal contamination of milk
Brucellosis	✓	
Caseous lymphadenitis	✓	
Cryptococcosis	✓	
Leptospirosis	✓	
Listeriosis	✓	
Louping-ill	✓	
Melioidosis	✓	
Q fever	✓	
Staphylococcal food poisoning	✓	
Toxoplasmosis	✓	
Tuberculosis	✓	
Campylobacteriosis		✓
Cryptosporidiosis		✓
<i>Escherichia coli</i> infection		✓
Listeriosis		✓
Salmonellosis		✓
Yersiniosis		✓

Source: Smith and Sherman (12)

### Trade in sheep wool and goat fibres

There is a substantial global trade in sheep wool, with Australia, New Zealand, South Africa, Germany and the United Kingdom (UK) being major exporters and China, India and Italy being major importers. Although the volume of trade is considerably less than that of wool, fibres from goats, namely cashmere and mohair, are also traded in international markets. Demand for mohair has declined in recent years, while demand for cashmere has increased substantially. The major producers of mohair, from Angora goats, are Turkey, South Africa and the United States. The major producers of cashmere fibre, the downy, seasonal undercoat of cashmere goats, are China, Mongolia, Iran and Afghanistan. China retains much of its cashmere for its own textile industry and it imports from the other producing countries, although it also exports cashmere, mainly to Italy. The main pathogen associated with trade in wool and goat fibres is *Bacillus anthracis*. The pulmonary form of anthrax, known colloquially as 'woolsorters disease', occurs mainly in workers handling bales of raw fibre.

### Trade in skins

Skins are generally a byproduct of slaughter and there is substantial export of small ruminant skins from developing countries, particularly in Africa and South Asia, for the tanning and leather goods industry. There is one case where the skin is the primary product and not a byproduct: the production of karakul pelts taken from day-old lambs of the karakul breed of sheep. Afghanistan and neighbouring central Asian countries are the primary sources of karakul pelts, which are exported principally for the manufacture of hats, coats and other outerwear. Raw, unprocessed skins of any type are a potential source of foot and mouth disease (FMD) and must be salted for 28 days in sea salt containing 2% sodium carbonate before entering international trade channels. Goat skins are also used for making drum heads and while this represents a miniscule element in trade, goat skin drum heads imported or carried from Africa to the United States and Europe have been associated with occasional cases of inhalation anthrax in people playing or having contact with the drums.

### Trade in breeding stock, semen and embryos

Finally, there is a global trade in breeding stock, semen and embryos of small ruminants. There are comprehensive guidelines for the production of semen and embryos to minimise the risk of disease transmission in commerce and trade and these are described in the *Terrestrial Code* (19). Similarly, breeding animals for export must meet the requirements of the importing countries relative to diseases of concern. Nevertheless, there are notable historical incidents in which the movement of small ruminant

breeding stock has been associated with the spread of disease. For example, scrapie was introduced into Australia, New Zealand, India, South Africa, Kenya, Brazil, and Colombia as a result of sheep importations from the UK occurring between the 1930s and 1970s. Australia and New Zealand subsequently eliminated the disease in the 1950s and have remained free through surveillance and strict importation rules. South Africa's last reported case was in 1972.

In the 1970s, pure-bred dairy goats of the European breeds were exported from the United States and Europe to various locations and this resulted in the introduction of caprine arthritis encephalitis (CAE) virus infection into some importing countries, notably Kenya (1). Both CAE and scrapie are chronic diseases and the carrier states were difficult to detect using the diagnostic techniques available at the time. Paratuberculosis due to *Mycobacterium paratuberculosis* is another chronic disease of small ruminants with a long incubation period, during which reliable detection of infection is difficult. This disease also poses risks in the trade of breeding animals. Although a causal relationship has not been definitively established, there are proposed associations between paratuberculosis in ruminants and Crohn's disease in humans, adding a potential public health dimension to concerns about trade.

## Pathogens posing significant risks in trade of small ruminants and their products

### **Peste des petits ruminants**

Peste des petits ruminants is an acute, contagious and frequently fatal disease of goats and sheep caused by a morbillivirus closely related to the rinderpest virus. The disease is characterised by fever, ocular and nasal discharges, oral erosions, diarrhoea and pneumonia. It was first reported in Côte d'Ivoire in 1942, where it was described as a disease mimicking rinderpest in sheep and goats. Owing to serological cross-reactions with rinderpest virus the disease was not recognised as a distinct entity of separate aetiology for many years. By the late 1970s, however, various studies had established that PPR was a disease distinct from rinderpest and that the small ruminant disease syndromes of West Africa known as kata and stomatitis pneumoenteritis complex were in fact PPR.

From the 1970s, PPR moved further eastward and there were reports of the disease occurring in sub-Saharan Africa, the Middle East and South Asia. An epizootic of highly virulent PPR appears to have developed in South Asia in the early 1990s and to have spread widely between Bangladesh, Turkey and the Middle East. It is still gaining

ground, as evidenced by widespread infection occurring in the central Asian countries in recent years and an incursion into China reported to the OIE for the first time in July 2007. There are serious concerns that the disease will spread into Southeast Asia.

Owing to its clinical severity, high mortality and its expanding distribution, PPR has emerged as the major disease constraint on small ruminant production in much of Asia and Africa. Trade in small ruminants, both regulated and unregulated is contributing to the widening dissemination of the disease. For example, trade in sheep and goats was implicated in the spread of an epizootic of PPR in Bangladesh in 2001. The author was asked to investigate this epizootic in 2002 and learned that it had originated in western Bangladesh. The epizootic occurred in association with a large influx of goats and sheep into the country from neighbouring India in the period preceding the festival of Eid ul-Adha. The epizootic spread eastward as goats were moved to the capital city and environs to meet demand for animals for ritual slaughter during the Eid festival.

As the majority of goats and sheep in Africa and Asia are owned by relatively poor subsistence farmers and herders, the spread of PPR is having a marked negative impact on fragile livelihoods and also undermines organised efforts to reduce poverty. For example, village women who avail themselves of microcredit schemes to take out loans to purchase goats can be badly affected if their goats are sickened or killed by PPR. Unfortunately, many of the countries in the region threatened by PPR have limited financial and human resources to support their Veterinary Services and the risk of further dissemination of the disease remains high.

The potential exists for eradication of PPR. The disease is closely related to rinderpest and, like rinderpest, there is a highly effective vaccine available which is considered to impart lifelong immunity after one injection. The two diseases are also similar in that a carrier state does not develop, so vaccinated and recovered animals are not a source of infection. Vaccination was highly instrumental in the successful campaign to eradicate rinderpest and could be applied similarly, in integrated large-scale programmes, to control PPR. Rinderpest, however, is a disease primarily of cattle and the economic value of cattle and cattle products in trade dwarfs that of sheep and goats, so it is not clear whether the financial investment or political will for a global PPR eradication campaign would be forthcoming.

### **Foot and mouth disease**

Foot and mouth disease is a highly contagious viral disease of wild and domestic cloven-hoofed animals caused by a

single stranded RNA virus of the genus *Aphthovirus* in the family *Picornaviridae*. Although infection usually produces low mortality, it does produce high morbidity and FMD is a disease of extreme economic importance to animal industries worldwide because of the resulting lost productivity and constraints on trade in livestock and livestock products.

In sheep and goats, FMD most often assumes a subclinical form, although clinical cases can and do occur. The major concern with FMD in small ruminants is that subclinically infected sheep and goats may act as a source of infection for cattle in mixed livestock systems and through movement and international trade. The disease in small ruminants has been reviewed (10).

Foot and mouth disease is one of the most highly regulated livestock diseases in the world, with extensive international efforts undertaken to control the spread of the virus through restricted movement of both live animals and animal products. Currently, FMD is enzootic in large areas of Africa, Asia, the Middle East, eastern Europe and South America. Areas free of FMD include North America, Central America, and the Caribbean, as well as Australia, New Zealand, Japan, and many islands of the Pacific.

Foot and mouth disease continues to be a threat to livestock worldwide, largely because the highly contagious virus is readily transmitted under a wide variety of conditions that are difficult to detect; these include:

- the shedding of virus by infected animals before the onset of clinical signs or during convalescence
- the existence of subclinically infected, convalescent or even vaccinated animals that can act as carriers
- the presence of virus in improperly processed products containing meat, milk, bone, blood, offal, or skin of infected animals.

It is now accepted that subclinically infected goats and sheep can play an important role in transmission of the disease to cattle. Small ruminants were deemed responsible for epizootics of FMD in cattle in Tunisia in 1989, Greece in 1994, Southeast Asia in 1999 and Turkey in 2001 (10). In many parts of the world, sheep and goats are herded or managed together and traded in commerce together, so it is often difficult to ascribe a specific role for goats, as opposed to sheep, in transmission or spread of FMD. However, there are also some documented situations where goats have been specifically identified as the source of new infections. A goat clandestinely brought from Turkey was deemed responsible for a type O outbreak in cattle in Bulgaria in 1991. Goats were also implicated in an outbreak of FMD in Kuwait with type Asia 1 when infected goats with this strain were imported from Bangladesh (10). The index case for the FMD outbreak in the Netherlands in

2001 was a dairy goat/veal calf farm and the first clinical cases were seen in goats. It is believed that the infection was introduced with purchased, imported calves, but as the calves on the premises were housed individually and the goats commingled freely, circulation and expression of the virus occurred first in the goats (5).

The role of small ruminants with clinically inapparent infections was dramatically illustrated in the FMD outbreak in the UK in 2001. While the infection probably did not begin with the importation of an infected sheep, the infection first became established in sheep and, because the sheep did not show obvious clinical signs of disease, the animals from the index farm were widely sold throughout the country and spread the infection before the diagnosis was made. The widespread distribution of the infection by the time it was recognised made the control effort extremely difficult, prolonged and costly.

Given the importance of FMD control for international trade, the role of small ruminants needs greater attention. In many endemic countries where FMD is present and vaccination is practised, small ruminants are often not included in vaccination programmes for reasons of cost, and therefore remain a potential source of infection. At livestock markets, border crossings and quarantine stations, small ruminants require very careful and detailed physical examination by inspectors and veterinarians, as clinical signs of disease may be subtle if present at all. Often there is no oral involvement and lesions may be limited to the feet, with or without the presence of lameness.

### Rift Valley fever

This arthropod-borne viral disease of ruminants, camels and humans is caused by an enveloped, single-stranded RNA *Phlebovirus* in the *Bunyaviridae* family. Currently, RVF is limited to Africa and the Arabian peninsula. The disease is characterised by acute, severe hepatic necrosis with abortion in pregnant dams and high mortality in neonatal animals. In humans, the clinical disease can range from mild influenza-like signs to a severe, fatal haemorrhagic fever.

Rift Valley fever was first identified in Kenya's Rift Valley in 1930. The disease was historically limited to East and Central sub-Saharan Africa and was first recognised in southern Africa in the 1950s. However, later outbreaks in Egypt, Senegal and Mauritania indicated its potential for further spread. It is now known to occur throughout Africa, including the island of Madagascar. In 2000, the disease was confirmed for the first time outside of Africa, on the Arabian peninsula in Yemen and Saudi Arabia and affected large numbers of livestock and humans, with over 120 human deaths (3).

The importation of millions of sheep and goats into Mecca in the weeks prior to Eid ul-Adha and their subsequent halal slaughter have been associated with the occurrence of RVF in humans. An analysis of this risk and the associated epidemiological factors has been described (6). In brief, the principal source of small ruminants transported to Mecca for Eid is the Horn of Africa, where RVF is endemic and clinical manifestations in animals and humans are usually minimal. The disease is transmitted mainly by mosquito vectors, and infected vector populations increase periodically in association with heavy rainfalls, which may occur at intervals of years or even decades. It is now well established that these heavy rainfalls, in what is a region of low rainfall, are associated with the El Niño/Southern Oscillation phenomenon, which now appears to be occurring more frequently. Following these heavy rains and increased vector activity, epizootics of RVF occur, affecting mainly sheep and goats and people who come into close contact with them by handling their aborted fetuses and birth fluids, or by butchering infected animals.

The historical trade in small ruminants from the Horn of Africa to Mecca for the Eid festival is so well established and finely tuned that animals leaving Africa can reach Mecca in less than a week, a period short enough for RVF-infected animals to still be in the incubation or viraemic stages of the disease when they arrive. Halal slaughtering consists of a swift, deep incision with a sharp knife on the neck, cutting the jugular veins and carotid arteries of both sides but leaving the spinal cord intact. The aim of this method is for the animal to bleed out fully. As a result, people conducting or observing halal slaughter are at a high risk of exposure to blood or aerosols containing RVF virus. During epizootics in Africa, the infection rate of small ruminants exported to Mecca has been estimated to be between 1.5% and 3%, which means that there could be between 15,000 and 30,000 infected animals slaughtered during Eid. There is, therefore, great potential for Haj pilgrims participating in halal slaughter to be exposed to RVF virus. Davies (6) recommends that the movement of sheep and goats to Mecca for Eid should be strictly prohibited from any area in which epizootic RVF virus has occurred in the previous three to six months.

### **Transmissible spongiform encephalopathies**

Transmissible spongiform encephalopathies (TSEs) are a group of chronic transmissible diseases caused by abnormal proteins known as prions, which are unique as infectious agents because they do not contain genetic material. Scrapie is the TSE of small ruminants and occurs naturally only in sheep and goats. It produces a chronic degenerative neurological disease which manifests

clinically only after a prolonged incubation period of a few months to several years.

Most nations where small ruminants are raised have never reported scrapie to the OIE. However, it is unclear whether these countries are actually free from the disease or if it exists undetected or unreported due to the lack of active surveillance programmes and a lack of recognition by farmers of the clinical picture of scrapie. An informative overview of the epidemiology of scrapie, with an extensive bibliography, has been published by the OIE (7).

Scrapie is enzootic in the United States, Canada and many countries of Europe, including the UK and Iceland. It also has been reported in Australia, New Zealand, India, South Africa, Kenya, Brazil, and Colombia as a result of sheep importations from the UK from the 1930s through to the 1970s. As mentioned earlier, Australia and New Zealand successfully eradicated the disease in the 1950s and South Africa has not had a case since 1972.

In recent years, as a result of increased surveillance associated with bovine spongiform encephalopathy (BSE) in the European Union (EU), information on the occurrence of scrapie in goats has been improving. Between 2002 and 2005 inclusive, for all 25 EU Member States (membership rose to 27 in 2007), a total of 420,299 goats were tested for scrapie and 0.4% were positive. These goats included healthy animals at slaughter as well as animals dead on farm and suspect clinical cases. In comparison, 1,511,375 sheep were tested during this same period and 0.6% were positive. It is noteworthy that this large-scale data collection suggests that the prevalence of scrapie infection in the goat population is not that different from the prevalence in sheep. The conventional wisdom has long been that scrapie, at least clinical scrapie, occurs less frequently in goats than sheep. A different perspective may emerge as more active surveillance of sheep and goats expands and continues.

Susceptibility to disease as well as the duration of the incubation period are now known to be genetically controlled in sheep and goats, although less is currently known about the latter species. The genetics of scrapie in sheep and goats has recently been reviewed (4). At present, three specific ovine prion protein (PrP) polymorphisms in sheep are known to affect the development of the disease in exposed sheep. There are numerous additional polymorphisms in sheep that have been identified in recent years in the PrP gene, but their effects on the development of scrapie are not yet fully established.

Knowledge about the genetics of goats relative to scrapie lags behind that of sheep. This is due in part to the fact that, historically, naturally occurring scrapie has been less commonly observed in goats than in sheep and infected flocks have been less available for relevant genetic studies.

Nevertheless, a number of polymorphisms have been identified in scrapie-infected goats from flocks representing different breeds, although no definitive picture has yet emerged as to the relative significance of these various polymorphisms in relation to the susceptibility of goats to scrapie. Moreover, it is not known whether the importance of these polymorphisms extends beyond the specific breeds studied.

In recent years, it has become apparent that so-called atypical strains of scrapie exist which have different molecular characteristics and produce different histopathological lesion patterns from those produced by the scrapie prion which causes classical scrapie. The first of these atypical strains was reported from Norway in association with five clinical cases of atypical sheep scrapie with unusual clinical and pathological features, the first of which was seen in 1998. The strain has been designated as Nor98. A significant feature of Nor98 and of other atypical strains later identified in France was that they produced disease in sheep with genotypes ordinarily associated with resistance to scrapie (2). Fortunately, atypical scrapie does not appear to be transmissible and is considered to be a spontaneous degenerative condition of older sheep (19). Therefore, the existence of atypical scrapie should not affect scrapie control programmes based on selection of genotypes resistant to the disease.

A second TSE, BSE, was first recognised as a disease of cattle in the UK in 1986. Then, in 1996, it was reported that a new, fatal human TSE, called variant Creutzfeldt-Jakob disease (vCJD), appeared to be associated with the consumption of contaminated animal products derived from BSE-infected cattle. Thus, BSE became a zoonotic disease, a major public health concern, a catastrophe for cattle farmers and the focus of enormous international media attention.

The reason for including mention of BSE in this paper is that in 2005, a naturally occurring case of BSE was confirmed in France in a goat tested at slaughter in 2002 through the TSE surveillance programme of the European Commission (EC). As the occurrence of BSE in cattle and vCJD has been steadily decreasing in recent years, the significance of the discovery of BSE may be only a footnote in the BSE saga. Between the years 2001 and 2006 inclusive, despite 607,180 goats being tested as part of the TSE surveillance programme of the EC, only the goat from France was definitively identified with BSE.

## Conclusions

While the international trade in small ruminants and small ruminant products is small relative to the trade in bovine, swine and poultry products, it is still economically

important, particularly on a regional basis. For example, the trade in small ruminants from the Horn of Africa to Saudi Arabia for the religious festivals in Mecca is estimated to be between US\$0.6 billion and US\$0.9 billion per year (6). As most of these animals originate with herders and subsistence farmers who have few alternative sources of income, this trade is the basis for livelihoods in the region. Trade in specialty products, such as karakul pelts from Afghanistan, goat cheeses from France and cashmere from Mongolia, plays a similar role in supporting the livelihoods of small ruminant livestock producers in specific places around the world.

Regardless of the size of the trade in small ruminants, the activity merits consideration because sheep and goats may transmit zoonotic diseases such as RVE, CCHF, brucellosis and listeriosis. They also may transmit highly infectious diseases such as PPR to naïve populations of small ruminants in other countries, with dramatic consequences. Furthermore, they may serve as a source of FMD for cattle, which has enormous global trade implications.

One major challenge in controlling the spread of pathogens through trade in small ruminants is that a large portion of the world's sheep and goat population is found in developing countries. Many of these countries do not have the resources to maintain or support Veterinary Services that meet international standards in terms of diagnostic capacity, surveillance activities, livestock movement and border control, and timely management of disease outbreaks. Such countries suffer economically as they may be effectively shut out of international trade opportunities because they cannot reliably establish, maintain and demonstrate disease-free status. Inadequacies in the national Veterinary Services may also increase the risk that livestock owners in these countries may suffer hardships if, due to failings in these services, new diseases such as peste des petits ruminants, contagious caprine pleuropneumonia or sheep and goat pox are introduced into the country.

The OIE recognises the importance of capacity building for national Veterinary Services and in 2005 established the OIE Tool for the Evaluation of Performance of Veterinary Services (the PVS Tool) to help assess Veterinary Services in any Member Country requesting such an assessment (18). At the time of writing, 108 Members have requested PVS assessments, including 46 in Africa, 16 in Asia and 12 in the Middle East. Ninety-nine of the PVS missions have been completed. The initial PVS evaluation and follow-up PVS Gap Analysis provide governments with information on the status and performance of their Veterinary Services as well as guidance on how to improve those services. The PVS results also can serve as a tool for Veterinary Service administrators to approach ministers and legislators to draw attention to the importance of the national Veterinary Services to the country's health and economic well-being

and to lobby for additional resources to improve the quality of the Veterinary Services. More recently, the OIE has launched a companion programme to evaluate the veterinary legislation in Member Countries that have had a PVS assessment done. The legislative assessment is important because in many cases, the existing legislation is outdated or inadequate. It does not facilitate (and in some

cases does not allow) the reforms necessary for countries to take the action needed to meet the international animal health standards for participation in international trade of livestock and livestock products, including those of small ruminants. ■

## La dissémination d'agents pathogènes lors des échanges internationaux de petits ruminants et de leurs produits dérivés

D.M. Sherman

### Résumé

Les petits ruminants et leurs produits font l'objet d'échanges internationaux significatifs au plan économique, même si les volumes concernés sont moins importants que pour le commerce de bovins, de porcs, de volailles et de leurs produits. Outre la laine, ces échanges portent sur certains produits exclusifs (notamment le fromage de chèvre et de brebis, le cachemire et l'astrakan), tandis que dans certaines régions du monde, la viande de mouton et de chèvre participe à l'économie de subsistance. D'autre part, le commerce international de petits ruminants et de leurs produits suscite des considérations sanitaires car les ovins et les caprins sont des sources potentielles de zoonoses telles que la fièvre de la Vallée du Rift, la fièvre hémorragique de Crimée-Congo, la brucellose et la listériose. Ces espèces peuvent également transmettre des maladies très contagieuses aux populations naïves de ruminants des pays importateurs, dont la peste des petits ruminants. Les conséquences peuvent en être dévastatrices, notamment pour les populations les plus pauvres qui dépendent des petits ruminants pour leur subsistance. En outre, les ovins et les caprins constituent une source importante de transmission du virus de la fièvre aphteuse aux bovins. Compte tenu des conséquences considérables de ces risques pour les échanges mondiaux, il est important de prendre en compte les espèces de petits ruminants dans les programmes de lutte contre la fièvre aphteuse destinés à améliorer l'accès aux marchés internationaux.

### Mots-clés

Cachemire – Chèvre – Commerce international – Encéphalopathie spongiforme bovine – Fièvre aphteuse – Fièvre de la Vallée du Rift – Laine – Lait – Maladie – Ovin – Peaux – Peste des petits ruminants – Tremblante – Viande – Zoonose. ■

## Diseminación de patógenos por el comercio de pequeños rumiantes y sus derivados

D.M. Sherman

### Resumen

El comercio internacional de pequeños rumiantes y sus derivados, pese a sus reducidas dimensiones en comparación con el comercio de productos bovinos, porcinos y aviares, no deja de revestir importancia económica. Además de la lana, incluye una serie de productos singulares (como quesos de leche de cabra y oveja, fibra de cachemira o piel de astracán), sin olvidar que el comercio de carne ovina y caprina es importante para mantener los medios de subsistencia en varias regiones del mundo. Asimismo, conviene prestar atención al comercio de pequeños rumiantes y sus derivados porque las cabras y ovejas pueden transmitir enfermedades zoonóticas como la fiebre del Valle del Rift, la fiebre hemorrágica de Crimea-Congo, la brucelosis o la listeriosis. Además, pueden transmitir patologías extremadamente contagiosas, como la peste de pequeños rumiantes, a poblaciones de pequeños rumiantes de otros países no expuestas previamente al patógeno en cuestión, lo que puede tener efectos de suma gravedad, en especial para personas pobres cuya subsistencia depende muchas veces de pequeños rumiantes. Por otro lado, las cabras y ovejas pueden ser una importante fuente de transmisión de fiebre aftosa al ganado vacuno. Dadas las enormes repercusiones que ello tiene en el comercio mundial, es importante tener en cuenta a los ovinos y caprinos en los programas de lucha contra la fiebre aftosa destinados a mejorar el acceso al comercio.

### Palabras clave

Cachemira – Caprinos – Carne – Comercio internacional – Cueros – Encefalopatía espongiiforme bovina – Enfermedad – Fiebre aftosa – Fiebre del Valle del Rift – Lana – Leche – Ovinos – Peste de pequeños rumiantes – Prurigo lumbar – Zoonosis.



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