IMPORT RISK ANALYSIS

UNPROCESSED FIBRE OF SHEEP AND GOATS

November 1998

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Approved for general release

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1. EXECUTIVE SUMMARY

This document is a non-quantitative analysis of the biosecurity risks posed by the importation of unprocessed fibre of sheep and goats into New Zealand.

The current conditions applied by the Ministry of Agriculture and Forestry (MAF) for the importation of animal fibre into New Zealand result from a review carried out in 1991. Under the terms of the veterinary agreement between New Zealand and the European Union, New Zealand is obliged to re-assess the disease risks posed by trade in animal fibre. Rather than consider fibre from the EU in isolation, MAF has opted to carry out a generic risk analysis on fibre of sheep and goats regardless of country of origin. Three forms of that commodity are considered :

- greasy fibre for scouring and further processing
- fleeces for home spinning
- fibre for laboratory testing

The risks to animal and human health, including the risks of zoonotic diseases to persons handling imported fibre, are analysed. The risk of introduction of weed seeds in imported fibre is not considered in this risk analysis.

The diseases considered in this risk analysis are predominantly the diseases of sheep and goats which are listed in OIE Lists A and B. Exotic mites and ticks were also considered.

The hazard identification consists of a consideration of the epidemiology of each disease, particularly the survival of the agent in the environment and route of transmission. It concludes that 11 exotic diseases might conceivably be carried in fibre of sheep and goats (see Table 1). Diseases which are likely to survive on fibre for a less than a week were not considered to be potential hazards.

The risk assessment considers each disease which was identified as a potential hazard in imported fibre of sheep and goats. This is done in several steps :

- The release assessment examines the treatments involved in scouring and further processing of fibre, to assess which of the identified disease agents would be able to survive through processing. It is concluded that scouring could not be relied on to inactivate all diseases of potential concern, and that waste products from scouring might also contain disease agents.

- The exposure assessment considers possible routes by which disease agents in imported fibre might result in disease establishment in New Zealand livestock. It is concluded that the likelihood of imported fibre coming into contact with New Zealand livestock is extremely small.

- The consequence assessment considers the effects of the introduction and establishment in New Zealand for each disease.

- The risk estimation summarises the overall risk, and comes to a conclusion as to whether or not safeguards are warranted.

Risk management measures are recommended for the each of the three forms of the commodity under consideration.

Recommendations are made regarding standards for transitional facilities handling imported wool and goat fibre.

It is important to note at the outset that the scientific literature contains no examples of imported fibre having been shown to be responsible for the introduction of disease agents into animal populations.

However, of the 35 diseases considered in the hazard identification, 11 diseases are identified as being potentially able to be carried on fibre of sheep and goats for more than a week.

Of greatest significance are the two zoonoses : anthrax and Q fever. These have long histories of causing serious disease in wool handlers.

Safeguards are recommended for the following diseases :

Foot and mouth disease (FMD)
Sheep pox and goat pox
Anthrax
Q fever
Caprine and ovine brucellosis *(B. melitensis)*
Contagious agalactia
Contagious caprine pleuropneumonia
Enzootic abortion of ewes
Salmonellosis (*S. abortus ovis*)
Sheep scab (*Psoroptes ovis*)
Exotic ticks within the family Ixodidae

2. INTRODUCTION

2.1 Scope

2.1.1 Background

The fleece is recognised as an environment suitable for microorganisms to persist and to grow, particularly those organisms which cause staining and heating of wool[1,2]. Animal fibre is also a well-recognised vehicle for the transmission of zoonotic diseases to humans, especially anthrax[3].

The possibility that diseases may be transmitted to animals by exposure to contaminated animal fibre is an issue which has been considered seriously by some countries[4]. However, a search of the recent international literature did not reveal any instances where imported fibre has been suggested as the route for the introduction of disease agents into livestock populations[5].

An analysis of the disease risks associated with the importation of wool and mohair was carried out by the New Zealand Ministry of Agriculture and Fisheries in 1991[6]. The results of that review formed the basis of the import health standards which have since been in use by the Ministry of Agriculture and Forestry (MAF).

According to Annex V of the European Union-New Zealand veterinary agreement, trade in wool and hair of ruminants in the EU is covered by Council Directive 92/118/EC (The "Balai Directive"). The EU veterinary agreement states that until New Zealand is able to complete a further risk assessment on wool and hair from the EU, only scoured wool will be accepted by New Zealand. This risk analysis constitutes New Zealand's obligation in regard to annex V of the EU veterinary agreement, but rather than confining this analysis to wool and hair from the EU, the approach taken is to consider fibre of sheep in goats in a general sense, irrespective of the country of origin.

2.1.2 Commodities considered in the risk analysis

The commodity which is considered in this risk analysis is defined as fibre of sheep or goats.

This risk analysis considers three forms of this commodity :

- greasy fibre for scouring and further processing
- fleeces for home spinning
- fibre for laboratory testing

The risk analysis also considers wool packs in which the imported fibre travels to New Zealand, as these can be recycled for use in New Zealand.

The majority of fibre of sheep and goats that is imported into New Zealand is greasy wool and mohair for scouring and further processing. While the quantities of such material imported are not large in comparison to New Zealand's domestic production,

there are periodically significant importations, comprising ultra-fine merino wool from Australia, and, in times when exchange rates are favourable, of carpet wool from Britain, which is valued for its springiness.

Fleeces for home spinning are imported by individuals, usually as part of passenger luggage when returning from visits to various foreign countries. Fleeces arriving by parcel post are also not uncommon.

The wool testing laboratories in New Zealand are often involved in proficiency testing trials for the purpose of assessing the laboratory's performance when applying internationally agreed measurement standards. The wools come from South Africa, Australia, Argentina, Uruguay and the UK. The laboratories that are involved with the development of International Wool Textile Organisation (IWTO) standards and the issuing of IWTO certificates for the sale of wool, are required to show to third party accreditation authorities, acting on ISO Guide 25 and the New Zealand Code of Laboratory Management Practice, that the necessary criteria have been achieved. Results are often reported to the National Council of New Zealand Wool Interests and the IWTO but are also available for auditing to maintain accreditation. The standards are contained in the IWTO Red Book, copies of which are held by all testing laboratories involved with IWTO testing[(7)].

There are other situations where wool is imported for testing. New Zealand has a relatively large woolscouring machinery industry, and it is necessary, from time to time, to import greasy wool to see what its scouring characteristics are, so that scours can be properly designed. In addition, the Wool Research Organisation of New Zealand (WRONZ) carries out international consultancy work with various countries which can include wool scouring performance. For example, consultancies with Tibet, Turkey, and Saudi Arabia, may include scouring testing[(8)].

This risk analysis does not cover the following products:

- hair of horses, cattle and pigs
- fur of chinchillas or rabbits
- fibre of South American camellids

2.1.3 Diseases associated with the species under consideration

This risk analysis concentrates on risks to animal and human health, including the risks of zoonotic diseases to persons handling imported fibre. The risk of introduction of weed seeds in imported fibre is not considered in this risk analysis.

The approach of this assessment in determining which animal diseases are of potential concern in imported fibre is to consider in detail the epidemiology of each of the diseases of international animal trade significance which are known to affect sheep and goats. Particular attention is given to the routes of disease transmission and the survival of the agent outside the host.

The Office International des Epizooties (OIE) has two lists of diseases of importance in international trade in animals and their products[9].

List A : Those communicable diseases which have the potential for very serious and rapid spread, irrespective of national borders, which are of serious socio-economic or public health consequence and which are of major importance in the international trade of livestock and livestock products.

List B : Those communicable diseases which are considered to be of socio-economic and/or public health importance within countries and which are significant in the international trade of livestock and livestock products.

The approach used in this risk analysis is to consider the List A and B diseases affecting sheep and goats and, in addition, a number of specific insect pests which are not listed by the OIE.

The OIE-listed diseases which are known to affect sheep and goats are :

LIST A Diseases

A10. Foot and mouth disease (FMD)
A40. Rinderpest
A50. Peste des petits ruminants
A80. Rift Valley fever
A90. Bluetongue
A100. Sheep pox and goat pox

LIST B Multiple species diseases

B051. Anthrax
B052. Aujeszky's disease
B053. Echinococcosis/Hydatidosis
B055. Heartwater
B056. Leptospirosis
B057. Q fever
B058. Rabies
B059. Johne’s disease
B060. Screwworm *(Cochliomyia hominivorax)*

LIST B Cattle diseases

B103. Bovine brucellosis *(B. abortus)*
B105. Bovine tuberculosis
B107. Dermatophilosis
B108. Enzootic bovine leukosis
B111. Theileriosis
B113. Trypanosomosis

B114. Bovine malignant catarrh

LIST B Sheep and goat diseases

B151. *Brucella ovis* infection
B152. Caprine and ovine brucellosis *(B. melitensis)*
B153. Caprine arthritis/encephalitis
B154. Contagious agalactia
B155. Contagious caprine pleuropneumonia
B156. Enzootic abortion of ewes
B157. Pulmonary adenomatosis
B158. Nairobi sheep disease
B159. Salmonellosis (*S. abortus ovis*)
B160. Scrapie
B161. Maedi-visna

Unlisted diseases affecting sheep and goats

Ectoparasites which are exotic to New Zealand are of potential concern because of their known association with fibre of sheep and goats :

a) *Psoroptes ovis*, the mite that causes sheep scab

b) Exotic ticks within the family Ixodidae are of concern, particularly from the point of view of their role in the transmission of a number of viral and parasitic diseases. Ticks of the following genera are particularly significant:
Ixodes
Boophilus
Margaropus
Hyalomma
Rhipicephalus
Haemaphysalis
Dermacentor
Amblyomma
Rhipicentor
Aponomma

2.2 Risk analysis methodology

The approach followed in this risk analysis is based on the Covello-Merkhofer model[10] which has been adapted to animal health import risk analysis[11]. The steps in the risk analysis process are :

- hazard identification
- risk assessment
  - release assessment
  - exposure assessment
  - consequence assessment
  - risk estimation
- risk management

2.2.1 Hazard identification

Hazard identification involves identifying the risk-producing agents and the conditions under which they potentially produce consequences. This is a fundamental part of any risk analysis because if a hazard is not identified a risk assessment cannot be conducted and risk mitigation measures cannot be formulated.

This hazard identification examines the epidemiology of each disease in turn, to determine whether imported fibre could be considered a vehicle for the introduction of the agent into New Zealand. Where the hazard identification concludes that imported fibre is a potential hazard for a particular disease, that disease is considered further in the following risk assessment steps.

2.2.2 Risk assessment

The risk assessment comprises four distinct steps.

a) Release assessment

This is the process of describing the potential for a risk source, in this case unprocessed fibre of sheep and goats, to introduce disease agents into New Zealand's animal and human populations. Each of the three forms of imported fibre are considered, and in the case of fibre imported for scouring and processing, the effect of those processes on the survival of the agent is covered.

b) Exposure assessment

This step describes the possible exposures of susceptible hosts in New Zealand to the hazard released from the risk source. In the case of imported fibre of sheep and goats, the analysis considers the likelihood of effective contact between imported fibre and animals in New Zealand. That contact could occur

prior to, during, or after processing in New Zealand. The likelihood of effective contact is also considered for processing wastes.

c) Consequence assessment. This is the process of describing the economic and health consequence associated with the exposure to the risk agents. In this risk analysis, if it is concluded in the release assessment that a disease agent is a potential hazard in imported fibre, then the consequences of its introduction and establishment are assessed.

d) Risk estimation

This is the step which integrates the results from the release assessment, exposure assessment, and consequence assessment. This step is a summarisation of the preceding three steps and involves a decision as to whether safeguards are necessary for a particular disease.

2.2.3 Risk management

Risk management is the formulation of risk mitigation measures (safeguards) which are considered appropriate for the identified hazards.

Table 1. Potential hazards in imported fibre

OIE Code	Disease Name	Zoonosis ?	NZ Status	Fibre Contamination ?	Duration of Risk on Fibre	Identified as a Hazard on Fibre ?
A10	Foot and mouth disease		exotic	yes	3 weeks	yes
A40	Rinderpest		exotic	yes	< 1 week	
A50	Peste des petits ruminants		exotic	yes	< 1 week	
A80	Rift Valley fever		exotic	no		
A90	Bluetongue		exotic	no		
A100	Sheep pox and goat pox		exotic	possible	months - years	yes
B051	Anthrax	yes	exotic	yes	years	yes
B052	Aujeszky's disease		rare endemic	no		
B053	Echinococcosis / hydatidosis		rare endemic	no		
B055	Heartwater		exotic	no		
B056	Leptospirosis	yes	endemic	no		
B057	Q fever	yes	exotic	yes	9 months	yes
B058	Rabies	yes	exotic	no		
B059	Johne's disease		endemic	yes	months	
B060	Screwworm		exotic	no		
B103	*Brucella abortus*	yes	exotic	yes	1 week	
B105	Bovine tuberculosis	yes	endemic	no		
B107	Dermatophilosis		endemic	yes	long periods	
B108	Enzootic bovine leukosis		endemic	no		
B111	Theileriosis		exotic	no		
B113	Trypanosomosis		exotic	no		
B114	Bovine malignant catarrh		endemic	no		
B151	*Brucella ovis*		endemic	no		
B152	*Brucella melitensis*	yes	exotic	possible	3 months	yes
B153	Caprine arthritis/encephalitis		endemic	no		
B154	Contagious agalactia		exotic	possible	weeks	yes
B155	Contagious caprine pleuropneumonia		exotic	possible	weeks	yes
B156	Enzootic abortion of ewes		exotic	possible	weeks	yes
B157	Pulmonary adenomatosis		exotic	no		
B158	Nairobi sheep disease		exotic	no		
B159	*Salmonella abortus ovis*		exotic	possible	months - years	yes
B160	Scrapie		exotic	no		
B161	Maedi-visna		exotic	no		
unlisted	Sheep scab (*Psoroptes ovis*)		exotic	yes	weeks	yes
unlisted	Ixodid ticks		exotic	yes	months - years	yes

3. SUMMARY OF RECOMMENDED SAFEGUARDS

The following summary of recommended safeguards comprises the measures for the 11 diseases which are identified as being potentially able to be carried on fibre of sheep and goats for more than a week. The safeguards that are presented here are justified by the epidemiological and processing considerations in the respective section on the particular disease agent, which can be seen in section 6 of this document.

The safeguards recommended cover the following diseases :

Foot and mouth disease (FMD)
Sheep pox and goat pox
Anthrax
Q fever
Caprine and ovine brucellosis *(B. melitensis)*
Contagious agalactia
Contagious caprine pleuropneumonia
Enzootic abortion of ewes
Salmonellosis (*S. abortus ovis*)
Sheep scab
Exotic Ticks within the family Ixodidae

The recommended safeguards will be used in formulating import health standards for fibre from individual countries, depending on the disease status of the country concerned.

3.1 Foot and mouth disease

Fibre for scouring

For fibre imported from countries which are not free of FMD,

- Documentary proof must be produced that the fibre has been at least 4 weeks in transit to New Zealand; or
- The fibre must be stored in an approved transitional facility for 4 weeks after arrival in New Zealand prior to scouring; or
- The fibre must be moved to an approved transitional facility where the following treatment must be carried out :
    - Scouring at 60-70°C in full flow back mode with hot water rinses; and
    - After scouring, all fibre must either be dyed or further washed in water at a temperature of at least 65°C for at least 15 minutes; and
    - In the transitional facility, the following measures must be applied to scouring wastes:
        - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and
        - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

Wool packs

For wool packs imported from countries which are not free of FMD :

- Documentary proof must be produced that the packs have been at least 4 weeks in transit to New Zealand; or
- The packs must be stored in an approved transitional facility for 4 weeks after arrival in New Zealand prior to use; or
- The packs must be moved to an approved transitional facility where they must be washed in water at a temperature of at least 65°C for at least 15 minutes; or
- The packs must be destroyed by incineration.

Fleeces for home spinning

For all fleeces imported for home spinning,

- Documentary proof must be produced that the fleeces have been at least 4 weeks in transit to New Zealand; or
- The fleeces must be stored in an approved transitional facility for 4 weeks after arrival in New Zealand prior to use; or
- The fleeces must be unpacked under official supervision and washed in water at a temperature of at least 65°C for at least 15 minutes.

Fibre for testing

For fibre imported from countries which are not free of FMD,

- Documentary proof must be produced that the fibre has been at least 4 weeks in transit to New Zealand; or
- The fibre must be stored in a transitional facility for 4 weeks after arrival in New Zealand prior to testing; or
- The fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must be destroyed by incineration or treated as follows :
    - Scouring at 60-70°C in full flow back mode with hot water rinses; and
    - After scouring, all fibre must either be dyed or further washed in water at a temperature of at least 65°C for at least 15 minutes; and
    - In the transitional facility, the following measures must be applied to scouring wastes:
        - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and
        - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

3.2 Sheep pox and goat pox

Fibre for scouring

Fibre imported for scouring from countries which are not free of sheep and goat pox, and for which there is no international sanitary certificate attesting that the fibre comes from animals which have not been kept in a sheep pox and/or goat pox infected zone, must be moved to an approved transitional facility where it must be treated as follows:

- Scouring at 60-70°C in full flow back mode with hot water rinses; and
- After scouring, all fibre must be either dyed or washed in water at a temperature of not less than 60°C for at least 60 minutes in the presence of a non-ionic detergent at a concentration of not less than 1 g per litre.
- In the transitional facility, the following measures must be applied to scouring wastes:
    - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and
    - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

Wool packs

Wool packs which are imported from countries which are not free of sheep and goat pox or which have been used to transport fibre from countries which are not free of sheep and goat pox must be :

- moved to an approved transitional facility where they must be washed in water at a temperature of not less than 60°C for at least 60 minutes in the presence of a non-ionic detergent at a concentration of not less than 1 g per litre; or
- destroyed by incineration.

Fleeces for home spinning

Fleeces imported from countries which are not free of sheep and goat pox, and for which there is no international sanitary certificate attesting that the fleece comes from animals which have not been kept in a sheep pox and/or goat pox infected zone, the fleeces must be :

- completely unpacked under official supervision and washed in water at a temperature of not less than 60°C for at least 60 minutes in the presence of a non-ionic detergent at a concentration of not less than 1 g per litre.

Fibre for testing

Fibre imported for testing from countries which are not free of sheep and goat pox, and for which there is no international sanitary certificate attesting that the fibre comes from animals which have not been kept in a sheep pox and/or goat pox infected zone, must be moved to an approved transitional facility where, after completion of testing, it must be destroyed by incineration or treated by one of the following methods :

- washing in water at a temperature of not less than 60°C for at least 60 minutes in the presence of a non-ionic detergent at a concentration of not less than 1 g per litre; or
- Scouring
    - Scour must be operated at 60-70°C in full flow back mode with hot water rinses; and
    - after scouring, all fibre must be either dyed or washed in water at a temperature of not less than 60°C for at least 60 minutes in the presence of a non-ionic detergent at a concentration of not less than 1 g per litre; and
    - In the transitional facility, the following measures must be applied to scouring wastes:
        - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and
        - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

3.3 Anthrax

Fibre for scouring

For fibre imported from countries or zones which are considered by MAF to pose a significant anthrax risk, the fibre must be moved to an approved transitional facility, where it must be treated as follows :

- Scouring at 60-70°C in full flow back mode with hot water rinses; and
- After scouring, all fibre must be either be dyed or must be treated by one of the following methods:

  (i) exposure to dry heat at 140°C for 3 hours; or

  (ii) immersion in water heated and maintained at a temperature of 95°C for 25 minutes or at a temperature of 100°C for 15 minutes; or

  (iii) autoclaving at 120°C for 10 minutes;

  and :

- In the transitional facility, the following measures must be applied to scouring wastes:
  - Machinery used for opening and dusting must be equipped with adequate dust control protection to prevent aerosols of anthrax spores; and
  - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and
  - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

Wool packs

Wool packs from countries which are considered by MAF to pose a significant anthrax risk must be moved to an approved transitional facility they must be treated by one of the following methods:

- exposure to dry heat at 140°C for 3 hours; or
- immersion in water heated and maintained at a temperature of 95°C for 25 minutes or at a temperature of 100°C for 15 minutes; or

- autoclaving at 120°C for 10 minutes.

Fleeces for home spinning

For fleeces imported for home spinning from countries or zones which are considered by MAF to pose a significant anthrax risk, fleeces must be completely unpacked under official supervision and treated by one of the following methods:

(i) fumigation with 10% formaldehyde vapour (under vacuum, to ensure penetration into the fleece). [Note that this is available only at Auckland]; or

(ii) exposure to dry heat at 140°C for 3 hours; or

(iii) immersion in water heated and maintained at a temperature of 95°C for 25 minutes or at a temperature of 100°C for 15 minutes; or

(iv) autoclaving at 120°C for 10 minutes.

Fibre for testing

For fibre imported from countries or zones which are considered by MAF to pose a significant anthrax risk,

- Fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must either be destroyed by incineration or be treated by scouring as follows :

  - The scour must be operated at 60-70°C in full flow back mode with hot water rinses; and

  - After scouring, all fibre must be either be dyed or must be treated by one of the following methods:

    (i) exposure to dry heat at 140°C for 3 hours; or

    (ii) immersion in water heated and maintained at a temperature of 95°C for 25 minutes or at a temperature of 100°C for 15 minutes; or

    (iii) autoclaving at 120°C for 10 minutes;

    and :

  - In the transitional facility, the following measures must be applied to scouring wastes:

- Machinery used for opening and dusting must be equipped with adequate dust control protection to prevent aerosols of anthrax spores; and

- Liquid effluent from the scour must be passed through an evaporation/combustion unit; and

- Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

3.4 Q fever

Fibre for scouring

For fibre imported from countries which are not free of Q fever, the fibre must be moved to an approved transitional facility for processing, where it must be treated as follows:

- Scouring at 60-70°C in full flow back mode with hot water rinses; and
- After scouring, all fibre must either be dyed or be further washed in water for at least 1 minute at a temperature of not less than 75°C; and
- In the transitional facility, the following measures must be applied to scouring wastes:
    - Machinery used for opening and dusting must be equipped with adequate dust control protection to prevent aerosols of the Q fever agent; and
    - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and
    - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

Wool packs

Wool packs from countries which are not free of Q fever must be moved to an approved transitional facility where they must be treated as follows :

- immersion in water heated and maintained at a temperature 75°C for at least one minute.

Fleeces for home spinning

Fleeces must be completely unpacked under official supervision and treated as follows:

- immersion in water heated and maintained at a temperature 75°C for at least one minute.

Fibre for testing

For fibre imported from countries which are not free of Q fever,

- Fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must be destroyed by incineration or treated as follows :

- immersion in water heated and maintained at a temperature 75°C for at least one minute; or

- Scouring

    - Scour must be operated at 60-70°C in full flow back mode with hot water rinses; and

    - After scouring, all fibre must either be dyed or be further washed in water for at least 1 minute at a temperature of not less than 75°C; and

    - In the transitional facility, the following measures must be applied to scouring wastes:

        - Machinery used for opening and dusting must be equipped with adequate dust control protection to prevent aerosols of the Q fever agent; and

        - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and

        - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

3.5 Caprine and ovine brucellosis *(B. melitensis)*

Fibre for scouring

For fibre imported from countries which are not free of *B. melitensis*, the fibre must be moved to an approved transitional facility for processing, where it must be treated as follows :

- scouring at 60-70°C in partial or full flow back mode.
- In the transitional facility, the following measures must be applied to scouring wastes:
    - Machinery used for opening and dusting must be equipped with adequate dust control protection to prevent aerosols of *B. melitensis*.

Wool packs

Wool packs from countries which are not free of *B. melitensis* must be moved to an approved transitional facility where they must be treated as follows :

- immersion in water heated and maintained at a temperature of at least 65°C for at least 5 minutes.

Fleeces for home spinning

Fleeces must be completely unpacked under official supervision and treated as follows:

- immersion in water heated and maintained at a temperature of at least 65°C for at least 5 minutes.

Fibre for testing

For fibre imported from countries which are not free of *B. melitensis*,

- Fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must be destroyed by incineration or treated as follows :
    - Immersion in water heated and maintained at a temperature of at least 65°C for at least 5 minutes; or
    - Scouring at 60-70°C in full or partial flow back mode.

3.6 Contagious agalactia

Fibre for scouring

For fibre imported from countries which are not free of *Mycoplasma agalactiae*, *M. capricolum* subsp. *capricolum*, *M. mycoides* subsp. *mycoides LC*, and *M. putrefacens*,

- Documentary proof must be produced that the fibre has been at least 2 weeks in transit to New Zealand; or
- The fibre must be stored in a transitional facility for 2 weeks after arrival in New Zealand prior to scouring; or
- The fibre must be moved to an approved transitional facility for processing, where it must be treated by scouring at 60-70°C in partial or full flow back mode.

Wool packs

For wool packs from countries which are not free of *Mycoplasma agalactiae*, *M. capricolum* subsp. *capricolum*, *M. mycoides* subsp. *mycoides LC*, and *M. putrefacens*,

- Documentary proof must be produced that the packs have been at least 2 weeks in transit to New Zealand; or
- The packs must be stored in a transitional facility for 2 weeks after arrival in New Zealand prior to use; or
- The wool packs must be moved to an approved transitional facility where they must be treated by immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes.

Fleeces for home spinning

- Documentary proof must be produced that the fleeces have been at least 2 weeks in transit to New Zealand; or
- The fleeces must be stored in a transitional facility for 2 weeks after arrival in New Zealand prior to use; or
- The fleeces must be completely unpacked under official supervision and treated by immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes.

Fibre for testing

For fibre imported from countries which are not free of *Mycoplasma agalactiae*, *M. capricolum* subsp. *capricolum*, *M. mycoides* subsp. *mycoides LC*, and *M. putrefacens*,

- Documentary proof must be produced that the fibre has been at least 2 weeks in transit to New Zealand; or

- The fibre must be stored in a transitional facility for 2 weeks after arrival in New Zealand prior to testing; or

- The fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must be destroyed by incineration or treated as follows :

    - Immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes; or

    - Scouring at 60-70°C in full or partial flow back mode.

3.7 Contagious caprine pleuropneumonia

Fibre for scouring

For fibre imported from countries which are not free of CCPP,

- Documentary proof must be produced that the fibre has been at least 2 weeks in transit to New Zealand; or
- The fibre must be stored in a transitional facility for 2 weeks after arrival in New Zealand prior to scouring; or
- The fibre must be moved to an approved transitional facility for processing, where it must be treated by scouring at 60-70°C in partial or full flow back mode.

Wool packs

For wool packs from countries which are not free of CCPP,

- Documentary proof must be produced that the packs have been at least 2 weeks in transit to New Zealand; or
- The packs must be stored in a transitional facility for 2 weeks after arrival in New Zealand prior to use; or
- The packs must be moved to an approved transitional facility where they must be treated by immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes.

Fleeces for home spinning

- Documentary proof must be produced that the fleeces have been at least 2 weeks in transit to New Zealand; or
- The fleeces must be stored in a transitional facility for 2 weeks after arrival in New Zealand prior to use; or
- The fleeces must be completely unpacked under official supervision and treated by immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes.

Fibre for testing

For fibre imported from countries which are not free of CCPP,

- Documentary proof must be produced that the fibre has been at least 2 weeks in transit to New Zealand; or

- The fibre must be stored in a transitional facility for 2 weeks after arrival in New Zealand prior to testing; or

- The fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must be destroyed by incineration or treated as follows :

    - Immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes; or

    - Scouring at 60-70°C in full or partial flow back mode.

3.8 Enzootic abortion of ewes

Fibre for scouring

For fibre imported from countries which are not free of ovine chlamydial abortion,

- Documentary proof must be produced that the fibre has been at least 4 weeks in transit to New Zealand; or
- The fibre must be stored in a transitional facility for 4 weeks after arrival in New Zealand prior to scouring; or
- The fibre must be moved to an approved transitional facility for processing, where it must be treated by scouring at 60-70°C in partial or full flow back mode.

Wool packs

For wool packs from countries which are not free of ovine chlamydial abortion,

- Documentary proof must be produced that the packs have been at least 4 weeks in transit to New Zealand prior to use; or
- The packs must be stored in a transitional facility for 4 weeks after arrival in New Zealand; or
- The packs must be moved to an approved transitional facility where they must be treated by immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes.

Fleeces for home spinning

- Documentary proof must be produced that the fleeces have been at least 4 weeks in transit to New Zealand; or
- The fleeces must be stored in a transitional facility for 4 weeks after arrival in New Zealand prior to use; or
- The fleeces must be completely unpacked under official supervision and treated by immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes.

Fibre for testing

Fibre imported for testing from countries which are not free of ovine chlamydial abortion,

- Documentary proof must be produced that the fibre has been at least 4 weeks in transit to New Zealand; or

- The fibre must be stored in a transitional facility for 4 weeks after arrival in New Zealand prior to use; or

- The fibre must be moved to an approved transitional facility for testing, and after completion of testing, it must be destroyed by incineration or treated by one of the following methods:

    - immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes; or

    - scouring at 60-70°C in full or partial flow back mode.

3.9 Salmonellosis (*S. abortus ovis*)

Fibre for scouring

For fibre imported from countries which are not free of *Salmonella abortus ovis*, the fibre must be moved to an approved transitional facility where it must be treated as follows:

- Scouring at 60-70°C in full flow back mode with hot water rinses; and
- After scouring, all fibre must be dyed or further washed in water at a temperature of not less than 60°C for at least 30 minutes.
- In the transitional facility, the following measures must be applied to scouring wastes:
    - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and
    - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

Wool packs

Wool packs imported from countries which are not free of *Salmonella abortus ovis* must be :

- moved to an approved transitional facility where they must be washed in water at a temperature of not less than 60°C for at least 30 minutes; or
- destroyed by incineration.

Fleeces for home spinning

Fleeces must be completely unpacked under official supervision and treated as follows:

- washing in water at a temperature of not less than 60°C for at least 30 minutes.

Fibre for testing

For fibre imported from countries which are not free of *Salmonella abortus ovis* :

- Fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must be destroyed by incineration or treated by one of the following methods:

- washing in water at a temperature of not less than 65°C for at least 60 minutes; or
- Scouring
    - Scour must be operated at 60-70°C in full flow back mode with hot water rinses; and
    - After scouring, all fibre must be dyed or further washed in water at a temperature of not less than 65°C for at least 60 minutes; and
    - the following measures must be applied to scouring wastes:
        - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and
        - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

3.10 Sheep scab

Fibre for scouring

For fibre imported from countries which are not free of *P. ovis*,

- Documentary proof must be produced that the fibre has been at least 3 weeks in transit to New Zealand; or
- The fibre must be stored in an approved transitional facility for 3 weeks after arrival in New Zealand prior to scouring; or
- The fibre must be moved to an approved transitional facility where the it is treated as follows :
    - Scouring at 60-70°C either in partial flow back mode or in full flow back mode; and
    - In the transitional facility, the following measures must be applied to scouring wastes:
        - Solid and semi-solid scouring wastes must be disposed of by incineration.

Wool packs

For wool packs imported from countries which are not free of *P. ovis*,

- Documentary proof must be produced that the packs have been at least 3 weeks in transit to New Zealand; or
- The packs must be stored in an approved transitional facility for 3 weeks after arrival in New Zealand prior to use; or
- The packs are to be destroyed by incineration; or
- The packs must be moved to an approved transitional facility where they must be treated by one of the following methods :
    - washing in water at a temperature of at least 65°C for at least 5 minutes in the presence of a non-ionic detergent at a concentration of at least 1 g per litre; or
    - fumigation with methyl bromide.

Fleeces for home spinning

- Documentary proof must be produced that the fleeces have been at least 3 weeks in transit to New Zealand; or

- The fleeces must be stored in an approved transitional facility for 3 weeks after arrival in New Zealand prior to use; or

- The fleeces must be unpacked under official supervision and treated by one of the following methods :

    - washing in water at a temperature of at least 65°C for at least 5 minutes in the presence of a non-ionic detergent at a concentration of at least 1 g per litre; or

    - fumigation with methyl bromide.

Fibre for testing

For fibre imported from countries which are not free of *P. ovis*,

- Documentary proof must be produced that the fibre has been at least 3 weeks in transit to New Zealand; or

- The fibre must be stored in a transitional facility for 3 weeks after arrival in New Zealand prior to testing; or

- The fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must be destroyed by incineration or treated as follows :

    - washing in water at a temperature of at least 65°C for at least 5 minutes in the presence of a non-ionic detergent at a concentration of at least 1 g per litre; or

    - Scouring

        - Scour must be operated at 60-70°C in partial flowback mode or full flow back mode with hot water rinses; and

        - Solid and semi-solid scouring wastes must be disposed of by incineration.

3.11 Exotic Ticks within the family Ixodidae

Fibre for scouring

For fibre imported from countries which are not free of ticks of the genera *Ixodes, Boophilus, Hyalomma, Rhipicephalus, Haemaphysalis, Dermacentor, and Amblyomma*,

- Fibre must be moved to an approved transitional facility where the following treatment must be carried out :
    - Scouring at 60-70°C either in partial flow back mode or in full flow back mode; and
    - Solid and semi-solid scouring wastes must be disposed of by incineration.

Wool packs

For wool packs imported from countries which are not free of ticks of the genera *Ixodes, Boophilus, Hyalomma, Rhipicephalus, Haemaphysalis, Dermacentor, and Amblyomma*,

- Packs must be moved to an approved transitional facility where they must be treated by one of the following methods :
    - washing in water at a temperature of at least 65°C for at least 5 minutes in the presence of a non-ionic detergent at a concentration of at least 1 g per litre; or
    - fumigated with methyl bromide; or
- Packs are to be destroyed by incineration.

Fleeces for home spinning

- Fleeces must be unpacked under official supervision and treated as follows:

    either :

    - washed in water at a temperature of at least 65°C for at least 5 minutes in the presence of a non-ionic detergent at a concentration of at least 1 g per litre; or
    - fumigated with methyl bromide.

Fibre for testing

For fibre imported from countries which are not free of ticks of the genera *Ixodes, Boophilus, Hyalomma, Rhipicephalus, Haemaphysalis, Dermacentor, and Amblyomma*,

- Fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must be destroyed by incineration or treated as follows :
    - fumigation with methyl bromide; or
    - washing in water at a temperature of at least 65°C for at least 5 minutes in the presence of a non-ionic detergent at a concentration of at least 1 g per litre; or
    - Scouring
        - Scour must be operated at 60-70°C in partial flowback mode or full flow back mode; and
        - Solid and semi-solid scouring wastes must be disposed of by incineration.

4. PROCESSING OF FIBRE

4.1 Fibre for home spinning

Fibre for home spinning is normally imported directly by individuals in New Zealand, and is not subjected to any routine processing.

4.2 Fibre for laboratory testing

Fibre for laboratory testing is normally imported directly by individual laboratories in New Zealand, and is not subjected to any routine processing prior to testing.

4.3 Fibre for scouring and further processing

Greasy wool and fibre is imported in bales of various sizes. The fibre remains in the original bales until it is opened for the first stage of processing i.e. in a wool scouring plant. Following scouring, wool may be baled and exported or it may be further processed, typically by dyeing, prior to spinning into yarn.

4.3.1 Opening and dusting

Opening, dusting and blending can be carried out on greasy wool before scouring and on scoured wool prior to packaging or further processing. In some wool processing plants greasy wool is sorted manually to remove stained and cotted wool, dags and other waste before it enters the scour train.

Opening and dusting of greasy fibre may be necessary for the following reasons :

- the fibre is cotted or matted to varying degrees
- the fibre is contaminated with dust, dirt, faecal or vegetable matter, or depilatory paint
- there may be a need to blend the fibre before it enters the scour.

Various degrees of opening are required in these cases, and a range of machinery has evolved to meet these needs[12]. Most wool handling systems in New Zealand include a dust removal stage, and the more advanced systems have up to three “cuts” where dust and other waste is removed prior to the fibre entering the scour[13].

Wastes from opening and dusting comprise broken fibres, dirt, dust, and plant material. This can be disposed of in various ways, but normally it would be sent to a landfill. Trials on the use of such material as a component in compost are underway at WRONZ.

4.3.2 Wool scouring

4.3.2.1 Scouring processes

The objective of the wool scouring process is to remove unwanted dirt and grease, and to develop the desirable properties of wool while leaving sufficient wax in the wool to facilitate the processes which follow. While the great majority of processors worldwide use an aqueous scouring system, a few use processes based on the use of solvents (usually hexane and isopropanol). Solvent scouring systems have not found widespread acceptance, largely due to cost. Emulsion (aqueous) scouring is the only process used in New Zealand[13].

4.3.2.2 Aqueous scouring

Aqueous scouring consists of a series of washes in water and detergent. The so-called "alkaline" scouring systems of years past have virtually disappeared, although some soda may be added to the scour when wools of low pH (e.g. Merino) are being processed.

As shown in Figure 1, in most modern scouring plants the scour train consists of 6 scouring bowls (range 5-8) through which the wool is passed, being squeezed through rollers between bowls to remove excess liquid.

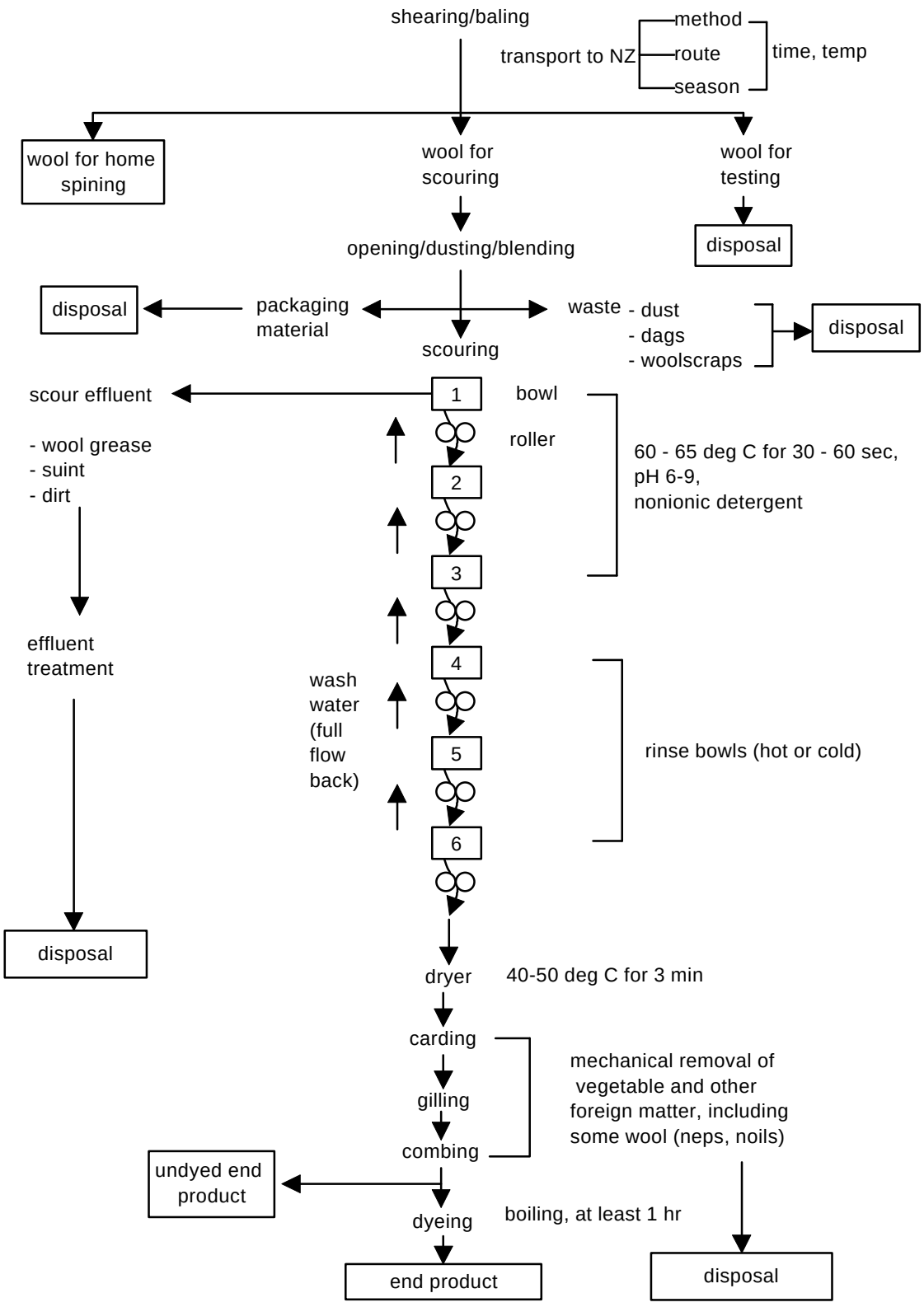
In New Zealand temperatures of 60-65°C are normal for the scouring liquor , and the wool spends 30-60 seconds in each bowl. The first three bowls usually contain a non-ionic detergent to a final concentration of 1-5 g/litre, and the system is run in a near neutral pH range (pH 6-9).

The last three bowls are rinse bowls, which in New Zealand usually comprise two cold rinses followed by a final hot rinse just prior to entering the dryer. In that case, the scour usually operates in partial flowback mode i.e. the hot water from bowl 6 flows back to bowl 3, bowl 3 into bowl 2, and bowl 2 into bowl 1. Thus the wool would be exposed to water at 60-65°C for on average 45 seconds for each of 4 bowls, or on average a total time of 3 minutes.

Some wool scours operate in full flowback mode. In this mode, all scouring bowls use hot water, with bowl 6 flowing back into bowl 5, bowl 5 into 4 etc. Therefore all the water in the scour ultimately passes through bowl 1. Because the rinses are hot (usually 60-65°C, but often not hotter than 30-40°C), they are more effective than when cold, so less water is used. Assuming all rinse bowls are using water at 60-65°C, the wool would be exposed to 60-65°C for on average 45 seconds per bowl for 6 bowls or 4.5 minutes.

After leaving the scour train the wool passes to a drier which reduces moisture content to around 16% by drying at 40-50°C for about 3 minutes. Because of evaporation of water, the wool does not reach the temperature of the heated air[13]. Dried wool is moved to a bailer, or to the processing line in the same plant.

Figure 1. Processing of fibre



4.3.2.3 Scour effluent

The wastes from greasy wool have long been regarded as important pollutants, and the treatment methods have evolved to deal with pollution rather than biosecurity risks.

The major scouring wastes are woolgrease, suint[a] and dirt.

Wool scoured in New Zealand usually contains 0.3-0.5% woolgrease and 0.2-1.5% dirt. Many imported wools are low yielding (very dirty) and scour liquor would be expected to have relatively high concentrations of residual dirt after scouring such wool.

Methods available for treatment of scouring wastes have been categorised as follows[(12)]:

a) primary treatments : reduction in pollutants of around 50%
b) secondary treatments : reduction in pollutants of at least 65-75%
c) tertiary treatments : reduction to 20/30[b] standards
d) complete treatments

Primary treatments include the removal of dirt in a settling tank, removal of grease by centrifuging, and fibre removal by passing effluent through screens. Secondary treatments include chemical and biological processes, ultra filtration and evaporation with or without further centrifugation. The aim of these is to further reduce dirt and grease, and to produce a suint solution for further treatment. Tertiary treatments include biological processes, incineration and solvent extraction of sludge. The most common complete treatment is evaporation and incineration[(12)].

In October 1997 there were 15 woolscours operating in New Zealand, using a variety of routes of disposal of effluent material[(13)]. Included in these were pasture irrigation and discharge to sea outfalls and sewage treatment plants. Anaerobic digestion methods and evaporation/incineration processes were also used.

Figure 2 shows a system of effluent handling involving a settling tank, a centrifuge, and an evaporation/incineration unit. Approximately 50% of dirt is removed from the effluent in the settling tank, resulting in spadeable sludge for disposal[(12)].

The supernatant from the settling tank is passed through a centrifuge for recovery of woolgrease. Centrifuging causes fractionation of the woolgrease, with the relatively unoxidised fraction of the woolgrease being retained while the more polar, oxidised and very well emulsified material remains in the wash water.

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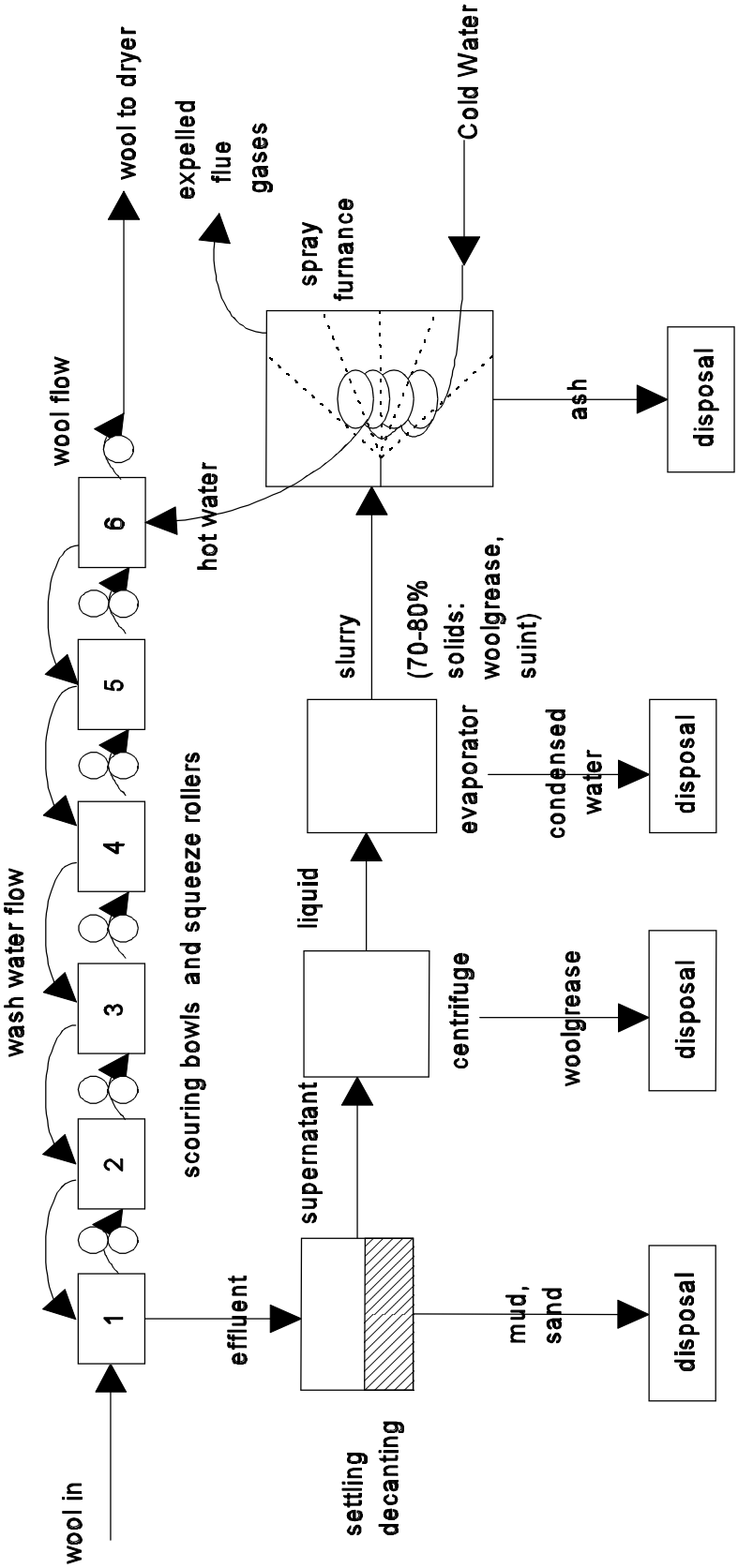
[a] Suint, the water soluble fraction of the fleece, is composed largely of potassium carbonate/bicarbonate, and potassium salts of organic acids and is an important potential source of watercourse pollution.

[b] 20/30 standards require that the biological oxygen demand of the discharge not to exceed 20 mg per litre, and suspended solids not to exceed 30 mg per litre.

Figure 2. Aqueous scouring process and effluent treatment

Full Flowback with Evaporation/Incineration



Woolgrease recovery rates of above 50% are possible by ensuring adequate centrifuge capacity and operation at a temperature of 90-95°C. Many centrifuges operate at about 80°C, and the effluent would remain inside for less than 5 seconds[8].

The recovered woolgrease from New Zealand wool is very green by world standards, due to the diet of sheep in this country, and for that reason it is exported to Europe for industrial use, and lanolin for use in cosmetic production in New Zealand is imported in a purified form.

After centrifuging, the wash water is passed to an evaporator unit, which removes water by evaporation and condensation. The operating temperature of the evaporator is 147°C, and the wash water spends at least 30 seconds in the unit, but possibly much longer, depending on burner demand. The evaporated and condensed water is disposed of, leaving a slurry composed of about 70 - 80% total solids which contains on average 20 - 30% woolgrease. The remaining solids are mostly suint, which is also combustible[8].

The combustible slurry is burnt in a spray furnace and the resulting energy is used to heat water for use in the scour. Gases from the combustion process are passed out of the flue, and ash is recovered for disposal.

4.3.3 Manufacture of woollen and worsted yarns

4.3.3.1 Mechanical processes

The machinery and the methods employed in yarn manufacture vary with the type of raw wool used and the type of finished article to be made. The production of woollen yarn mainly uses fine short wools and longer coarse wools, whereas manufacture of worsted yarn requires long fine fibres. Wool leaving the drier after scouring may contain significant amounts of vegetable matter and other foreign material, which needs to be removed as thoroughly as possible[12].

The worsted carding machine is intended to remove as much burr and seed as possible and lays the fibres parallel to each other before passing the carding sliver to the gill box, and then to the combing process.

Combing removes short fibres, neps[c] and residual foreign matter, producing long parallel fibres which are wound into tops[d]. At this stage the fibre is virtually free of visible foreign matter[13].

Carding machines sometimes, but not invariably, incorporate a crushing roller working at high pressure to pulverise seeds and other vegetable matter, which is then removed.

Neither combing nor gilling are part of the processes of woollen yarn manufacture.

4.3.3.2 Carding waste disposal

Waste from carding machines of both 'woollen' and 'worsted' types consists of dirt, dust, neps, noils[e] and plant material, including seeds.

4.3.3.3 Dyeing and finishing

Dyeing can be done either prior to carding, gilling and combing (loose stack dyeing) or after spinning into yarn. In New Zealand, approximately 70% of wool is dyed as loose stock, and 30% as yarn. Wool is dyed by boiling for at least one hour. The pH of the dye is generally in the range 4.5 - 5.5, and is set with acetic, formic, or sulphuric acid. The production of hydrogen sulphide and ammonia during the dyeing process indicates a reduction process[13].

Finishing is carried out on dyed wool. Finishing encompasses any wet process other than dyeing: bleaching, yarn-setting, shrink-resistance, insect resistance (moth proofing), and flame-proofing. Bleaching involves treatment with hydrogen peroxide at elevated temperatures. Setting (twist stabilisation) treatment with sodium metabisulphite at 85°C. Shrink resistance is a severe oxidative treatment, usually with chlorine. Flame-proofing is carried out at very low pH, or with boric acid. Insect-resistant chemicals are frequently biocidal[13].

5. EXPOSURE ASSESSMENT

[c] neps : 'Neps' are small balls of wool formed during carding, perhaps 1-2 mm in diameter. They are probably formed by a few fibres felting together during carding. They are more common with fine wools than crossbred. formed in the card web. These are removed in gilling and combing. They are waste, but they have some uses. They are deliberately made as a way to use wool for bedding - the little balls are easy to blow into a duvet, and they do not felt. They are also used for mopping up oil in oil spillages. They are sometimes deep dyed and spun into 'effect yarns', like Berbers. They then give a small patch of colour in the yarn. When deliberately manufactured, eg, for wool pillow fill, of effects in carpet yarn, they are called 'knops'.

[d] tops : After wool is carded, the card web is divided into strips about 5 cm in diameter. These are 'gilled', a process which aligns the fibres. The gilled wool is combed, which further aligns it and removes short fibre. The resulting wool is now a 'sliver', and it is still about 5 cm in diameter. A whole lot of sliver is called a' top'. The tops are often wound up in a fat bundle called a 'cheese'. The wool in a top is clean and lustrous, and is usually expensive. The top is drawn and spun into worsted yarn.

[e] noils : Noils are the short fibres combed from the wool when making top. They are waste, but can be used in the woollen spinning system.

Exposure assessment examines the possible exposure pathways for susceptible hosts in New Zealand to come into contact with the risk agents (the diseases identified in the hazard identification) released from the risk source (imported fibre of sheep and goats). The exposure assessment considers the likelihood that a susceptible host could come into contact with the imported fibre before, during or after processing. The disposal of wastes from wool scouring plants is another potential avenue for the exposure of susceptible hosts to introduced disease agents, and the exposure pathways for such wastes are also examined.

5.1 Unprocessed fibre imported for scouring and processing

5.1.1 Imported greasy fibre

This commodity would arrive at a port in bales, and be transported to a scouring plant where scouring and further processing would be carried out. Providing bales remained sealed during unloading at the port and provided they were securely covered during transport to the processing plant, it would not be possible for the fibre within the bales to come into contact with animals in New Zealand.

Opening and dusting and manual sorting of imported wool may constitute a zoonotic disease risk to workers.

5.1.2 Recycled imported wool packs

Imported wool packs could be re-used in New Zealand, by being sent out to farms to be filled with wool from New Zealand animals. There could be opportunities for direct or indirect contact of susceptible livestock with these packs.

5.1.3 Imported fibre after scouring

After scouring, fibre is either tightly baled for export or loosely baled for transport to mills where it is dyed and manufactured into yarn.

Scoured fibre in storage awaiting further processing or being transported to mills would not come into contact with animals prior to further processing. Once reaching mills for future processing, there is no chance of contact with animals. At mills the fibre is dyed and manufactured into yarn which is in turn transported to other factories where after variable periods of storage it is manufactured into carpets and garments.

Scoured wool with the highest probability of coming into contact with animals would be that which is manufactured into coats for lambs and calves by carding and then subjected to a manufacturing process known as needle punching. However, most of the wool used in the manufacture of these animal covers is recycled and therefore previously scoured and dyed[(14)].

5.1.4 Imported wool after dyeing and finishing

Once processing is complete, wool is either used in manufacturing or is exported. The opportunity for such processed wool to have contact with livestock in New Zealand is no different to that for imported manufactured wool products.

5.2 Scouring wastes

Effluent and wastes from the scouring process are solid or semi-solid, and include dust, dags, fragments of fibre, scouring liquor and sludge.

Scour effluent may be disposed of into sea outfalls and sewage treatment plants; anaerobic digestion methods and evaporation/incineration processes are also used.

Possible pathways for livestock to come into contact with scour effluents include:

- spraying of effluent on pastures which are then grazed by livestock
- discharge of effluents into waterways which could flood over farmland which is later grazed
- dumping of uncovered solid wastes in any open area where livestock could gain access

5.3 Unprocessed fibre imported for wool testing

Unprocessed fibre imported for testing could not come into contact with susceptible animals while being tested. After testing, provided such wool were adequately disposed of, there would be no opportunity for contact with domestic animals.

5.4 Unprocessed fibre imported for home spinning

The fibre in fleeces imported for home spinning might come into direct or indirect contact with susceptible animals, particularly if such fleeces were used by persons living in rural areas.

5.5 Zoonoses

Persons handling imported fibre could be exposed to dust and wool waste, especially during the opening and dusting stage. Diseases of public health concern could possibly be transmitted to humans at that time.

6. RISK ANALYSIS

6.1 Foot and mouth disease - A10

6.1.1 Hazard identification

The disease

Foot and mouth disease (FMD) is one of the most contagious of animal diseases. It is caused by a Picornavirus, and affects cattle, sheep, pigs, goats, buffalo, and many species of cloven-hoofed wildlife.

In domestic ruminants the pharynx and dorsal soft palate are predilection sites for FMD virus replication. Other than in the mucosa of the pharyngeal region, replication does not persist more than 14 days. Of all the secretions and excretions in acutely infected animals, saliva contains the highest concentrations of virus. The importance of urine and faeces in transmission is uncertain; both have been claimed to contain large quantities of virus[15].

The signs of FMD are generally much milder in sheep and goats than in cattle and pigs. Lesions are small and may be confined to the feet. Many infections are inapparent and may go undetected, but sheep and goats excrete significant quantities of virus when acutely infected[15].

Fibre may become heavily contaminated with aerosols or by saliva, urine and faeces of infected animals, all of which may contain large amounts of the virus[16].

Agent survival

The FMD virus is sensitive to both acid and alkaline conditions. It is most stable at pH 7.4 - 7.6, but all strains are rapidly inactivated below pH 4 and above pH 11[17]. There is some strain variation at intermediate values, but the major determinant is temperature. The virus will retain infectivity at pH 6.7 - 9.5 at 4°C or lower, but the pH range narrows as the temperature rises.

The effect of temperature on viral infectivity is influenced by the suspending medium; organic matter provides some protection against inactivation [17].

Suspensions of FMD virus will remain infective for 8-10 weeks at ambient temperatures of 22°C, and for up to 10 days at 37°C. Above this temperature, inactivation is more rapid[17].

There is a critical relative humidity range of 55-60% below which virus survival is poor[15]. Sunlight has little effect on the virus[18]; environmental inactivation is related more to the effects of desiccation and temperature than to sunlight *per se*[19].

FMD virus may survive on inanimate objects for long periods, depending on the temperature and weather conditions[20]. It may persist for 10-12 weeks on clothing and animal feed, and for up to a month on hair[21].

Several studies have shown that the virus can be found on wool of sheep. A study carried out in Kazakhstan in 1952-53 showed that the survival of the FMD virus on the wool of sheep was dependent on air temperature. In winter when the mean 24-hour temperature was minus 6.7°C, the virus lost its virulence between 15 and 20 days. In summer, when the mean 24 hour temperature was from 12°C to 22°C, the virus was inactivated within 3 days[22]. Another Central Asian study carried out in 1968 concluded that the virus will survive on wool for 3-8 days in spring/summer conditions[23]. In a recent Australian study, wool which was contaminated with faeces, urine or blood from infected sheep was found to contain detectable levels of the virus for 5-11 days at 18°C[16]. Studies carried out at Plum Island in the USA in the 1970s, found that FMD virus on wool stored at 21°C survived for 7 days but not for 14 days[24].

The humidity and pH within baled wool would be conducive to virus survival. The duration of survival would therefore depend largely on temperature. The average humidity inside a wool bale is around 60%, the pH would usually be within the range of pH 6-7 for fine wools and pH 7-9 for coarser wools, and the temperature of baled wool would be relatively stable from 0°C to 40°C, depending on the environmental temperature[13].

Fibre as a vehicle

If wool were harvested from animals in flocks with clinical disease, it could harbour the FMD virus for up to 3 weeks at temperatures near freezing, but survival of the virus would be unlikely for more than a week if the wool was stored at temperatures above 20°C.

Hazard identification conclusion

FMD is a potential hazard in imported fibre of sheep and goats.

6.1.2 Release assessment

Agent inactivation

Normal pasteurisation (72°C for 2-5 minutes) is insufficient to inactivate all virus in whole milk or skim milk[25]. Laboratory experiments with virus suspended in acetate buffer at different temperatures demonstrated that more than 99.9% of virus was inactivated in less than one minute at 61°C and pH 7.5. However, the residual virus remaining had increased heat stability, and the time required for total inactivation at 61°C was 11 minutes[26].

Effect of scouring

Laboratory simulation of scouring of FMD-contaminated wool at 60°C to 70°C usually reduced virus to undetectable levels. The detergent component of the scour was considered to have little if any antiviral effect[16].

The physical process of washing fibre would reduce the concentration of virus present. Organic matter, which is known to prolong FMD virus survival, would also be largely removed from the fibre by washing, and this would be assisted by the detergent included in scouring liquor.

The time/temperature regime of standard (partial flow back mode) aqueous scouring in New Zealand (60-65°C for on average 3 minutes) would be sufficient to destroy the majority but not all of FMD virus in the fibre. The time/temperature regime of a full flow back aqueous scouring system (60-65°C for on average 4.5 minutes) would destroy still more, but not all, of the FMD virus in the fibre.

Effect of further processing

Dyeing (boiling for at least 1 hour) and finishing of scoured fibre would ensure that any residual FMD virus would be destroyed.

Effect of home spinning

Home spinning would not have any effect on virus survival.

Effect of wool testing

Wool testing would not have any effect on virus survival.

6.1.3 Exposure assessment

The opportunities for exposure of susceptible animals in New Zealand to imported fibre were discussed in section 4 of this risk analysis. Exposure to scoured fibre would be extremely limited, but exposure to scouring wastes might be possible with certain systems of disposal (e.g. spraying of effluent on pastures, dumping solid wastes in areas where stock could gain access). Exposure to wool packs containing contaminated wool is a theoretical possibility in the case of packs sent to farms for re-use. Exposure to fibre imported for home spinning is a theoretical possibility. Exposure to fibre imported for testing would be very unlikely during testing, and exposure after that would depend on methods of disposal.

6.1.4 Consequence assessment

The introduction and establishment of FMD into New Zealand livestock would have an extremely severe effect. The greatest impact would be on international trade, but there would also be production losses and the cost of eradication could be high[27].

6.1.5 Risk estimation

Fibre harvested from sheep and goats with FMD can harbour the virus. The virus can survive for up to 3 weeks in wool stored at temperatures near freezing, but not longer than a week at temperatures greater than 20°C. Aqueous scouring cannot be relied on to completely destroy the virus. Exposure pathways are unlikely for fibre, but possible for scour effluent. The consequences of introduction and establishment of the disease would be extremely severe.

Safeguards are justified.

6.1.6 Risk management

In article 2.1.1.21 of the International Animal Health Code[9] it is stated that *veterinary administrations of countries importing fibre of sheep and goats destined for industrial use from FMD infected countries should require the presentation of an international sanitary certificate attesting that :*

1) the products have been processed to ensure the destruction of the FMD virus according to procedures in Appendix 4.3.2.2.; (and)

2) Necessary precautions were taken after collection or processing to avoid contact of the products with any potential source of FMD virus.

Appendix 4.3.2.2 states that *one of the following measures should be applied to wool and hair :*

a) industrial washing, which consists of the immersion of the wool in a series of baths of water, soap and soda or potash.

b) chemical depiliation by means of slaked lime or sodium sulphide.

c) fumigation in formaldehyde in a hermetically sealed chamber for at least 24 hours.

d) industrial scouring which consists of the immersion of wool in a water-soluble detergent held at 60-70°C.

e) storage of wool at 18°C for 4 weeks, or at 4°C for 4 months, or 37°C for eight days.

The risk analysis has considered the two measures listed in article 2.1.1.21 of the International Animal Health Code. With regard to the first measure, some of the treatments in appendix 4.3.2.2 appear to be inappropriate for treating fibre prior to export, and that some others would be unable to offer adequate protection. In appendix 4.3.2.2, treatment 1b), 1c) 1d) and 2 are not adequately specified to make certification practical, and not all of the specified measures are appropriate for imported fibre of sheep and goats. However, treatment 1e) is considered appropriate, and a similar conclusion has been reached in the risk analysis. With regard to the second measure in article 2.1.1.21 of the International Animal Health Code, it is considered to be inadequately specified to be useful in export certification.

The risk analysis concludes that if fibre of sheep and goats were imported from countries which are not free of FMD, then to be certain that any FMD virus on imported fibre was destroyed, the following safeguards would be necessary.

Fibre for scouring

For fibre imported from countries which are not free of FMD,

- Documentary proof must be produced that the fibre has been at least 4 weeks in transit to New Zealand; or
- The fibre must be stored in an approved transitional facility for 4 weeks after arrival in New Zealand prior to scouring; or
- The fibre must be moved to an approved transitional facility where the following treatment must be carried out :
    - Scouring at 60-70°C in full flow back mode with hot water rinses; and
    - After scouring, all fibre must either be dyed or further washed in water at a temperature of at least 65°C for at least 15 minutes; and
    - In the transitional facility, the following measures must be applied to scouring wastes:
        - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and
        - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

Wool packs

For wool packs imported from countries which are not free of FMD :

- Documentary proof must be produced that the packs have been at least 4 weeks in transit to New Zealand; or
- The packs must be stored in an approved transitional facility for 4 weeks after arrival in New Zealand prior to use; or
- The packs must be moved to an approved transitional facility where they must be washed in water at a temperature of at least 65°C for at least 15 minutes; or
- The packs must be destroyed by incineration.

Fleeces for home spinning

For all fleeces imported for home spinning,

- Documentary proof must be produced that the fleeces have been at least 4 weeks in transit to New Zealand; or
- The fleeces must be stored in an approved transitional facility for 4 weeks after arrival in New Zealand prior to use; or
- The fleeces must be unpacked under official supervision and washed in water at a temperature of at least 65°C for at least 15 minutes.

Fibre for testing

For fibre imported from countries which are not free of FMD,

- Documentary proof must be produced that the fibre has been at least 4 weeks in transit to New Zealand; or
- The fibre must be stored in a transitional facility for 4 weeks after arrival in New Zealand prior to testing; or
- The fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must be destroyed by incineration or treated as follows :
    - Scouring at 60-70°C in full flow back mode with hot water rinses; and
    - After scouring, all fibre must either be dyed or further washed in water at a temperature of at least 65°C for at least 15 minutes; and

- In the transitional facility, the following measures must be applied to scouring wastes:

    - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and

    - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

6.2 Rinderpest - A40

6.2.1 Hazard identification

The disease

Rinderpest is an acute contagious disease caused by a *Morbillivirus*. It is primarily a disease of cattle and buffalo resulting in high mortalities. The virus also affects sheep, goats, pigs, and many wild cloven-hoofed animals, without always producing clinical disease[28].

Transmission is commonly by direct contact between animals via infected aerosols. The virus is present in high concentrations in expired air, tears, nasal discharges, saliva, faeces and urine of infected animals. Excretion of the virus may commence 1-2 days before the onset of clinical signs, and surviving animals shed the virus up to about 3 weeks post infection. Longer virus shedding, up to 12 weeks, has been described in individual cases, and the virus has been demonstrated in peripheral blood lymphocytes of cattle for up to 3 months after recovery and cessation of viraemia. However, it is generally accepted that there are no virus carriers or permanent shedders of the virus in cattle[29]. The situation in other cloven hoofed animals is less clear. Small ruminants and pigs have been suggested as reservoirs[29]. This has shown to be the case in India, where strains of rinderpest, clearly distinguishable from peste des petits ruminants (PPR), have become established in sheep and goats, from which the disease can be passed back to cattle[28].

Agent survival

The fragility of the rinderpest virus ensures that most of the virus remains infectious for only a few hours outside the host, though some virus may persist under favourable conditions (e.g. in dried secretions and excretions) for 2 to 4 days[28,30].

Fibre as a vehicle

Although fibre could become contaminated by excretions and secretions of animals affected by rinderpest, the virus would not survive on fibre for more than a few days. Therefore the risk of introduction of rinderpest virus with imported fibre is considered to be negligible.

Hazard identification conclusion

Rinderpest is not a potential hazard in imported fibre of sheep and goats.

6.3 Peste des petits ruminants - A50

6.3.1 Hazard identification

The disease

Peste des petits ruminants (PPR) is an acute contagious disease caused by a *Morbillivirus*. The virus is closely related to that of rinderpest, and causes disease in sheep and goats with clinical signs similar to rinderpest in cattle. The virus will infect cattle without clinical signs, and has been reported in wild ruminants[31].

Large amounts of virus are present in all body excretions and secretions, especially in diarrhoeic faeces. Aerosols are the major mode of transmission and the infection spreads readily when there is close contact between sick and healthy animals[32].

As with rinderpest, the requirement for the maintenance of the transmission cycle of PPR seems to be a regular supply of susceptible hosts plus sufficient animal movement to allow mixing of the population. However, unlike rinderpest, PPR is also maintained at the village level as well as in large nomadic flocks. The ease with which goats and sheep are infected with PPR virus, as opposed to cattle with rinderpest, is a major factor in the spread of this virus. Virtually all outbreaks can be traced to stock movements, either migration to new areas or introduction of new animals. The agent reservoir is most likely partially immune populations of small ruminants in endemic areas[31].

Serological surveys have shown that infection is far more prevalent than clinical disease; many, if not most, infections are subclinical or insufficiently severe to attract veterinary attention[31].

Agent survival

The survival of PPR virus outside the body has not been widely studied; it is assumed to be very similar to rinderpest virus. The virus has been shown to have a half life of approximately 2 hours at 37°C and is destroyed within an hour at 50°C[31].

Fibre as a vehicle

Although fibre could become contaminated by excretions and secretions of affected animals, the virus would not survive on fibre for more than a few days. Therefore the risk of introduction of PPR virus with imported fibre is considered to be negligible.

Hazard identification conclusion

PPR is not a potential hazard in imported fibre of sheep and goats.

6.4 Rift Valley fever - A80

6.4.1 Hazard identification

The disease

Rift Valley fever (RVF) is a peracute or acute disease of domestic ruminants in Africa, caused by a mosquito-borne *Phlebovirus*. The disease is most severe in sheep, cattle and goats, producing high mortality rates in newborn animals and abortions in pregnant animals. However, many infections are inapparent or mild. The disease is a zoonosis. Humans become infected by contact with carcasses of infected animals or aborted foetuses and by mosquito bite, and usually show mild to moderate "flu-like" symptoms[33].

The virus has been isolated from 12 species of mosquito in the African subcontinent: five *Aedes*, three *Culex*, three *Anopheles*, and one *Eretmapodites*. In general, floodwater breeding *Aedes* mosquitoes are the maintenance vectors, and the others are epidemic vectors. The onset of epidemics in African countries is determined by conditions favouring the breeding of these specific mosquito vectors[33].

Epidemics, which occur in late summer, are precipitated by abnormally heavy rains at irregular intervals (5-15 years in southern Africa) which leads to an explosive increase in *Aedes* populations in inland floodpans and low-lying grassy areas. The emerging *Aedes* mosquitoes preferentially feed on cattle, and amplification of the virus in this host leads to infection of other species of mosquito (especially *Culex* spp) which in turn infect other species of vertebrate hosts[34].

An intense viraemia develops in lambs less than a week old within 16 hours of infection. In older sheep, goats and cattle, viraemia is detectable 1-2 days after infection and persists for up to 7 days. Low concentrations of the virus have been found in milk and body fluids, such as saliva and nasal discharges of sheep and cattle, and the virus has been shown to persist in visceral organs of sheep, particularly the spleen, for up to 21 days after infection[33].

Agent survival

Under natural conditions the virus is rapidly inactivated outside its host or vector[33].

Fibre as a vehicle

As this is an insect-borne disease and the virus is rapidly inactivated outside its host or vector, fibre is not a vehicle for transmission.

Hazard identification conclusion

Rift valley fever is not a potential hazard in imported fibre of sheep and goats.

6.5 Bluetongue - A90

6.5.1 Hazard identification

The disease

Bluetongue (BT) is an infectious non-contagious disease of sheep and other domestic and wild ruminants, caused by an *Orbivirus* and transmitted by *Culicoides* midges.

Clinical signs of disease are uncommon and are generally seen only in sheep and some wild ruminants. The disease may vary from peracute to chronic, with mortality ranging from 2 to 30%. However, many infections in sheep are clinically inapparent, even in fully susceptible animals[35].

Endemic areas for BT are defined by climate - they are largely restricted to the tropics and subtropics, closely following the spatial and temporal distribution of competent *Culicoides* vectors. Bluetongue has been reported from countries in a broad band about 35°N to 35°S. Worldwide only about 17 species of *Culicoides* are efficient vectors for the virus, and in any given environment usually only one or two species are important[36].

Cattle are the main amplifying host for BT virus, and are probably also important maintenance hosts. The competent species of *Culicoides* are generally preferential cattle feeders[37]. In sub-tropical environments, outbreaks in sheep occur in late summer and autumn, suggesting that populations of infected midges build up in the primary cycle involving cattle or wild animals during spring and early summer, and that sheep become infected in a secondary cycle as a "spillover"[35].

Viraemia begins 3-6 days after infection, reaching a peak 7-8 days after infection. In sheep, viraemia rarely lasts longer than 14 days, and is usually present for 6-8 days. Results which conflict with this statement were reported by early workers, but can be explained by natural reinfections with different serotypes which were unknown at that time. In cattle it appears that virus may persist in the blood stream for up to 49 days, and possibly longer[35].

Bluetongue is not contagious and very little virus is found in the secretions and excretions of infected animals. Transmission only occurs when infective blood or tissue suspensions are inoculated parenterally. Susceptible animals are refractory to infection by the oral route[38]. Oral or aerosol transmission is therefore highly unlikely and animal tissues and products, even from infected animals, can be disregarded as a source of infection[35].

Agent survival

Under natural conditions the BT virus does not persist outside its host or vector.

Fibre as a vehicle

As this is an insect-borne disease and the virus is rapidly inactivated outside its host or vector, fibre is not a vehicle for transmission.

Hazard identification conclusion

Bluetongue is not a potential hazard in imported fibre of sheep and goats.

6.6 Sheep pox and goat pox - A100

6.6.1 Hazard identification

The disease

Sheep pox and goat pox are acute or subacute contagious diseases of small ruminants, caused by the capripox virus. Severe cases are almost invariably fatal. Total mortality in an affected flock may be as high as 50%, but in younger animals mortality may approach 100%. If recovery occurs, it is over an extended period[39].

Infected animals shed the virus in all secretions and excretions, and in scabs of recovering animals. Transmission is mainly by the respiratory route, and this usually requires close contact between animals, often in places where animals are herded together such as watering places and saleyards. Contamination of small skin lesions with infectious material in the environment is probably responsible for maintaining a low prevalence of the disease in endemic areas. The rate of transmission is probably related to the severity of lesions which develop in clinical cases; peracute cases usually die before significant amounts of virus are excreted[39].

Agent survival

Sheep pox and goat pox viruses are relatively stable. The virus may persist in dried pox scabs and wool / hair of recovering animals for at least 3 months[40], possibly years[41], and in premises for up to 6 months if protected from sunlight[42]. It is inactivated by direct sunlight[39].

Fibre as a vehicle

Unprocessed fibre of sheep and goats from areas where sheep and goat pox is endemic could contain the virus, especially if the fibre was derived from animals which were affected by or had died from the disease.

Hazard identification conclusion

The capripox virus is a potential hazard in imported fibre of sheep and goats.

6.6.2 Release Assessment

Agent inactivation

Pox viruses are sensitive to common detergents, formaldehyde, oxidizing agents, ether, and temperatures greater than 40°C[41,43]. Suitable disinfectants for vaccinia virus (the type species of the related orthopoxvirus genus) are formalin (1-3%), common detergents, acids and all virucidal disinfectants[44].

Cell-free vaccinia virus is inactivated in 1-2 hours at 56°C[44]. However, the heat inactivation curves of the virus between 50°C and 60°C show that the virus is heterogeneous in its heat sensitivity. The inactivation of heat-sensitive virus is temperature-dependent, while the heat-resistant fraction is inactivated at a constant slow rate unrelated to temperatures within the range studied[45].

In laboratory experiments, temperatures of 50° - 60°C for 30 minutes have been shown to reduce by 2 or more $\log_{10}$ units the infectiousness of poxviruses for cells in culture, and treatment of the virus with a non-ionic detergent reduced infectiousness by 3 or more $\log_{10}$ units[46]. The scientist who carried out this work was of the opinion that synergistic effects of temperature and detergent acting together could be expected to affect titres more profoundly than either treatment alone[46]. Another authority reported that in his laboratory, vaccinia virus is routinely inactivated by heating at 60°C for 60 minutes[47].

Sheep-pox isolates may be more sensitive to heat than other pox viruses, and the virus is reported to be easily inactivated by heating at 52-53°C, but some isolates from goats are reported to be more resistant[48]. A report from the USA indicated that sheep pox virus is inactivated when heated for 3 minutes at 56-58°C[49].

Pox viruses have an outer lipid-containing envelope, which is destroyed by treatment with non-ionic detergents[43], and one authority pointed out that because of that lipid outer layer, the sheep pox virus is extremely sensitive to detergent inactivation[50]. However, it is clear that both non-enveloped and enveloped poxviruses are infectious[51,52].

Effect of scouring

It has been difficult to get a clear picture of the heat and detergent sensitivity of the virus at the temperatures present encountered during wool scouring.

The physical process of washing fibre in the presence of a detergent would remove the majority of particulate matter from the fibre, and would reduce the concentration of virus present.

One authority consulted during the course of this risk assessment was of the opinion that a fleece treated with any effective detergent for even a few minutes at 60°C would reduce the capripoxvirus titre to a level that no longer provided a threat to livestock[50]. Several other authorities consulted were of a similar opinion[46,47].

It is concluded that the time/temperature regime of standard (partial flow back mode) aqueous scouring in New Zealand (60-65°C for on average 3 minutes, in the presence of a non-ionic detergent) would be sufficient to destroy the majority of most strains of capripox virus, and scouring carried out in the full flow back aqueous scouring system (60-65°C for on average 4.5 minutes) would destroy virtually all of the capripox virus present. However, in the case of heat resistant strains of the capripox virus, some viable virus might remain after scouring.

Effect of further processing

Dyeing (boiling for at least 1 hour) of scoured fibre would ensure that any residual capripox virus would be inactivated.

Effect of home spinning

Home spinning would not have any effect on virus survival.

Effect of wool testing

Wool testing would not have any effect on virus survival.

6.6.3 Exposure Assessment

The opportunities for exposure of susceptible animals in New Zealand to imported fibre were discussed in section 4 of this risk analysis. Exposure to scoured fibre would be extremely limited, but exposure to scouring wastes might be possible with certain systems of disposal (e.g. spraying of effluent on pastures, dumping solid wastes in areas where stock could gain access). Exposure to wool packs containing contaminated wool is a theoretical possibility in the case of packs sent to farms for re-use. Exposure to fibre imported for home spinning is a theoretical possibility. Exposure to fibre imported for testing would be very unlikely during testing, and exposure after that would depend on methods of disposal.

6.6.4 Consequence Assessment

There are a number of pox viruses in New Zealand, among which is the parapox virus which causes contagious ecthyma (scabby mouth) in sheep. Therefore there is no reason to believe that the capripox virus would not easily establish in New Zealand, and the effect of its establishment would be severe. There could be high mortalities, there would be loss of international markets, and the costs of control would be high.

6.6.5 Risk Estimation

The virus may persist for months in the wool of recovering animals. Aqueous scouring cannot be relied on to completely destroy the virus. Exposure pathways are unlikely for fibre, but possible for scour effluent. The consequences of introduction and establishment of the disease would be severe.

Safeguards are justified.

6.6.6 Risk Management

In article 2.1.10.8 of the International Animal Health Code[9] it is suggested that *veterinary administrations of countries importing fibre of sheep and goats destined for industrial use from countries considered infected with sheep pox and/or goat pox should require the presentation of an international sanitary certificate attesting that the products :*

1) come from animals which have not been kept in a sheep pox and/or goat pox infected zone; or

2) have been processed to ensure the destruction of sheep pox and/or goat pox virus, in premises controlled and approved by the veterinary administration of the exporting country.

Article 2.1.10.2 defines an infected zone for sheep and goat pox as follows:

> *a sheep pox and/or goat pox infected zone shall be considered as such until at least 21 days have elapsed after the last case has been reported and following the completion of a stamping-out policy and disinfection procedures, or 6 months after the clinical recovery or death of the last affected animal if a stamping-out policy is not practised.*

and a country which is free of sheep and goat pox is defined as follows :

> *a country may be considered free from sheep pox and/or goat pox when it has been shown that sheep pox and/or goat pox has not been present for at least the past 3 years. This period shall begin 6 months after the occurrence of the last case of sheep pox and/or goat pox for countries in which a stamping out policy is practised, with or without vaccination against sheep pox and/or goat pox.*

This risk analysis considers that the second measure in article 2.1.10.8 is not adequately specified to be useful. However, the first measure, together with the definitions of infected zone and free country, is considered to be appropriate.

To be certain that any pox virus on imported fibre was destroyed, the following safeguards would be necessary.

<u>Fibre for scouring</u>

Fibre imported for scouring from countries which are not free of sheep and goat pox, and for which there is no international sanitary certificate attesting that the fibre comes from animals which have not been kept in a sheep pox and/or goat pox infected zone, must be moved to an approved transitional facility where it must be treated as follows:

- Scouring at 60-70°C in full flow back mode with hot water rinses; and

- After scouring, all fibre must be either dyed or washed in water at a temperature of not less than 60°C for at least 60 minutes in the presence of a non-ionic detergent at a concentration of not less than 1 g per litre.

- In the transitional facility, the following measures must be applied to scouring wastes:

    - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and

    - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

Wool packs

Wool packs that are imported from countries which are not free of sheep and goat pox or which have been used to transport fibre from countries which are not free of sheep and goat pox must be :

- moved to an approved transitional facility where they must be washed in water at a temperature of not less than 60°C for at least 60 minutes in the presence of a non-ionic detergent at a concentration of not less than 1 g per litre; or

- destroyed by incineration.

Fleeces for home spinning

Fleeces imported from countries which are not free of sheep and goat pox, and for which there is no international sanitary certificate attesting that the fleece comes from animals which have not been kept in a sheep pox and/or goat pox infected zone, the fleeces must be :

- completely unpacked under official supervision and washed in water at a temperature of not less than 60°C for at least 60 minutes in the presence of a non-ionic detergent at a concentration of not less than 1 g per litre.

Fibre for testing

Fibre imported for testing from countries which are not free of sheep and goat pox, and for which there is no international sanitary certificate attesting that the fibre comes from animals which have not been kept in a sheep pox and/or goat pox infected zone, must be moved to an approved transitional facility where, after completion of testing, it must be destroyed by incineration or treated by one of the following methods :

- washing in water at a temperature of not less than 60°C for at least 60 minutes in the presence of a non-ionic detergent at a concentration of not less than 1 g per litre; or

- Scouring

    - Scour must be operated at 60-70°C in full flow back mode with hot water rinses; and

    - after scouring, all fibre must be either dyed or washed in water at a temperature of not less than 60°C for at least 60 minutes in the presence of a non-ionic detergent at a concentration of not less than 1 g per litre; and

    - In the transitional facility, the following measures must be applied to scouring wastes:

        - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and

        - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

6.7 Anthrax - B051

6.7.1 Hazard Identification

The disease

Anthrax is a peracute, acute or subacute infectious bacterial disease of domestic and wild animals and humans caused by an aerobic spore-forming bacillus, *Bacillus anthracis*. The disease is an important zoonosis. Transmission is by ingestion or inhalation of material contaminated with spores[53].

Anthrax spores, which are highly resistant, are never found in the animal body during life, but form when the vegetative form of the anthrax organism is exposed to air either in bloody discharges from body orifices of affected animals or when the carcass of an animal that has died of the disease is opened. Anthrax bacilli do not remain alive in most tissues of unopened carcasses for longer than three days at temperatures of 25-30°C or higher, as they are rapidly killed by putrefactive organisms. However, at temperatures of 5-10°C the rate of decomposition of a carcass is reduced, and anthrax bacilli may still be recovered for up to 4 weeks[53].

Ambient temperature has an important effect on spore formation. Sporulation is slow at temperatures below 20°C. In countries with a cold climate, the temperature is unfavourable for sporulation for much of the year and anthrax tends to be self-limiting. However in countries with a warm climate which favours the sporulation of *B. anthracis* in body fluids and in pools of blood or serum in the immediate surroundings of an opened carcass, the occurrence of anthrax is closely integrated with a soil phase[53].

The survival of anthrax spores in soil is best explained by the 'persistent spore' concept rather than the theory of 'incubator areas'. Spore survival depends of a number of factors such as the initial number of spores, the climate, topography, and the presence of soil saprophytes, certain chemicals, plant material and anthrax bacteriophages. In soils of high biological activity that contain a great diversity of microbial life, the survival period of spores is probably limited to around 3 - 4 years. However, anthrax spores may remain viable in soil for 50 years, or even up to 250 years if the soil is dry and has either a very low or a very high pH which adversely affects the biological activity of other microbial organisms[53]. Persistent outbreaks seem to be dependent on soils comprising calcium top soils, a granular alkaline soil, and shallow pans[54]. A recent outbreak in Australia was restricted to farms which had areas of poorly drained, swampy, alluvial soils[55]. Sporadic outbreaks on farms in Great Britain may be related to flooding of rivers in areas near disused tanneries where infected imported hides were processed three decades ago[56].

Anthrax occurs all over the world, particularly in warm climates where spore production occurs readily. However, it is likely that specific socio-economic conditions are also necessary for the persistence of soil contamination. The disease remains endemic in Africa and Asia where, following sudden death, the value of a carcass as meat for local consumption and as hide, hair, wool, and/or bones for sale greatly outweighs the perceived merits of burying or burning it[57]. In temperate regions, infection in animals

tends to occur sporadically through the importation of contaminated animal feed, while infections in humans are usually related to handling imported hides and wool[58].

The disease was last diagnosed in New Zealand in 1954[59], but despite several introductions in bone meal fertilizer, anthrax has never established in this country. This is probably due to soil and climate conditions being unsuitable for the production and long-term survival of spores.

Humans may develop localised cutaneous lesions (malignant pustule or malignant carbuncle) from contact of broken skin with infected blood or tissues, acquire a highly fatal haemorrhagic condition (woolsorters' disease or Bradford disease) from spore inhalation when handling contaminated wool or hair. Humans may occasionally develop acute meningitis as a complication of bacteraemia or intestinal anthrax from consumption of undercooked meat of animals which have died of anthrax[60]. The most common form in humans is cutaneous anthrax which accounts for about 95-98% of human cases[61].

There are few records of anthrax occurring in humans in New Zealand, and all reported cases were the cutaneous form in farmers who skinned animals which had died of the disease. Woolsorters' disease has not been reported in New Zealand[62]. The recent Australian outbreak resulted in one human case of cutaneous anthrax in a knackery worker, presumably from direct contact with infected carcasses[63].

Agent survival

Spores are highly resistant and they can survive for years on contaminated hides, skins and wool[64].

Fibre as a vehicle

Fibre taken from the carcass of an animal which had died of anthrax may be contaminated with bloody discharges, particularly if the carcass is opened or butchered, or if the skin of a dead animal is removed prior to harvesting the fibre. This can result in massive numbers of spores in the fibre, and once contaminated with spores, fibre could remain contaminated for years. While the number of spores in contaminated soil may be sufficient to infect susceptible animals orally, it is unlikely that soil or dust could result in significant passive contamination of fleeces with anthrax spores[65,66].

Fibre harvested from clinically normal animals would not be expected to be contaminated with anthrax spores.

Animal fibre is well recognised as a vehicle for the transmission of anthrax to humans. In Great Britain at the beginning of the 20th century, internal anthrax in humans was considered to be a major problem in factory workers processing imported wool and goat hair, in particular that from India, Pakistan and Persia. The problem was considered so serious that in 1918 a pilot Government Wool Disinfection Station at Liverpool was built at Liverpool. The treatment was similar to scouring, with the addition of a 20 minute

bath in 2% formalin. It was proposed that a series of similar disinfection stations would be built in exporting countries to disinfect fibre before shipping to the UK, but because of a lack of international cooperation this did not eventuate. The UK pilot plant had the capacity to treat less than 1% of the fibre being imported into the UK at that time, which meant that only part of the identified "high risk" fibre could be treated. In spite of the small fraction of imported fibre that was treated, the incidence of anthrax in humans in the UK declined markedly over the second 20 years of the century, suggesting that factors other than the disinfection plant were responsible[3]. The plant was eventually closed in the late 1950s.

Sporadic human cases still occur in the UK; in 1994 cutaneous anthrax was diagnosed in a worker in a Scottish woollen mill[67].

Hazard identification conclusion

Anthrax is a potential hazard in imported fibre of sheep and goats.

6.7.2 Release Assessment

Agent inactivation

The spores of *B. anthracis* are resistant to temperatures below 70°C. They withstand exposure to alcohols, phenols, quaternary ammonium compounds, ionic or non-ionic detergents, acids or alkalis[53]. Spores can be inactivated only by very harsh physical and chemical conditions.

Anthrax spores may be inactivated by heat or radiation. Inactivation by dry heat at 140°C may require up to three hours[68]. Spores exposed to moist heat survive for 15-45 minutes at 90°C, for 10-25 minutes at 95°C, and for 2-15 minutes at 100°C[69]. Autoclaving at 120°C takes 10 minutes to destroy spores[69]. For the decontamination of wool, hair and skins by gamma irradiation from ^{60}Co, a dose of between 1.5 and 2 Mrad is recommended[68]. UV-radiation is effective at a dose of 48000 W/cm^2 on smooth surfaces like aluminium, but is not effective for spores on rough surfaces like wood[68].

Most commercial disinfectants are ineffective against anthrax. At 20°C and 65% relative humidity, surfaces contaminated with anthrax spores are sterilised by 10% formaldehyde, 2% glutaraldehyde (pH 8-8.5), 3% hydrogen peroxide, or 0.3% peracetic acid[68].

Effect of scouring

The time/temperature regime in either the partial or full flow back aqueous scouring system (60-65°C for 3 - 4.5 minutes) would have no significant effect on anthrax spore viability. The detergent used in the scour would probably assist the physical flushing of a large proportion of the spores out of contaminated wool. Spores washed out of wool would remain viable in the scour effluent.

The majority of spores in scour effluent would be expected to be found in the sediment from the settling tank. Any spores in the supernatant would remain viable unless the supernatant were processed through an evaporation/incineration unit.

Therefore, while scouring would substantially reduce any risk of fibre contamination, there remains a remote possibility that small numbers of viable spores could remain in fibre after scouring. Viable spores from the scour could be expected to be largely concentrated in sediments. Other scouring wastes such as dirt and dust from the opening and dusting process could be expected to contain some viable spores.

Effect of further processing

Dyeing (boiling for at least an hour) of scoured fibre would inactivate any anthrax spores which remained in fibre after scouring.

Effect of home spinning

Anthrax spores would not be affected by home spinning.

Effect of wool testing

Anthrax spores would not be affected by wool testing.

6.7.3 Exposure Assessment

The opportunities for exposure of susceptible animals in New Zealand to imported fibre were discussed in section 4 of this risk analysis. Exposure of humans to greasy fibre during processing could be a public health issue for fibre containing anthrax spores. Exposure of animals to scoured fibre would be extremely limited, but exposure to scouring wastes might be possible with certain systems of disposal (e.g. spraying of effluent on pastures, dumping solid wastes in areas where stock could gain access). Exposure to wool packs containing contaminated wool is a theoretical possibility in the case of packs sent to farms for re-use. Exposure to fibre imported for home spinning is a theoretical possibility. Exposure to fibre imported for testing would be very unlikely during testing, and exposure after that would depend on methods of disposal.

5.7.4 Consequence Assessment

Despite a number of introductions in the past, anthrax has never established in New Zealand, most probably because of unsuitable environmental conditions. Therefore, the further introduction of anthrax would be unlikely to result in its establishment, but even if it did become established it might not be of great significance in terms of direct losses. While sporadic outbreaks would cause losses for individual farmers there would probably be minimal effect on international trade[70]. However, wool exports might be adversely affected. Moreover, anthrax is an important zoonosis, and its introduction in imported fibre could result in cases of human anthrax in wool scour workers.

6.7.5 Risk Estimation

Fibre of sheep and goats can become contaminated with anthrax spores which are highly resistant and would not be destroyed by aqueous scouring. Exposure of humans to unprocessed wool could be a public health issue, and exposure of livestock to spores is theoretically possible via scour effluent. The consequences of the introduction of the disease agent could be serious.

Safeguards are justified.

6.7.6 Risk Management

In article 3.1.1.5 of the International Animal Health Code[9] it is suggested that *veterinary administrations of countries importing products of animal origin destined for industrial use should require the presentation of an international sanitary certificate attesting that these products:*

1) originate from healthy animals
2) have been processed to ensure the destruction of both bacillary and spore forms of Bacillus anthracis
3) have been kept in areas in which anthrax is not prevalent.

None of these suggested measures provide any real level of protection. Regarding the first measure, the intention appears to be to prevent the export of fibre that is collected from fallen stock, as such fibre is recognised as having a high risk of carrying anthrax spores. However, a regulatory veterinarian faced with a bale of wool requiring certification could not be expected to know whether the fibre had been harvested from healthy, diseased or dead animals. Regarding the second measure, which would not be necessary if the first could be certified, the necessary processing measures are not specified, and therefore certification would be meaningless. The third measure is not relevant, as it is not important where fibre is kept after it has been harvested and in any case it would not be possible for a regulatory veterinarian to provide meaningful certification.

Note that the International Animal Health Code does not attempt to establish a definition as to what constitutes a country or a zone which should be considered to pose a significant anthrax risk. Therefore, MAF will make that judgement based on available surveillance information.

To be certain that any anthrax spores on imported fibre were destroyed, the following safeguards would be necessary.

Fibre for scouring

For fibre imported from countries or zones which are considered by MAF to pose a significant anthrax risk, the fibre must be moved to an approved transitional facility, where it must be treated as follows :

- Scouring at 60-70°C in full flow back mode with hot water rinses; and
- After scouring, all fibre must be either be dyed or must be treated by one of the following methods :

  (i) exposure to dry heat at 140°C for 3 hours; or

  (ii) immersion in water heated and maintained at a temperature of 95°C for 25 minutes or at a temperature of 100°C for 15 minutes; or

  (iii) autoclaving at 120°C for 10 minutes;

  and :

- In the transitional facility, the following measures must be applied to scouring wastes:
  - Machinery used for opening and dusting must be equipped with adequate dust control protection to prevent aerosols of anthrax spores; and
  - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and
  - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

Wool packs

Wool packs from countries which are considered by MAF to pose a significant anthrax risk must be moved to an approved transitional facility they must be treated by one of the following methods:

- exposure to dry heat at 140°C for 3 hours; or
- immersion in water heated and maintained at a temperature of 95°C for 25 minutes or at a temperature of 100°C for 15 minutes; or
- autoclaving at 120°C for 10 minutes.

Fleeces for home spinning

For fleeces imported from countries or zones which are considered by MAF to pose a significant anthrax risk, fleeces must be completely unpacked under official supervision and treated by one of the following methods:

(i) fumigation with 10% formaldehyde vapour (under vacuum, to ensure penetration into the fleece). [Note that this is available only at Auckland]; or

(ii) exposure to dry heat at 140°C for 3 hours; or

(iii) immersion in water heated and maintained at a temperature of 95°C for 25 minutes or at a temperature of 100°C for 15 minutes; or

(iv) autoclaving at 120°C for 10 minutes.

Fibre for testing

For fibre imported from countries or zones which are considered by MAF to pose a significant anthrax risk,

- Fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must either be destroyed by incineration or be scoured as follows :
  - The scour must be operated at 60-70°C in full flow back mode with hot water rinses; and
  - After scouring, all fibre must be either be dyed or must be treated by one of the following methods:

    (i) exposure to dry heat at 140°C for 3 hours; or

    (ii) immersion in water heated and maintained at a temperature of 95°C for 25 minutes or at a temperature of 100°C for 15 minutes; or

    (iii) autoclaving at 120°C for 10 minutes;

    and :

  - In the transitional facility, the following measures must be applied to scouring wastes:
    - Machinery used for opening and dusting must be equipped with adequate dust control protection to prevent aerosols of anthrax spores; and

- Liquid effluent from the scour must be passed through an evaporation/combustion unit; and

- Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

6.8 Aujeszky's disease - B052

6.8.1 Hazard Identification

The disease

Aujeszky's disease, also known at pseudorabies, is a contagious disease caused by an alpha-herpes virus with an extremely wide host range. It is primarily associated with pigs, in which it causes a severe, frequently fatal disease of newborn animals. Pigs remain latently infected following clinical recovery. Infection of sheep, and other livestock appears to be invariably fatal[71].

Agent survival

Herpesvirus particles are fragile and do not survive well outside the body[72]. Aujeszky's disease virus survives only a few hours on material contaminated with faeces and urine, and is rapidly inactivated by sunlight, heat, and dry conditions[73].

Fibre as a vehicle

It is unlikely that fibre could become contaminated with the Aujeszky's disease virus, but as the agent does not survive more than a few hours outside the host, even if a mechanism for fibre contamination could be demonstrated, it could not be considered a vehicle for this disease.

Hazard identification conclusion

Aujeszky's disease virus is not a potential hazard in imported fibre of sheep and goats.

6.9 Echinococcosis / Hydatidosis - B053

6.9.1 Hazard Identification

The disease

Four species of *Echinococcus* tapeworms are recognised internationally, occurring in the small intestine of dogs or other carnivores. Eggs passing in the faeces of the definitive host are ingested by intermediate hosts, in which the cystic stage develops, usually in offal. Infestation of dogs can only be by eating fertile protoscolices in raw offal containing viable hydatid cysts.

Intermediate hosts are usually ruminants and pigs. Humans may act as a dead-end intermediate host, and cystic hydatid disease in humans is an important zoonosis.

There is evidence that tapeworm eggs spread from the site of deposition within an area of 10 hectares, but the mechanisms of spread are not understood. Wind and air currents have been suggested, but the experimental evidence is not convincing[74].

Echinococcus granulosus is close to eradication in New Zealand[75].

Agent survival

Eggs of *Echinococcus* spp. are infective only if they contain viable embryos (oncospheres). When eggs were stored at relative humidities of 60 to 80%, which is similar to the humidity inside a wool bale[13], oncospheres survived 1 and 2 days respectively. Survival is shorter at lower relative humidities[76], and the absence of surface moisture during storage prevents hatching[76]. However, in moist conditions, oncospheres can survive for long periods, especially at low temperatures; embryos stored at 21°C survived 28 days but not 56 days, whereas those stored at 7°C survived for 294 days[77].

Fibre as a vehicle

Fibre is not a vehicle for this disease. While it is theoretically possible that fibre could become contaminated with dog faeces containing eggs of *Echinococcus* spp, oncospheres on wool would not survive longer than 1 or 2 days at the humidity levels found in wool bales, and therefore fibre cannot be considered a vehicle for transmitting hydatids to intermediate hosts. As fibre cannot harbour hydatid cysts or protoscolices, it is not a vehicle for transmission of the disease to dogs.

Hazard identification conclusion

Echinococcus spp. is not a potential hazard in imported fibre of sheep and goats.

6.10 Heartwater - B055

6.10.1 Hazard Identification

The disease

Heartwater is a non-contagious tick-borne rickettsial disease of ruminants caused by *Cowdria ruminantium*. The disease is characterised by high fever, nervous signs, hydropericardium, hydrothorax, oedema of the lungs and brain, and death.

Sheep are more susceptible that cattle, and there is some variation in breed susceptibility in both species. Recovery of animals which show clinical signs is rare. However, many infections are inapparent; animals with such infections act as reservoirs[78].

The distribution of the disease in Africa coincides with the presence of *Amblyomma* ticks which require a warm and relatively humid climate and bushy grass country for their development. Ten *Amblyomma* spp. are capable of transmitting the organism in Africa, but not all of these are good vectors. Their importance in the transmission of heartwater depends not only on their competence as vectors but also on their distribution and adaptation to domestic stock, and their activity and abundance, which is influenced by temperature and humidity. The agent multiplies in the salivary glands of the tick, which may remain infected for life[79].

Agent survival

The organism is very fragile, and outside the host it loses its viability within 12-36 hours at room temperature[79].

Fibre as a vehicle

As this is an insect-borne disease and the virus is rapidly inactivated outside its host or vector, fibre is not a vehicle for transmission.

Hazard identification conclusion

Heartwater is not a potential hazard in imported fibre of sheep and goats.

6.11 Leptospirosis - B056

6.11.1 Hazard Identification

The disease

Leptospirosis is bacterial disease caused by spirochaetes of the genus *Leptospira.* The disease in sheep and goats is characterised by agalactia and redwater. It is an important zoonosis. Pathogenic leptospires are identified in seven species of *Leptospira.* Antigenically related serovars are placed in serogroups; there are now 198 serovars arranged in 23 serogroups[80].

Leptospiral infection can result in localisation and persistence of leptospires in the kidney and in the male and female genital tract. This can occur with few or no clinical signs. Such animals may shed leptospires in their urine, and are of major epidemiological importance as maintenance hosts[81].

Agent survival

The survival of leptospires in the environment is dependent particularly on variations in temperature and humidity. The organisms are very sensitive to drying, and pH values below 6 or exceeding 8 are detrimental to their survival outside hosts. Leptospires will survive for as long as 183 days in water-saturated soil, but for only 30 minutes when the soil is air dried[81].

Fibre as a vehicle

Although fibre might be contaminated with organisms passed in the urine, leptospires would survive very briefly on dry fibre. Therefore fibre is not considered a vehicle for this disease.

Hazard identification conclusion

Leptospirosis is not a potential hazard in imported fibre of sheep and goats.

6.12 Q fever - B057

6.12.1 Hazard Identification

The disease

Q fever is a zoonotic disease which occurs in most countries apart from New Zealand. It is caused by the rickettsia *Coxiella burnetii* which infects a wide range of domestic and wild animals. Infection appears to cycle silently between ticks and small mammals. Natural infection has been verified in 35 species of hard and soft ticks of 11 genera[82], but not all of these can transmit infection; most of these carry the organism for only a short time after engorging on contaminated blood[83]. Natural infections have not been reported in the New Zealand cattle tick, *Haemaphysalis longicornis*, and in experimental infections of that tick, transovarial transmission has not been demonstrated[84]. This suggests that if *C. burnetii* were introduced into New Zealand, it would not become established.

Infection in domestic animals localises in the genital tract and mammary gland. The organism multiples in those sites and in milking animals is shed in the milk either continuously or intermittently throughout the lactation, as well as in the faeces and urine. In pregnant animals the organism colonises the placenta, but abortion is uncommon. At parturition, enormous numbers of the organisms are discharged in the foetal and uterine fluids, contaminating pastures, bedding and premises, as well as hair and fleece of parturient animals. Susceptible livestock become infected by inhaling aerosols of this material. Between pregnancies the infection is latent and cannot be isolated[82].

There are some differences between cattle, sheep and goats in their responses to infection with *C. burnetii*, in particular the proportion of infected animals that become carriers. Sheep infections seldom become chronic; these tend to be transient infections with spontaneous cure. In contrast, cattle and goat infections frequently result in long term shedding of the organism, particularly around parturition.

Humans are aberrant hosts who, when infected, occasionally develop disease. Infection of humans is by inhalation of aerosols of infectious material in abattoirs, dairies and on farms, through exposure to contaminated hides and wool, or through exposure to dust containing dried excreta from infected ticks and grazing animals[82].

Agent survival

C. burnetii is very stable outside the host, and is resistant to desiccation and putrefaction. When dried, the organism survives for 30-500 days[85]. It remains viable for 1-2 months in urine and dried sputum, for 6-9 months in blood, and as long as 1-2 years in dried tick faeces kept at ambient temperatures. Infected uterine discharges and other excretions and secretions dried in air can remain viable for many months[86]. Survival on wool has been shown to extend to 9 months[87].

Fibre as a vehicle

Wool is well recognised as a vehicle for the transmission of Q fever to humans.

Hazard identification conclusion

Q fever is a potential hazard in imported fibre of sheep and goats.

6.12.2 Release Assessment

Agent inactivation

Unlike other rickettsias, *C. burnetii* is very resistant to physical and chemical agents. Neither pasteurisation nor chemical methods of sterilisation will completely eliminate the organism. It is known to survive for at least 30 minutes at 62°C, and for about one minute at 71°C[88]. Moist heat at 75°C inactivates the organism within 8 seconds, and at 100°C within 1 second[85]. The effect of non-ionic detergents is unknown, but is assumed for the purposes of this risk analysis to be negligible.

Effect of scouring

The physical process of washing fibre would reduce the concentration of the agent in fibre, and while the detergent included in scouring liquor is unlikely to have any direct effect on agent survival it would assist in the flushing of organic and other particulate matter from the fibre.

The time/temperature regime in the scour (60-65°C for on average 3 - 4.5 minutes, followed by drying 40-50°C for about 3 minutes) would be inadequate to inactivate all *C. burnetii*.

Effect of further processing

Dyeing (boiling for at least 1 hour) of scoured fibre would inactivate any *C. burnetii* which survived the scouring process.

Effect of home spinning

The Q fever agent would not be affected by home spinning.

Effect of wool testing

The Q fever agent would not be affected by wool testing.

6.12.3 Exposure Assessment

The opportunities for exposure of susceptible animals in New Zealand to imported fibre were discussed in section 4 of this risk analysis. Exposure of humans to raw fibre during processing could be a public health issue for fibre contaminated with the Q fever agent. Exposure of animals to scoured fibre would be extremely limited, but exposure to scouring wastes might be possible with certain systems of disposal (e.g. spraying of effluent on pastures, dumping solid wastes in areas where stock could gain access). Exposure to wool packs containing contaminated wool is a theoretical possibility in the case of packs sent to farms for re-use. Exposure to fibre imported for home spinning is a theoretical possibility. Exposure to fibre imported for testing would be very unlikely during testing, and exposure after that would depend on methods of disposal.

6.12.4 Consequence Assessment

C. burnetii has probably been introduced into New Zealand in the past with live animal imports, but has failed to establish, presumably because of the lack of suitable insect vectors. The effects on livestock in New Zealand if Q fever were to establish would probably be minimal and there would not be an impact on trade[89]. However, the disease is an important zoonosis, and it could cause cases of human Q fever, particularly among slaughterhouse workers and people working with livestock.

6.12.5 Risk Estimation

Fibre of sheep and goats can be contaminated with the Q fever agent, and aqueous scouring would not destroy all of the agent present. It is theoretically possible that viable organisms would remain in scour effluent for several months. Exposure of humans to fibre during processing could be a public health issue. Exposure of livestock to the agent is theoretically possible via scour effluent. The consequences of the introduction and establishment of the disease agent could be serious.

Safeguards are justified.

6.12.6 Risk Management

The International Animal Health Code[9] does not contain any suggested safeguards for Q fever.

To be certain that any Q fever organisms on imported fibre were destroyed, the following safeguards would be necessary.

<u>Fibre for scouring</u>

For fibre imported from countries which are not free of Q fever, the fibre must be moved to an approved transitional facility for processing, where it must be treated as follows:

- Scouring at 60-70°C in full flow back mode with hot water rinses; and

- After scouring, all fibre must either be dyed or be further washed in water for at least 1 minute at a temperature of not less than 75°C; and

- In the transitional facility, the following measures must be applied to scouring wastes:

    - Machinery used for opening and dusting must be equipped with adequate dust control protection to prevent aerosols of the Q fever agent; and

    - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and

    - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

Wool packs

Wool packs from countries which are not free of Q fever must be moved to an approved transitional facility where they must be treated as follows :

- immersion in water heated and maintained at a temperature 75°C for at least one minute.

Fleeces for home spinning

Fleeces must be completely unpacked under official supervision and treated as follows:

- immersion in water heated and maintained at a temperature 75°C for at least one minute.

Fibre for testing

For fibre imported from countries which are not free of Q fever,

- Fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must be destroyed by incineration or treated as follows :

    - immersion in water heated and maintained at a temperature 75°C for at least one minute; or

    - Scouring

        - Scour must be operated at 60-70°C in full flow back mode with hot water rinses; and

- After scouring, all fibre must either be dyed or be further washed in water for at least 1 minute at a temperature of not less than 75°C; and

- In the transitional facility, the following measures must be applied to scouring wastes:

    - Machinery used for opening and dusting must be equipped with adequate dust control protection to prevent aerosols of the Q fever agent; and

    - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and

    - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

6.13 Rabies - B058

6.13.1 Hazard Identification

The disease

Rabies is a fatal nervous disease of warm-blooded vertebrates, caused by a Lyssavirus. Transmission is generally by the bite of diseased animals, most commonly dogs and other carnivores. Apart from dogs and cats, the most commonly affected domestic animal is cattle. Sheep, goats, buffalo, horses and pigs are rarely affected. Rabies is an important zoonosis.

Agent survival

Rabies virus is sensitive to sunlight, ultraviolet irradiation, and detergents. It is inactivated by heating to 56°C for 30 minutes[(90)].

Fibre as a vehicle

As rabies is generally transmitted only by the bite of an infected animal, fibre is not considered to be a vehicle for this disease.

Hazard identification conclusion

Rabies is not a potential hazard in imported fibre of sheep and goats.

6.14 Paratuberculosis - B059

6.14.1 Hazard Identification

The disease

Paratuberculosis or Johne's disease is a chronic infectious enteritis of cattle, deer, sheep, goats and llamoids, and is caused by *Mycobacterium paratuberculosis*. It is endemic in New Zealand and is not subject to any official control programme.

The agent is shed in the faeces of infected animals, and transmission is mainly by the faecal-oral route.

Agent survival

M. paratuberculosis is able to survive and remain infectious in the environment for long periods, depending on the conditions. The organism persisted in 45% of samples of infected faeces held at room temperature for 10 days. It will survive for shorter periods in dry conditions, especially when exposed to sunlight; on filter paper exposed to sunlight the organism survived 65 hours but not 100 hours[(91)].

Fibre as a vehicle

Although contaminated fibre has not been reported as a vehicle for the transmission of Johne's disease, it is theoretically possible that faeces-contaminated fibre harvested from infected flocks could harbour the organism. However, survival on dry wool, especially if exposed to sunlight, is likely to be short-lived. For these reasons, and because the organism is endemic in New Zealand and is not subject to any official control programme, it is not considered further in this risk analysis.

Hazard identification conclusion

Johne's disease is not a potential hazard in imported fibre of sheep and goats.

6.15 Screwworm - B060

6.15.1 Hazard Identification

The disease

Screwworm fly (SWF) is an obligate parasite of warm-blooded animals. There are two species of SWF, the Old World SWF (*Chrysomya bezziana*) and the New World SWF (*Cochliomyia hominivorax*), but despite their similarities only the latter species is listed by the OIE. Myiasis by SWF can cause serious production losses to livestock industries. Wounding is usually a pre-requisite for SWF strike; eggs are laid on the periphery of wounds or body orifices in masses of up to 250. The eggs hatch within 12-20 hours, and the larvae burrow deep into the wound and feed on blood for 6-7 days, after which they drop off the host and burrow into soil to a depth of 2 cm or more to pupate, usually within a week, but pupation may take up to 60 days in adverse conditions[92].

Agent survival

Average life span of adults is 21 days, but they require a supply of water and carbohydrate to survive more than a day or two. Optimal temperature range for the flies is 20-30°C. Flies will not move at temperatures below 10°C, and in the range 10-16°C they will not mate. Long distance spread of the disease is most likely to be by transport of infested animals[92].

Fibre as a vehicle

Adult flies would be unlikely to be found in fibre, and would not survive transport. Therefore fibre is not considered to be a vehicle for screwworm.

Hazard identification conclusion

Screwworm fly is not a potential hazard in imported fibre of sheep and goats.

6.16 Bovine brucellosis - B103

6.16.1 Hazard Identification

The disease

Bovine brucellosis is a highly contagious bacterial disease caused by *Brucella abortus*. It is characterised by abortion and infertility in cows and is also a serious zoonosis, causing undulant fever in humans. The organism may occasionally cause abortions in sheep and goats, but it does not spread in these species[93] and is highly unlikely to spread from them to other species[94].Transmission in animals is almost exclusively by the ingestion of infected milk, discharges or contaminated feed[93].

Agent survival

The organism is not very resistant to sunlight and drying. It has been shown to survive on hairy hides for up to 8 days[95].

Fibre as a vehicle

Rare cases of abortions in sheep and goats could result in skin and fleece contamination, but the organism is unlikely to survive longer than a 8 days on fibre. The probability of imported fibre being contaminated with viable organisms is considered to be extremely remote.

Hazard identification conclusion

B. abortus is not a potential hazard in imported fibre of sheep and goats.

6.17 Bovine tuberculosis - B105

6.17.1 Hazard Identification

The disease

Bovine tuberculosis is caused by *Mycobacterium bovis.* Sheep and goats are rarely affected and are not considered to be important epidemiologically.

The disease is endemic in New Zealand, and is under a compulsory control programme (a National Pest Management Strategy) administered by the Animal Health Board.

Agent survival

If a severe clinical case of tuberculosis did occur in sheep and goats, organisms might be coughed onto the fleece, but survival would be relatively short as the fleece would typically be exposed to sunlight. For example, sputum containing *M. tuberculosis*, when exposed to direct or diffuse sunlight, remained infectious for less than 10 hours[(96)].

Fibre as a vehicle

As sheep and goats are only rarely infected with *M. bovis*, and as the organism would not be expected to survive longer than a few hours on fibre even in the extremely unlikely event that contamination occurred, fibre is not considered to be a vehicle for this disease.

Hazard identification conclusion

M. bovis is not a potential hazard in imported fibre of sheep and goats.

6.18 Dermatophilosis - B107

6.18.1 Hazard Identification

The disease

Dermatophilosis is an exudative pustular dermatitis, caused by the bacterium *Dermatophilus congolensis*. The infective form of the organism is the thick-walled motile zoospore, which is released by the vegetative form of the organism[97].

It affects many domestic animals. It is endemic and widespread in New Zealand, and not under any form of regulatory control.

Infection is spread by contact with infected animals and contaminated shearing equipment, by the splashing effects of heavy rain, and by insects[97].

Agent survival

D. congolensis survives well in the environment and has been shown to occur in soil collected during dry seasons[97]. The motile zoospores of the organism survive only a few hours, but dried spores can survive for long periods. However, after moistening of contaminated materials, their lifespan is very limited unless they can penetrate into the skin of a susceptible host[98].

Fibre as a vehicle

While it is possible that fibre harvested from infected flocks could harbour spores of the organism, as it is endemic in New Zealand and is not under any official control programme, it is not considered further in this risk analysis.

Hazard identification conclusion

D. congolensis is not a potential hazard in imported fibre of sheep and goats.

6.19 Enzootic bovine leukosis - B108

6.19.1 Hazard Identification

The disease

Enzootic bovine leukosis is a disease of adult cattle, and occasionally sheep, caused by the bovine leukaemia virus, which is a member of the Retroviridae family. Infection with the virus in cattle is lifelong, giving rise to a persistent antibody response. Most infections are asymptomatic; while up to 30% of infected cattle develop persistent lymphocytosis, only 1% of infected cattle develop lymphosarcoma[(99)].

High antibody titres develop in sheep, but persistent lymphocytosis has not been observed. It is not certain whether goats may be infected or not[(99)].

Transmission requires the transfer of blood between animals, by multiple use of syringes, biting insects or rectal palpation. Calves become infected by the ingestion of contaminated milk[(99)].

Infection is endemic in New Zealand. Surveys have shown that 3-4% of herds are infected, with an average within-herd prevalence of 6%. A voluntary control programme for the dairy cattle industry is administered by the Livestock Improvement Corporation, but there is no programme in the beef cattle industry.

Agent survival

Retroviruses are sensitive to heat but relatively resistant to UV light[(100)]. The EBL virus in milk is inactivated by heating to 60°C for one minute[(101)]. As with other retroviruses the EBL virus is cell-associated, and it does not survive well outside the host. A related human retrovirus, HIV, lost all infectivity after 11-15 days in suspension at 37°C, and when dried and held at room temperature (23-27°C), it lost 1 log of infectivity every 9 hours[(102)].

Fibre as a vehicle

As infection in sheep and goats is uncommon and the virus survives very briefly outside the host, fibre is not considered a vehicle for this disease.

Hazard identification conclusion

EBL is not a potential hazard in imported fibre of sheep and goats.

6.20 Theileriosis - B111

6.20.1 Hazard Identification

The disease

Theileriosis is caused by tick-transmitted protozoa in the genus *Theileria*. The taxonomy of the theilerial parasites of sheep and goats is very confused. *T. hirci* causes malignant ovine theileriosis, and is probably spread by the tick *Rhipicephalus bursa*[103]. Benign ovine theileriosis is caused by *T. ovis* and is transmitted by *R. bursa* and *R. evertsi evertsi*, and probably *Hyalomma* spp. a non-pathogenic form of ovine theileriosis occurs in southern Africa, caused by *T. separata* and transmitted by *R. evertsi evertsi*[104].

Although carrier animals are common, theileriosis is not a contagious disease. Spread is only possible through specific infected tick vectors. Suitable vectors for ovine theileriosis do not exist in New Zealand.

Agent survival

Theileria spp. do not survive outside infected animals or ticks[104].

Fibre as a vehicle

As theilerial parasites do not survive in the environment, fibre is not considered to be a vehicle for this disease.

Hazard identification conclusion

Theileriosis is not a potential hazard in imported fibre of sheep and goats.

6.21 Trypanosomosis - B113

6.21. 1 Hazard Identification

The disease

Trypanosomosis results from infection with parasitic protozoa of the genus *Trypanosoma*. In Africa, where the disease is of greatest importance, transmission is almost entirely dependent on bloodsucking flies of the genus *Glossina*, commonly known as "tsetse flies"[105]. Some trypanosomes are transmitted mechanically by biting flies *e.g. T. evansi*, which causes the disease surra in a wide range of host animals.

With the exception of the stable fly *Stomoxys calcitrans*, which might be able to transmit the parasite mechanically, there are no suitable insect vectors in this country.

Trypanosomosis of goats and sheep is generally of little significance as natural infections are rarely detected. However, severe disease can occur in sheep and goats infected with *T. congolense* and *T. brucei*, and mild disease may be caused by *T.vivax*. Asymptomatic infection with *T. simiae* also occurs[105].

Agent survival

Trypanosomes cannot persist outside hosts or vectors[105].

Fibre as a vehicle

As the agent does not survive in the environment, fibre is not considered to be a vehicle for this disease.

Hazard identification conclusion

Trypanosomosis is not a potential hazard in imported fibre of sheep and goats.

6.22 Bovine malignant catarrh - B114

6.22.1 Hazard Identification

The disease

Bovine malignant catarrh or malignant catarrhal fever (MCF) is a sporadic but almost invariably fatal viral disease of cattle, buffalo and deer, caused by a gamma-herpesvirus. Ovine herpes virus-2, which is present in all breeds of domestic sheep as a subclinical infection, is the cause of sheep-associated MCF in most regions of the world[106].

Sheep-associated MCF is endemic in New Zealand. The disease in cattle and deer occurs sporadically, usually after close contact with sheep, although the route of natural infection is not known. There is no official control programme for the disease in New Zealand.

Agent survival

Gammaherpesviruses are highly cell-associated, and can only be recovered from living cells[107].

Fibre as a vehicle

As the agent does not survive in the environment, fibre is not considered to be a vehicle for this disease.

Hazard identification conclusion

MCF is not a potential hazard in imported fibre of sheep and goats.

6.23 *Brucella ovis* infection - B151

6.23.1 Hazard Identification

The disease

The bacterium *Brucella ovis* produces a clinical or subclinical disease in sheep that is characterised by genital lesions in rams and placentitis in ewes. Transmission is by the venereal route.

The organism is endemic and widespread in New Zealand, and under a voluntary control scheme.

Agent survival

Although the organism can survive on pasture for several months, transmission by fomites appears to have no practical significance[108].

Fibre as a vehicle

Fibre is not considered to be a vehicle for this disease.

Hazard identification conclusion

B. ovis is not a potential hazard in imported fibre of sheep and goats.

6.24 Caprine and ovine brucellosis - B152

6.24.1 Hazard Identification

The disease

Brucella melitensis (biovars 1,2, or 3) is the main causative agent of caprine and ovine brucellosis causing abortion, retained placenta, orchitis, epididymitis and arthritis. The organism is highly pathogenic for humans, and is a serious zoonosis[109].

Genital discharges of infected goats and sheep are usually copious and persist for up to 3 months following abortion, kidding or lambing. These discharges often contain large numbers of the organism and are the prime sources of infection. Although infection occurs by the ingestion of infected milk, inhalation is the most important route of infection in goats and sheep, and the herding of these animals into pens at night creates an ideal environments for the spread of infection. Young animals usually recover spontaneously from infection, but recovery in mature animals is rare. Congenital latent infection is suspected but has never been proven[110]. The duration of shedding of organisms in milk and in uterine discharges of sheep may be less prolonged than in goats[111].

Humans may become infected by contact with infectious material while handling infected animals or by drinking infected milk[112].

Agent survival

B. melitensis has been shown to survive on dried cloth for up to 80 days, and in street dust for up to 72 days[113].

Fibre as a vehicle

Fibre could possibly become contaminated with infected genital discharges and such fibre might harbour the organism for up to 3 months. Unprocessed fibre could therefore serve as a vehicle for introduction *B. melitensis*.

Hazard identification conclusion

B. melitensis is a potential hazard in imported fibre of sheep and goats.

6.24.2 Release Assessment

Agent inactivation

B. melitensis is inactivated quickly by moist heat. At 60°C the organism survived 7.5 minutes but not 10 minutes, at 61.1°C it survived 5 but not 7.5 minutes, and at 62.8°C no viable organism was detected after 5 minutes[114].

Effect of scouring

The time/temperature regime in the scour and drier (60-65°C for 3 - 4.5 minutes, followed by 40-50°C for about 3 minutes) would destroy any *B. melitensis* in fibre.

Effect of home spinning

Home spinning would not have any effect on agent survival.

Effect of wool testing

Wool testing would not have any effect on agent survival.

6.24.3 Exposure Assessment

The opportunities for exposure of susceptible animals in New Zealand to imported fibre were discussed in section 4 of this risk analysis. Exposure to scoured fibre would be extremely limited, but exposure to scouring wastes might be possible with certain systems of disposal (e.g. spraying of effluent on pastures, dumping solid wastes in areas where stock could gain access). Exposure to wool packs containing contaminated wool is a theoretical possibility in the case of packs sent to farms for re-use. Exposure to fibre imported for home spinning is a theoretical possibility. Exposure to fibre imported for testing would be very unlikely during testing, and exposure after that would depend on methods of disposal.

6.24.4 Consequence Assessment

The introduction and establishment of *B. melitensis* into New Zealand would have a serious impact on the sheep industry in terms of production losses, cost of control, and on international market access. It would also have a serious effect on human health.

6.24.5 Risk Estimation

B. melitensis might persist for several months on fibre. Aqueous scouring would destroy the organism. Exposure pathways are unlikely, but the consequences of introduction and establishment of the disease would be very severe.

Safeguards are justified.

6.24.6 Risk Management

The International Animal Health Code[9] does not contain any suggested safeguards for brucellosis.

To be certain that any *B. melitensis* organisms on imported fibre were destroyed, the following safeguards would be necessary.

Fibre for scouring

For fibre imported from countries which are not free of *B. melitensis*, the fibre must be moved to an approved transitional facility for processing, where it must be treated as follows :

- scouring at 60-70°C in partial or full flow back mode.
- In the transitional facility, the following measures must be applied to scouring wastes:
    - Machinery used for opening and dusting must be equipped with adequate dust control protection to prevent aerosols of *B. melitensis*.

Wool packs

Wool packs from countries which are not free of *B. melitensis* must be moved to an approved transitional facility where they must be treated as follows :

- immersion in water heated and maintained at a temperature of at least 65°C for at least 5 minutes.

Fleeces for home spinning

Fleeces must be completely unpacked under official supervision and treated as follows:

- immersion in water heated and maintained at a temperature of at least 65°C for at least 5 minutes.

Fibre for testing

For fibre imported from countries which are not free of *B. melitensis*,

- Fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must be destroyed by incineration or treated as follows :
    - Immersion in water heated and maintained at a temperature of at least 65°C for at least 5 minutes; or
    - Scouring at 60-70°C in full or partial flow back mode.

6.25 Caprine arthritis / encephalitis - B153

6.25.1 Hazard Identification

The disease

Caprine arthritis / encephalitis (CAE) is caused by a retrovirus in the ovine/caprine group of lentiviruses, closely related to the maedi-visna virus. It is considered to be endemic in goats in New Zealand, although it is recognised to be more common in dairy goats than in goats raised for fibre. A voluntary flock accreditation scheme began for dairy goats in 1984[115], but industry participation has declined sharply in recent years. Testing of fibre goats is usually only carried out for export certification.

Most infected animals show no symptoms, but remain persistent carriers of the virus. The main route of transmission is via colostrum or milk, but the disease can also be transmitted by contact during and following the perinatal period. The mechanism of contact transmission is not known, but respiratory secretions cannot be ruled out[116].

Agent survival

Retroviruses are sensitive to heat but relatively resistant to UV light[100]. The lentiviruses of goats and sheep are susceptible to most forms of chemical inactivation because of the fragile lipoprotein envelope of the virion. The CAE virus is inactivated by heating at 56°C for 10 minutes[117]. As with other retroviruses it is cell-associated, and does not survive well outside the host. A related human retrovirus, HIV, lost all infectivity after 11-15 days in suspension at 37°C, and when dried and held at room temperature (23-27°C), it lost 1 log of infectivity every 9 hours[102].

Fibre as a vehicle

As the virus survives for only a short period outside the host, fibre is not considered to be a vehicle for this disease.

Hazard identification conclusion

CAE is not a potential hazard in imported fibre of sheep and goats.

6.26 Contagious agalactia - B154

6.26.1 Hazard Identification

The disease

Contagious agalactia is a disease complex of sheep and goats, manifesting as mastitis, arthritis and keratoconjunctivitis. It is not seen in New Zealand. The cause is not completely clear[118]. It was originally associated only with *Mycoplasma agalactiae*, but there are now three other mycoplasmas that have been shown to cause similar diseases, particularly in goats. These are *M. capricolum* subsp. *capricolum*, *M. mycoides* subsp. *mycoides LC*, and *M. putrefacens*[119]. *M. arginini* may also be involved[118].

Of the above mycoplasmas, only *M. arginini,* has been isolated from New Zealand sheep and goat populations.

Clinically diseased animals shedding the agent in milk, urine, nasal and lacrimal secretions are the main source of infection. Sporadic shedding of the organism occurs in chronically infected animals, mainly in the milk[120].

Agent survival

Mycoplasmas are generally quite sensitive to desiccation, but under favourable conditions (high moisture, low temperature) they may survive for considerable periods in the environment. For example, *M. mycoides* subsp. *mycoides* SC has been shown to survive on hay kept in the shade for at least 9 days[121]. *M. agalactiae* subsp. *bovis* may survive in manure for almost 8 months at 23-28°C[122]. However, mycoplasmas are relatively sensitive to exposure to sunlight. Corn straw contaminated with *M. bovis* and exposed to light remained contaminated for 4 days at 23-28°C, while textiles exposed to light remained contaminated for 9 days[123].

Fibre as a vehicle

Fibre could become contaminated with mycoplasmas in milk or in the environment. Such fibre could possibly remain contaminated for several weeks.

Hazard identification conclusion

Mycoplasmas causing contagious agalactia are potential hazards in imported fibre of sheep and goats.

6.26.2 Release Assessment

Agent inactivation

Mycoplasmas are generally not particularly resistant to physical and chemical influences. Sealed cultures of *Mycoplasma agalacticae* subsp. *agalacticae* survived less than 8 minutes at 53°C[124]. *M. gallisepticum* culture, exposed to different temperatures in an incubator, showed an exponential decrease in viability of the organism as temperature increased over 40°C[125]. *M. mycoides* subsp. *mycoides* is inactivated by disinfectants based on formalin, phenol or cresol, even in low concentrations[126].

Effect of scouring

The time/temperature regime in the scour and drier (60-65°C for on average 3 - 4.5 minutes, followed by 40-50°C for about 3 minutes) would destroy any mycoplasmas in fibre.

Effect of home spinning

Home spinning would not have any effect on agent survival.

Effect of wool testing

Wool testing would not have any effect on agent survival.

6.26.3 Exposure Assessment

The opportunities for exposure of susceptible animals in New Zealand to imported fibre were discussed in section 4 of this risk analysis. Exposure to scoured fibre would be extremely limited, but exposure to scouring wastes might be possible with certain systems of disposal (e.g. spraying of effluent on pastures, dumping solid wastes in areas where stock could gain access). Exposure to wool packs containing contaminated wool is a theoretical possibility in the case of packs sent to farms for re-use. Exposure to fibre imported for home spinning is a theoretical possibility. Exposure to fibre imported for testing would be very unlikely during testing, and exposure after that would depend on methods of disposal.

6.26.4 Consequence Assessment

The establishment of the contagious agalactia disease complex in sheep and goats in New Zealand would result in significant production losses and there would be some effects on international trade, especially in live animals.

6.26.5 Risk Estimation

Mycoplasmas causing contagious agalactia might survive for several weeks on fibre. Aqueous scouring would destroy the organism. Exposure pathways are unlikely, but the consequences of introduction and establishment of the disease could be serious.

Safeguards are justified.

6.26.6 Risk Management

The International Animal Health Code[9] does not contain any suggested safeguards for contagious agalactia.

To be certain that any organisms on imported fibre were destroyed, the following safeguards would be necessary.

Fibre for scouring

For fibre imported from countries which are not free of *Mycoplasma agalactiae*, *M. capricolum* subsp. *capricolum*, *M. mycoides* subsp. *mycoides LC*, and *M. putrefacens*,

- Documentary proof must be produced that the fibre has been at least 2 weeks in transit to New Zealand; or
- The fibre must be stored in a transitional facility for 2 weeks after arrival in New Zealand prior to scouring; or
- The fibre must be moved to an approved transitional facility for processing, where it must be treated by scouring at 60-70°C in partial or full flow back mode.

Wool packs

For wool packs from countries which are not free of *Mycoplasma agalactiae*, *M. capricolum* subsp. *capricolum*, *M. mycoides* subsp. *mycoides LC*, and *M. putrefacens*,

- Documentary proof must be produced that the packs have been at least 2 weeks in transit to New Zealand; or
- The wool packs must be stored in a transitional facility for 2 weeks after arrival in New Zealand prior to use; or
- The wool packs must be moved to an approved transitional facility where they must be treated by immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes.

Fleeces for home spinning

- Documentary proof must be produced that the fleeces have been at least 2 weeks in transit to New Zealand; or

- The fleeces must be stored in a transitional facility for 2 weeks after arrival in New Zealand prior to use; or

- The fleeces must be completely unpacked under official supervision and treated by immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes.

Fibre for testing

For fibre imported from countries which are not free of *Mycoplasma agalactiae*, *M. capricolum* subsp. *capricolum*, *M. mycoides* subsp. *mycoides LC*, and *M. putrefacens*,

- Documentary proof must be produced that the fibre has been at least 2 weeks in transit to New Zealand; or

- The fibre must be stored in a transitional facility for 2 weeks after arrival in New Zealand prior to testing; or

- Fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must be destroyed by incineration or treated as follows :

    - Immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes; or

    - Scouring at 60-70°C in full or partial flow back mode.

6.27 Contagious caprine pleuropneumonia - B155

6.27.1 Hazard Identification

The disease

Contagious caprine pleuropneumonia (CCPP) is a serious contagious disease of goats caused by *Mycoplasma capricolum* subsp. *capripneumoniae* (strain F38).

The taxonomy and identification of caprine mycoplasmas is difficult and confusing. The F38 strain is closely related to three other mycoplasmas - *M. mycoides* subsp. *mycoides*, *M. mycoides* subsp. *capri*, and *M. capricolum* subsp. *capricolum* - all of which may confuse the diagnosis of CCPP both because the diseases they produce can resemble the classical disease and because they share several serological and biochemical characteristics with F38[127].

Pleuropneumonia has not been reported in goats in New Zealand, and surveys for mycoplasmas have never isolated strain F38.

Transmission is by inhalation of infectious aerosols. Latently infected animals are often responsible for spreading the disease between herds and regions[128].

Agent survival

Mycoplasmas are generally quite sensitive to desiccation, but under favourable conditions (high moisture, low temperature) they may survive for considerable periods in the environment. For example, *M. mycoides* subsp. *mycoides* (SC) has been shown to survive on hay kept in the shade for at least 9 days[121]. *M. agalactiae* subsp. *bovis* may survive in manure for almost 8 months at 23-28°C[122]. However, mycoplasmas are relatively sensitive to exposure to sunlight. Corn straw contaminated with *M. bovis* and exposed to light remained contaminated for 4 days at 23-28°C, while textiles exposed to light remained contaminated for 9 days[123].

Fibre as a vehicle

Assuming that respiratory aerosols are responsible for spread of the disease, fibre could possibly become contaminated with mycoplasmas, and such fibre might remain contaminated for several weeks.

Hazard identification conclusion

CCPP is a potential hazard in imported fibre of sheep and goats.

6.27.2 Release Assessment

Agent inactivation

Mycoplasmas are generally not particularly resistant to physical and chemical influences. Sealed cultures of *Mycoplasma agalacticae* subsp. *agalacticae* survived less than 8 minutes at 53°C[124]. *M. gallisepticum* culture, exposed to different temperatures in an incubator, showed an exponential decrease in viability of the organism as temperature increased over 40°C[125]. *M. mycoides* subsp. *mycoides* is inactivated by disinfectants based on formalin, phenol or cresol, even in low concentrations[126].

Effect of scouring

The time/temperature regime in the scour and drier (60-65°C for on average 5 minutes, followed by 40-50°C for about 3 minutes) would destroy any mycoplasmas in fibre.

Effect of home spinning

Home spinning would not have any effect on agent survival.

Effect of wool testing

Wool testing would not have any effect on agent survival.

6.27.3 Exposure Assessment

The opportunities for exposure of susceptible animals in New Zealand to imported fibre were discussed in section 4 of this risk analysis. Exposure to scoured fibre would be extremely limited, but exposure to scouring wastes might be possible with certain systems of disposal (e.g. spraying of effluent on pastures, dumping solid wastes in areas where stock could gain access). Exposure to wool packs containing contaminated wool is a theoretical possibility in the case of packs sent to farms for re-use. Exposure to fibre imported for home spinning is a theoretical possibility. Exposure to fibre imported for testing would be very unlikely during testing, and exposure after that would depend on methods of disposal.

6.27.4 Consequence Assessment

The introduction and establishment of CCPP to New Zealand could have severe effects on local goat production and on trade in live goats and goat meat.

6.27.5 Risk Estimation

The mycoplasma causing CCPP might survive for several weeks on fibre. Aqueous scouring would destroy the organism. Exposure pathways are unlikely, but the consequences of introduction and establishment of the disease could be serious.

Safeguards are justified.

6.27.6 Risk Management

The International Animal Health Code[9] does not contain any suggested safeguards for CCPP.

To be certain that any organisms on imported fibre were destroyed, the following safeguards would be necessary.

Fibre for scouring

For fibre imported from countries which are not free of CCPP,

- Documentary proof must be produced that the fibre has been at least 2 weeks in transit to New Zealand; or
- The fibre must be stored in a transitional facility for 2 weeks after arrival in New Zealand prior to scouring; or
- The fibre must be moved to an approved transitional facility for processing, where it must be treated by scouring at 60-70°C in partial or full flow back mode.

Wool packs

For wool packs from countries which are not free of CCPP,

- Documentary proof must be produced that the packs have been at least 2 weeks in transit to New Zealand; or
- The packs must be stored in a transitional facility for 2 weeks after arrival in New Zealand prior to use; or
- The packs must be moved to an approved transitional facility where they must be treated by immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes.

Fleeces for home spinning

- Documentary proof must be produced that the fleeces have been at least 2 weeks in transit to New Zealand; or
- The fleeces must be stored in a transitional facility for 2 weeks after arrival in New Zealand prior to use; or

- The fleeces must be completely unpacked under official supervision and treated by immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes.

Fibre for testing

For fibre imported from countries which are not free of CCPP,

- Documentary proof must be produced that the fibre has been at least 2 weeks in transit to New Zealand; or

- The fibre must be stored in a transitional facility for 2 weeks after arrival in New Zealand prior to testing; or

- The fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must be destroyed by incineration or treated as follows :

    - Immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes; or

    - Scouring at 60-70°C in full or partial flow back mode.

6.28 Enzootic abortion of ewes - B156

6.28.1 Hazard Identification

The disease

Enzootic abortion of sheep and goats (ovine chlamydiosis) is caused by a specific strain of *Chlamydia psittaci* . It is one of the commonest causes of ovine abortion in many countries, especially in Europe on intensively managed sheep farms. It is a zoonosis; pregnant women working with sheep have become infected and aborted as a result[129]. New Zealand is free of ovine chlamydiosis[130].

The environment becomes contaminated with *Chlamydia* by both diseased and carrier animals shedding the organism in faeces and discharges from the genital and respiratory tracts. The faecal-oral route is probably the most common means of transmission[131].

Agent survival

Most *Chlamydia* spp are highly resistant to freezing and to desiccation[131]. An ovine strain spread on straw remained infectious for 20 days, while in urine the same strain survived 11 days[132].

Fibre as a vehicle

It is possible that fibre could become contaminated with the agent, and that such fibre could remain contaminated for several weeks at normal room temperature. Fibre kept in very cold and damp conditions could remain contaminated for longer periods.

Hazard identification conclusion

Ovine chlamydiosis is a potential hazard in imported fibre of sheep and goats.

6.28.2 Release Assessment

Agent inactivation

The cell wall of *Chlamydia* spp contains a considerable amount of lipid, which makes them susceptible to detergents. They are rapidly destroyed by heat, but the time taken to die is related to the amount of protective cellular material present[133]. *C. psittaci* suspension in broth stored at 56°C survived less than 4 minutes[134].

Effect of scouring

The time/temperature regime in the scour and dryer (60-65°C for on average 3 - 4.5 minutes, followed by 40-50°C for about 3 minutes) would destroy *C. psittaci*.

Effect of home spinning

Home spinning would not have any effect on agent survival.

Effect of wool testing

Wool testing would not have any effect on agent survival.

6.28.3 Exposure Assessment

The opportunities for exposure of susceptible animals in New Zealand to imported fibre were discussed in section 4 of this risk analysis. As far as ovine chamlydiosis is concerned, the possible exposure pathways do not include wool after scouring or wastes from scouring plants. Wool packs containing contaminated wool is a theoretical possibility in the case of packs sent to farms for re-use. Exposure to fibre imported for home spinning is a theoretical possibility. Exposure to fibre imported for testing would be very unlikely during testing, and exposure after that would depend on methods of disposal.

6.28.4 Consequence Assessment

The introduction and establishment of ovine chlamydial abortion would have serious consequences for New Zealand. It would cause high abortion rates in infected flocks, and it would be difficult to eliminate infection once established. It could probably have a significant effect on international trade, at least in live animals, and it is a zoonosis.

6.28.5 Risk Estimation

Fibre of sheep and goats might possibly become contaminated with *C. psittaci*, and such contamination might remain for weeks or even longer under certain conditions. Aqueous scouring would destroy the organism. Exposure pathways are unlikely, but the consequences of introduction and establishment of the disease would be serious.

Safeguards are justified.

6.28.6 Risk Management

The International Animal Health Code[9] does not contain any suggested safeguards for *C. psittaci*.

To be certain that any organisms on imported fibre were destroyed, the following safeguards would be necessary.

Fibre for scouring

For fibre imported from countries which are not free of ovine chlamydial abortion,

- Documentary proof must be produced that the fibre has been at least 4 weeks in transit to New Zealand; or
- The fibre must be stored in a transitional facility for 4 weeks after arrival in New Zealand prior to scouring; or
- The fibre must be moved to an approved transitional facility for processing, where it must be treated by scouring at 60-70°C in partial or full flow back mode.

Wool packs

For wool packs from countries which are not free of ovine chlamydial abortion,

- Documentary proof must be produced that the packs have been at least 4 weeks in transit to New Zealand; or
- The packs must be stored in a transitional facility for 4 weeks after arrival in New Zealand prior to use; or
- The packs must be moved to an approved transitional facility where they must be treated by immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes.

Fleeces for home spinning

- Documentary proof must be produced that the fleeces have been at least 4 weeks in transit to New Zealand; or
- The fleeces must be stored in a transitional facility for 4 weeks after arrival in New Zealand prior to use; or
- The fleeces must be completely unpacked under official supervision and treated by immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes.

Fibre for testing

Fibre imported for testing from countries which are not free of ovine chlamydial abortion,

- Documentary proof must be produced that the fibre has been at least 4 weeks in transit to New Zealand; or
- Fibre must be stored in a transitional facility for 4 weeks after arrival in New Zealand prior to testing; or

- The fibre must be moved to an approved transitional facility for testing, and after completion of testing, it must be destroyed by incineration or treated by one of the following methods:

    - immersion in water heated and maintained at a temperature of at least 60°C for at least 5 minutes; or

    - scouring at 60-70°C in full or partial flow back mode.

6.29 Pulmonary adenomatosis - B157

6.29.1 Hazard Identification

The disease

Pulmonary adenomatosis or jaagsiekte ("driving disease") is a contagious neoplasm which affects the lungs of mature sheep, and rarely goats. It is caused by a type D retrovirus. The disease has a protracted course but is invariably fatal. Annual mortality in infected flocks varies from less than 1% to as high as 25%[135]. The disease is often closely associated with lentivirus infections (see OIE listed diseases B153 and B161).

It is assumed that sheep with lung lesions excrete the virus, and infect other animals by droplet infection. Outbreaks occur when infected sheep are introduced into clean flocks, particularly when animals are in close contact such as in overnight housing[136].

Agent survival

Retroviruses are sensitive to heat but relatively resistant to UV light[100]. Although it is relatively resistant to repeated freezing and thawing, only small quantities of the jaagsiekte virus will survive storage at 4°C for 4 months, and heating at 50°C (in 1% serum) inactivated 90% of the infectivity in 10-15 minutes[135]. As with other retroviruses the jaagsiekte virus is cell-associated, and since it does not survive well outside the host, it does not persist in the environment[135].A related human retrovirus, HIV, lost all infectivity after 11-15 days in suspension at 37°C, and when dried and held at room temperature (23-27°C), it lost 1 log of infectivity every 9 hours[102].

Fibre as a vehicle

As the agent survives for only a short period outside the host, fibre is not considered a vehicle for this disease.

Hazard identification conclusion

Pulmonary adenomatosis is not a potential hazard in imported fibre of sheep and goats.

6.30 Nairobi sheep disease - B158

6.30.1 Hazard Identification

The disease

Nairobi sheep disease (NSD) is a tick-transmitted disease of small ruminants, especially sheep, caused by a Bunyavirus. The disease is severe, characterised by fever, haemorrhagic gastroenteritis, abortion and a high mortality (up to 90%). *Rhipicephalus appendiculatus* is by far the most efficient vector, and the only one in which transovarial transmission has been demonstrated. Other ticks (*R. pulchellus*, *R. simus*, and *Amblyomma variegatum*) can also transmit the virus, but it is doubtful whether the disease could be sustained by these alone[137].

Most sheep and goats in endemic areas have antibody for the virus, and only incidental losses are observed. Outbreaks of NSD usually arise either as a result of the movement of susceptible animals into endemic areas or the incursion of infected ticks into NSD free flocks or areas. The latter situation may occur in years with excessive or prolonged rains which result in vegetation and microclimatic changes favourable for an extension in the range of *R. appendiculatus*[137].

The incubation period is 4-6 days after tick attachment. Fever lasts 1-7 days, and is accompanied by viraemia, which disappears within 24 hours of the temperature returning to normal.

Agent survival

The virus is rapidly inactivated at either high or low pH. Even in the range of optimal stability (pH 7.4 - 8.0), in the presence of 2% serum, the virus is easily inactivated with a half-life of about 7 days at 0°C and 1½ hours at 37°C[137].

Fibre as a vehicle

As this is an insect-borne disease and the virus is rapidly inactivated outside its host or vector, fibre is not considered to be a vehicle for transmission.

Hazard identification conclusion

Nairobi sheep disease is not a potential hazard in imported fibre of sheep and goats.

6.31 Salmonellosis (*S. abortus ovis*) - B159

6.31.1 Hazard Identification

The disease

Salmonella abortus ovis causes abortion in sheep[138]. Sheep which have recovered from clinical disease may become subclinical carriers and excrete organisms in their faeces intermittently. Infection is predominantly by the oral route. Stress plays an important role.

S. abortus ovis is highly adapted to sheep and is not considered to be important as a zoonosis[139].

Agent survival

Important factors affecting survival include temperature and humidity (in warm, humid conditions the organism will grow, and in cold conditions the organism will survive for considerable periods), the medium (protein-rich waste water and sewage promote growth), and pH (the organism is destroyed quickly below pH 4.0). Salmonellas can survive for more than 3 years in dry faeces and at low temperatures, and for more than a year in liquid manure and soil. Ultraviolet light destroys them quickly. Protein-rich feed stuffs and even green fodder and hay may remain contaminated for several months[140]. Salmonellas are rapidly inactivated by moist heat. Survival time at 56°C is 10-20 minutes, and less at higher temperatures. At 80°C most salmonellas survive less than 3 minutes[141].

Fibre as a vehicle

Fibre could become contaminated with *S. abortus ovis* in infected faeces or discharges, and under certain conditions such fibre could remain contaminated for months or years.

Hazard identification conclusion

S. abortus ovis is a potential hazard in imported fibre of sheep and goats.

6.31.2 Release Assessment

Agent inactivation

Salmonellas, with the exception of some heat-resistant strains, are killed in about 10-20 minutes at 56°C[142]. Non-ionic detergents are assumed to have little effect on their viability.

Effect of scouring

The physical process of washing fibre would reduce the concentration of the agent in the fibre. The detergent included in scouring liquor is unlikely to have any direct effect on survival of the agent, but it would assist in the removal of particulate matter and aid the flushing of infectious material from fibre.

Scouring of fibre (60-65°C for on average 3-4.5 minutes, followed by drying at 40-50°C for about 3 minutes) would considerably reduce the number of viable *Salmonella* organisms present. However, an authority consulted was of the opinion that while scouring of fibre would have a diluting effect in terms of *S. abortus ovis*, scoured fibre could not be considered completely free from contamination[143].

Dyeing (boiling for at least 1 hour) of scoured fibre would destroy any *Salmonella* organisms which survived scouring.

Effect of home spinning

Home spinning would not have any effect on agent survival.

Effect of wool testing

Wool testing would not have any effect on agent survival.

6.31.3 Exposure Assessment

The opportunities for exposure of susceptible animals in New Zealand to imported fibre were discussed in section 4 of this risk analysis. Exposure to scoured fibre would be extremely limited, but exposure to scouring wastes might be possible with certain systems of disposal (e.g. spraying of effluent on pastures, dumping solid wastes in areas where stock could gain access). Exposure to wool packs containing contaminated wool is a theoretical possibility in the case of packs sent to farms for re-use. Exposure to fibre imported for home spinning is a theoretical possibility. Exposure to fibre imported for testing would be very unlikely during testing, and exposure after that would depend on methods of disposal.

6.31.4 Consequence Assessment

The introduction and establishment of *S. abortus ovis* would have a serious effect on productivity. Abortion storms in affected flocks could involve up to 10% of ewes in late pregnancy. However, the effects on international trade would probably be minimal, with the possible exception of the export of live sheep.

6.31.5 Risk Estimation

Fibre could become contaminated with faeces containing *S. abortus ovis*, and such fibre could remain contaminated for long periods. Scouring would not completely remove contamination. The consequences of introduction and establishment and establishment of the disease would be severe.

Safeguards are justified.

6.31.6 Risk Management

The International Animal Health Code[9] does not contain any suggested safeguards for *S. abortus ovis*.

To be certain that any organisms on imported fibre were destroyed, the following safeguards would be necessary.

<u>Fibre for scouring</u>

For fibre imported from countries which are not free of *Salmonella abortus ovis*, the fibre must be moved to an approved transitional facility where it must be treated as follows:

- Scouring at 60-70°C in full flow back mode with hot water rinses; and
- After scouring, all fibre must be dyed or further washed in water at a temperature of not less than 60°C for at least 30 minutes.
- In the transitional facility, the following measures must be applied to scouring wastes:
    - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and
    - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

Wool packs

Wool packs imported from countries which are not free of *Salmonella abortus ovis* must be :

- moved to an approved transitional facility where they must be washed in water at a temperature of not less than 60°C for at least 30 minutes; or
- destroyed by incineration.

Fleeces for home spinning

Fleeces must be completely unpacked under official supervision and treated as follows:

- washing in water at a temperature of not less than 60°C for at least 30 minutes.

Fibre for testing

For fibre imported from countries which are not free of *Salmonella abortus ovis* :

- Fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must be destroyed by incineration or treated by one of the following methods:
    - washing in water at a temperature of not less than 65°C for at least 60 minutes; or
    - Scouring
        - Scour must be operated at 60-70°C in full flow back mode with hot water rinses; and
        - After scouring, all fibre must be dyed or further washed in water at a temperature of not less than 65°C for at least 60 minutes; and
        - the following measures must be applied to scouring wastes:
            - Liquid effluent from the scour must be passed through an evaporation/combustion unit; and
            - Solid and semi-solid scouring wastes must be disposed of by incineration or deep burial.

6.32 Scrapie - B160

6.32.1 Hazard Identification

The disease

Scrapie is a transmissible spongiform encephalopathy of sheep and goats. It has been recognised in Great Britain and Western Europe for around 250 years, predominantly in sheep. Although it is generally accepted that scrapie is an infectious, contagious disease, the means of natural transmission are not understood[144]. There appears to be a genetic influence on susceptibility and incubation period, and there is evidence for a dose-response relationship[145]. Infectivity is associated with an abnormal isoform of a host-encoded cellular glycoprotein PrP^{C}. The abnormal form, PrP^{SC}, which is protease resistant, may be the scrapie agent or may be somehow coupled to the agent, but its presence is specific to the diseased state[144].

The most likely route of infection in natural scrapie appears to be the oral route. Other routes which have been shown to be effective experimentally are scarified skin and the conjunctiva[144].

Mechanisms for horizontal transmission remain the subject of speculation. Studies of the distribution of the scrapie agent in tissues and organs of sheep clinically affected with naturally acquired scrapie have indicated that the agent is confined to tissues of the central nervous system, reproductive tract and reticulo-endothelial system[145,146]. Infectivity in these tissues is detectable only in sheep with clinical signs of scrapie or in sheep in the late pre-clinical stage of the disease. Tissues with no detectable infectivity are heart, kidney, mammary gland, salivary glands, seminal vesicle, skeletal muscle, testis, and thyroid[147,148]. Infectivity has also not been detected in the faeces, urine, milk, colostrum, clotted blood, semen or saliva of infected sheep or goats[145].

Many studies have shown that the offspring of infected dams have a significantly increased risk of developing scrapie[145]. This has given rise to the use of the term “maternal transmission”, but precisely how and when transmission occurs (*in utero* and/or *post partum*) remains unknown[144]. Very few studies have addressed this question, and the results are inconclusive[145].

Scrapie infectivity has been reported in several tissues from the reproductive tract of ewes with clinical disease. The detection of infectivity in the placenta of six ewes with clinical scrapie[149,150], led to wide acceptance that placenta, and possibly the foetal fluids may play a significant role in the spread of the disease[144,145]. However, the amount of infectivity in placenta of sheep or goats with natural scrapie has not been established[151]. There is one report in the literature of infectivity being found in small numbers of clinically affected sheep from the ovary, uterus, uterine caruncle, foetal cotyledon, foetus and amniotic fluid[152]. The fact that the isolation of infectivity in the foetal fluids has not been repeated by other workers[153] raises some uncertainty about the validity of these findings.

The course of the disease is progressive, with death occurring 1-6 months after the development of clinical signs[144,154]. Low titres of the scrapie agent have been detected in several tissues prior to the development of clinical signs, and there appears to be a sudden rise of titre in several tissues around the time of development of clinical signs[155].

Agent survival

The scrapie agent is highly resistant to heating, disinfectants and UV light. The survival of the scrapie agent in soil has been demonstrated experimentally. However, a limited number of studies have been carried out to assess the significance of this under natural conditions, and the results are not convincing[144].

Fibre as a vehicle

A 1997 World Health Organisation (WHO) consultation on the animal transmissible encephalopathies, which included representation from the OIE, reviewed earlier experimental work on the tissue distribution of infectivity in natural scrapie[147,148], and concluded that animal fibre and products derived from wool (wool alcohols and lanolin) were unlikely to present any risk of contamination[156]. The European Union position is similar[157].

In view of the uncertainty surrounding the transmission of natural scrapie, five international experts were consulted during the course of this risk analysis for their opinions on whether unprocessed fibre should be considered to be a vehicle for transmission of the disease. All five experts acknowledged that the scrapie agent had been identified in the placenta of infected sheep[158,159,160,161,162]. Three of the consulted experts offered the opinion that it was possible that foetal fluids might also contain the scrapie agent, and they considered that the possibility of contamination of wool could therefore not be excluded[158,160,162].

The way that infectivity has been demonstrated in placenta is highly relevant to this consideration. Infectivity in the placenta has been investigated only in sheep showing clinical signs of the disease, and it has been demonstrated only in some of those clinically affected sheep[144,145]. Trials to demonstrate the presence of infectivity involved the grinding up of the placenta of clinically affected ewes and administering it orally to apparently normal sheep, which subsequently developed scrapie[149,150]. Since the levels of infectivity in placental tissue have not been established, the titre administered by this experimental route is not known. Therefore it remains unclear how this route corresponds to natural transmission, but it has been suggested that so-called “cannibalistic” behaviour by sheep at lambing, when sheep eat or nibble the placenta of other sheep, could be an important route of transmission[149].

In considering this possibility further, several questions arise. Firstly, where is infectivity located in the placenta? Is it only within the placental tissues, associated with certain cells, or is infectivity found on the surface of the placenta? Further, if infectivity is present in the foetal fluids, then how could it get there?

The answers to these questions are currently unknown, but the fundamental point is that PrP is a normal cellular protein, and the abnormal isoform of that protein, PrP^{SC}, is closely involved in the disease process.

A brief examination of the nature of the ovine placenta together with what is known about the scrapie agent suggests that infectivity is unlikely to be associated either with the foetal part of the placenta or with the foetal fluids[f], and it is concluded that placental infectivity in clinically affected sheep is most probably associated with maternal placental tissues.

If it is accepted that infectivity is present on the surface of the placenta, then it follows that the placenta might contaminate wool of sheep at lambing, at least that wool which comes into direct contact with the placental tissues. In reality there would only be a very small area of wool in the perineal area that could have such direct contact with the placenta. However, if one accepts the view that the foetal fluids might also carry infectivity[158,160,162], then it follows that there may be a theoretical possibility that a larger area of the perineal wool of sheep could become contaminated with the scrapie agent at lambing.

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[f] The foetal fluids comprise the fluids in the amniotic and allantoic cavities. The amniotic cavity arises as a layer of somatopleure which enfolds the developing embryo, and when completed, it becomes filled with amniotic fluid which surrounds the foetus and protects it from mechanical injury. Amniotic fluid is clear, colourless, and mucoid. It contains : pepsin, a diastatic ferment, a lipopolytic ferment, protein, fructose, fat and salts[163]. Studies in humans show that the water in amniotic fluid is completely replaced every 3 hours, and the electrolytes sodium and potassium are replaced once every 15 hours. The sources of the fluid and the points of resorption are not well understood. A small portion of the fluid is derived from the foetal kidney, and a certain amount of resorption occurs by way of the gastrointestinal tract and lungs of the foetus. However, even after the death of the foetus, the rate of turnover is still half the rate that occurs when the foetus is normal, indicating that much of the fluid is formed and absorbed directly through the amniotic membranes[164]. Late in gestation, the release of foetal urine into the amniotic cavity stops, and the amniotic fluid becomes viscous and mucoid, probably from the saliva and secretions of the nasopharynx of the foetus[163]. In late gestation the amniotic fluid comprises 400-1200 ml in the goat, and 350-700 in ewe[163].

The allantois develops from the hindgut of the embryo, and eventually forms the foetal part of the placenta and the allantoic cavity. The allantoic cavity stores the allantoic fluid, which is the waste products of the foetal kidneys. Allantoic fluid is clear, watery and amber in colour, and contains albumen, fructose and urea. Toward the end of gestation the volume of allantoic fluid varies from 500 ml to 1500 ml in the sheep and goat[163].

The fusing of the foetal chorioallantois with the wall of the uterus forms the placenta, which assumes the function of metabolic interchange between the foetus and the mother. The interchange of glucose, amino acids and oxygen from the maternal bloodstream and the elimination into the maternal blood of carbon dioxide and nitrogenous wastes is by diffusion and absorption across the endothelial wall of the blood vessels and the overlying connective tissue and epithelium. However, at no time during pregnancy is there any mingling of foetal and maternal bloodstreams. The foetal circulation is, from its first establishment, a closed circuit[165].

The ovine placenta is impermeable to macromolecules, such as proteins. These would not normally cross the placenta in either direction unless the placenta is damaged. If proteins from the dam were to enter the foetal circulation, the resulting immunological reaction would result in abortion. Therefore it is considered extremely unlikely that PrP^{SC} from a scrapie-infected dam could be present either in the foetal tissue component of the placenta or in the foetal fluids.

But the proportion of a sheep's total wool that comes from the perineal area is small, so that even if the possibility of amniotic fluid contamination is accepted, only a small proportion of the wool from a clinically affected ewe could be considered to be contaminated at lambing time.

Therefore, if it is accepted that contamination of wool at lambing is theoretically possible by contact with either the placenta or the amniotic fluids, then it is necessary to pose the question "in which sheep might this occur?" That is, is this risk a possibility for all sheep that are infected with the scrapie agent, including those sheep that are in the pre-clinical phase of the infection, or should consideration of this risk be restricted to sheep that are showing clinical signs of scrapie at the time of lambing?

While small titres of scrapie infectivity are indeed detectable in certain tissues prior to the development of clinical signs (especially intestine and lymphatic tissues), there is a sudden rise in the titre of infectivity in tissues at the time of the development of clinical signs. So, even if infectivity is presumed to be present in the placenta of infected sheep prior to the development of clinical signs, it still remains uncertain whether the titre would be sufficient to cause contamination of wool.

In addition to the above considerations, there are a number of practical matters which suggest that the risk is not large so far as wool is concerned.

a) If pre-lambing crutching is carried out, then the wool in the perineal area would be short at lambing, and would be less likely to be contaminated either through direct contact with placenta or with birth fluids.

b) An important point in assessing the risk of scrapie contamination in imported wool is the timing of shearing with respect to lambing. Sheep are generally not shorn immediately after lambing, as that would result in mismothering and lamb losses. In most production systems in the world it would be unusual for sheep to be shorn prior to weaning, which is generally at least 3 months after lambing. During that time most sheep which had been showing clinical signs of the scrapie at lambing would no longer be in the flock, as they would have developed clinical signs of the disease and would have been removed. In any case, any previous contamination of the perineal wool with foetal fluids would have been considerably reduced by weathering.

Therefore, in summary:

- the placenta has been shown to harbour infectivity at lambing time in sheep with clinical signs of scrapie;

- if the possibility is accepted that foetal fluids as well as placenta might harbour the scrapie agent, it follows that there could be a risk of foetal fluids

contaminating wool with the scrapie agent but only for sheep which were showing clinical signs of the disease at lambing;

- if contamination of wool with foetal fluids did occur, it would be limited to a relatively small area of wool in the perineal area of those sheep which were showing clinical signs of scrapie at lambing;

- it would be unlikely that sheep which were showing clinical signs of scrapie at lambing would still be in the flock at the time of the post-weaning shearing 3 months after lambing, and therefore their contaminated wool would not be harvested at the post-weaning shearing;

- for any sheep that may have been in the late preclinical stage of scrapie at the time of lambing, and for which there may have been a theoretical possibility of contamination of perineal wool with foetal fluids, post-weaning shearing might be carried out, but only if clinical signs of scrapie had not subsequently developed to an advanced level;

- any remaining amount of contamination in perineal wool of the few animals still in the flock which had been showing clinical signs of scrapie at lambing would be considerably diluted by the normal wool from all of the clinically normal animals in the flock.

After consideration of the above facts and opinions, it is concluded that the likelihood of imported wool being a vehicle for the introduction of scrapie is extremely remote.

Hazard identification conclusion

Scrapie is not a potential hazard in imported fibre of sheep and goats.

6.33 Maedi-visna - B161

6.33.1 Hazard Identification

The disease

Maedi-visna is one of the so-called “slow virus diseases” of sheep, and is caused by a retrovirus in the ovine/caprine group of lentiviruses, closely related to the CAE virus. The Icelandic name denotes the two most common forms of the disease, maedi (dyspnoea) and visna (wasting). Clinical signs are variable, but there is no recovery once clinical signs develop. Most infected sheep show little or no signs of disease, but the virus is able to survive latently, generally in the presence of high antibody titres, within monocytes and macrophages[166], and infected animals are carriers for life[167]. Transmission occurs under conditions of close contact - presumably by droplet infection. Transplacental transmission either does not occur or is negligible. However, transmission from ewe to lamb, most probably by colostrum, is an important means of spread[168].

Agent survival

Retroviruses are sensitive to heat but relatively resistant to UV light[100]. Heating of the maedi-visna virus in 1% serum at 50°C inactivated 90% of infectivity in 10-15 minutes[169]. As with other retroviruses the maedi-visna virus is cell-associated, and it survives only a few minutes outside the host[170]. A related human retrovirus, HIV, lost all infectivity after 11-15 days in suspension at 37°C, and when dried and held at room temperature (23-27°C), it lost 1 log of infectivity every 9 hours[102].

Fibre as a vehicle

As the agent survives for only a short period outside the host, fibre is not a vehicle for this disease.

Hazard identification conclusion

Maedi-visna is not a potential hazard in imported fibre of sheep and goats.

6.34 Sheep scab

6.34.1 Hazard Identification

The disease

The mite *Psoroptes ovis* which is the cause of sheep scab, is highly host-specific. The mites live on the surface of the skin and puncture the epidermis to suck lymph. This results in skin inflammation and the formation of crusts from exuded serum.

Eggs are laid on the skin at the edges of the lesion and normally hatch in 1-3 days. The life cycle consists of the usual larval and nymph stages, and is complete within 10-11 days. Eggs separated from the skin by crusts may hatch in 4-5 days. Eggs removed with wool from the body or drawn several centimetres away from the skin may hatch up to 10 days after having been laid, or they may die. Females begin to lay eggs 8-9 days after hatching from the egg. On infested animals the female mite lives for 30-40 days[171]. Moist, cool conditions are optimal for development.

P. ovis spreads between animals by direct contact or, less commonly, by indirect means through fomites. Clean sheep can pick up infestations from contaminated pens that have been unoccupied for several days[172]. Rest periods of 8-30 days prior to restocking infested premises are recommended in different countries[173].

Agent survival

Mites are highly vulnerable to desiccation, and the majority die within days of removal from the host. However, at 4°C and 70% humidity, *P. ovis* can survive up to 49 days off its host, although under natural conditions the ability of mites to produce new infestations is limited to around 12-15 days[174, 175, 176].

Fibre as a vehicle

While eggs in wool could hatch up to 10 days after removal from the sheep, the resulting larvae could not survive in wool for more than a few days without feeding. Transmission of adult mites by exposure of susceptible animals to contaminated fibre would be possible, but probably only for up to 2 weeks following shearing of infested animals.

Hazard identification conclusion

Psoroptes ovis is a potential hazard in imported fibre of sheep and goats.

6.34.2 Release Assessment

Agent inactivation

Adult *Psoroptes ovis* mites can live independently of the host for not more than 3 weeks. As with most insects they are killed quickly by exposure to temperatures over 50°C. Moreover, exposure to detergents in water would kill mites even more quickly by breaking down surface tension and allowing water to penetrate the respiratory system, which would effectively drown them[177]. As with other insects, mites are killed by methyl bromide fumigation[178].

Effect of scouring

Scouring fibre at 60-65°C for 3 - 4.5 minutes, in the presence of detergents, would destroy any mites present.

Effect of home spinning

Home spinning would not have any effect on agent survival.

Effect of wool testing

Wool testing would not have any effect on agent survival.

6.34.3 Exposure Assessment

The opportunities for exposure of susceptible animals in New Zealand to imported fibre were discussed in section 4 of this risk analysis. Exposure to scoured fibre would be extremely limited, but exposure to scouring wastes might be possible with certain systems of disposal (e.g. spraying of effluent on pastures, dumping solid wastes in areas where stock could gain access). Exposure to wool packs containing contaminated wool is a theoretical possibility in the case of packs are sent to farms for re-use. Exposure to fibre imported for home spinning is a theoretical possibility. Exposure to fibre imported for testing would be very unlikely during testing, and exposure after that would depend on methods of disposal.

6.34.4 Consequence Assessment

The introduction and establishment of sheep scab in the New Zealand sheep population would cause significant production losses. The costs of control and eradication could be considerable. Any effects on international trade would probably be confined to live animals.

6.34.5 Risk Estimation

The mites causing sheep scab can be transmitted by wool, but only for a period of 3 weeks following shearing. Scouring would quickly kill any mites in imported wool. Exposure pathways are limited, but the consequences of introduction and establishment of sheep scab would be severe.

Safeguards are justified.

6.34.6 Risk Management

P. ovis is not an OIE- listed disease, and therefore the International Animal Health Code[9] does not contain any suggested safeguards for it.

To be certain that any mites on imported fibre were destroyed, the following safeguards would be necessary.

Fibre for scouring

For fibre imported from countries which are not free of *P. ovis*,

- Documentary proof must be produced that the fibre has been at least 3 weeks in transit to New Zealand; or
- The fibre must be stored in an approved transitional facility for 3 weeks after arrival in New Zealand prior to scouring; or
- The fibre must be moved to an approved transitional facility where the it is treated as follows :
    - Scouring at 60-70°C either in partial flow back mode or in full flow back mode; and
    - In the transitional facility, the following measures must be applied to scouring wastes:
        - Solid and semi-solid scouring wastes must be disposed of by incineration.

Wool packs

For wool packs imported from countries which are not free of *P. ovis*,

- Documentary proof must be produced that the packs have been at least 3 weeks in transit to New Zealand; or
- The packs must be stored in an approved transitional facility for 3 weeks after arrival in New Zealand prior to use; or

- The packs are to be destroyed by incineration; or

- The packs must be moved to an approved transitional facility where they must be treated by one of the following methods :

    - washing in water at a temperature of at least 65°C for at least 5 minutes in the presence of a non-ionic detergent at a concentration of at least 1 g per litre; or

    - fumigation with methyl bromide.

Fleeces for home spinning

- Documentary proof must be produced that the fleeces have been at least 3 weeks in transit to New Zealand; or

- The fleeces must be stored in an approved transitional facility for 3 weeks after arrival in New Zealand prior to use; or

- The fleeces must be unpacked under official supervision and treated by one of the following methods :

    - washing in water at a temperature of at least 65°C for at least 5 minutes in the presence of a non-ionic detergent at a concentration of at least 1 g per litre; or

    - fumigation with methyl bromide.

Fibre for testing

For fibre imported from countries which are not free of *P. ovis*,

- Documentary proof must be produced that the fibre has been at least 3 weeks in transit to New Zealand; or

- The fibre must be stored in a transitional facility for 3 weeks after arrival in New Zealand prior to testing; or

- The fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must be destroyed by incineration or treated as follows :

    - washing in water at a temperature of at least 65°C for at least 5 minutes in the presence of a non-ionic detergent at a concentration of at least 1 g per litre; or

    - Scouring

- Scour must be operated at 60-70°C in partial flowback mode or full flow back mode with hot water rinses; and

- Solid and semi-solid scouring wastes must be disposed of by incineration.

6.35 Ixodid ticks

6.35.1 Hazard Identification

The disease

Ticks of the family Ixodidae have a hard shell, and for this reason they are referred to as “hard ticks”. Of the ten genera of ticks in the family Ixodidae, the genera *Ixodes, Boophilus, Hyalomma, Rhipicephalus, Haemaphysalis, Dermacentor, and Amblyomma* are of veterinary significance[179].

Ticks can be classified according to how many different hosts they require to complete their life cycle :
One host ticks: complete their life cycle on the same animal e.g. *Boophilus* spp.
Two host ticks: the second moult occurs after the nymph drops off onto the ground, and the adult engorges on a second animal e.g. several *Hyalomma* spp., *Rhipicephalus evertsi*.
Three host ticks: these require a different host for each stage, as each molt occurs on the ground e.g. *Ixodes ricinus*, *Rhipicephalus annulatus*, and most other ixodid ticks[179]

The female tick lays all her eggs in one batch, up to 18,000 in some species, and then dies. Larvae hatch from the eggs, climb onto grass or shrubs and wait until a suitable host passes, to which they attach. After engorging, the larva moults and becomes a nymph, which then engorges and moults to become an adult. After mating and engorging the adult female drops off the host, lays her eggs, and dies. Males remain longer on the host than females, in some cases up to 4 months or even longer.

Juvenile and adult stages of ticks may be found in unprocessed fibre of sheep and goats.

Agent survival

Each species of tick is adapted to certain ranges of temperature and moisture, some occurring only in warm regions with a fair degree of humidity, while others are winter ticks most active in a dry climate[179]. Certain tick species that parasitise livestock can survive for months, occasionally for a few years without food, if environmental conditions permit[180]. The temperature and humidity inside a wool bale would be relatively stable[13], and it is considered that unfed larvae, nymphs and adults could survive for months or years in that environment.

Fibre as a vehicle

Unfed larvae, nymphs and adults could be introduced in unprocessed fibre, where they could survive for months or years.

Hazard identification conclusion

Ixodid ticks are a potential hazard in imported fibre of sheep and goats.

6.35.2 Release Assessment

Agent inactivation

Most insects are killed quickly by exposure to temperatures over 50°C. Exposure to detergents in water would kill insects quickly by breaking down surface tension and allowing water to penetrate the respiratory system, effectively drowning them[177]. None of 10 engorged female *Boophilus microplus* survived after 2 minutes of incubation at 55°C with a 0.1% solution of the detergent Triton X-100[181]. As with other insects, ticks can be killed by methyl bromide fumigation[178].

Effect of scouring

Any ticks in fibre would be killed quickly by scouring at 60-65°C for 3 - 4.5 minutes, in the presence of detergents.

Effect of home spinning

Home spinning would not have any effect on agent survival.

Effect of wool testing

Wool testing would not have any effect on agent survival.

6.35.3 Exposure Assessment

The opportunities for exposure of susceptible animals in New Zealand to imported fibre were discussed in section 4 of this risk analysis. Exposure to scoured fibre would be extremely limited, but exposure to scouring wastes might be possible with certain systems of disposal (e.g. spraying of effluent on pastures, dumping solid wastes in areas where stock could gain access). Exposure to wool packs containing contaminated wool is a theoretical possibility in the case of packs sent to farms for re-use. Exposure to fibre imported for home spinning is a theoretical possibility. Exposure to fibre imported for testing would be very unlikely during testing, and exposure after that would depend on methods of disposal.

5.35.4 Consequence Assessment

Ixodid ticks are vectors of a number of important animal diseases including babesiosis, theileriosis, anaplasmosis, African swine fever, Nairobi sheep disease, heartwater, Q fever and louping ill. Apart from *Haemaphysalis longicornis*, New Zealand is free of ixodid ticks. Although most exotic ixodid ticks are restricted to tropical climates, the possibility of their becoming established if introduced could not be ruled out, and the consequences of their establishment could be severe.

5.35.5 Risk Estimation

Ticks could survive for long periods in imported fibre. Scouring would quickly kill any ticks in imported wool. Exposure pathways are limited, but the consequences of introduction and establishment of exotic ixodid ticks could be severe.

Safeguards are justified.

5.35.6 Risk Management

The International Animal Health Code[9] does not contain any suggested safeguards for Ixodid ticks.

To be certain that any ticks on imported fibre were destroyed, the following safeguards would be necessary.

Fibre for scouring

For fibre imported from countries which are not free of ticks of the genera *Ixodes, Boophilus, Hyalomma, Rhipicephalus, Haemaphysalis, Dermacentor, and Amblyomma*,

- Fibre must be moved to an approved transitional facility where the following treatment must be carried out :
    - Scouring at 60-70°C either in partial flow back mode or in full flow back mode.; and
    - Solid and semi-solid scouring wastes must be disposed of by incineration.

Wool packs

For wool packs imported from countries which are not free of ticks of the genera *Ixodes, Boophilus, Hyalomma, Rhipicephalus, Haemaphysalis, Dermacentor, and Amblyomma*,

- Packs must be moved to an approved transitional facility where they must be treated by one of the following methods :
    - washing in water at a temperature of at least 65°C for at least 5 minutes in the presence of a non-ionic detergent at a concentration of at least 1 g per litre; or
    - fumigated with methyl bromide; or
- Packs are to be destroyed by incineration.

Fleeces for home spinning

- Fleeces must be unpacked under official supervision and treated as follows:

  either :

  - washed in water at a temperature of at least 65°C for at least 5 minutes in the presence of a non-ionic detergent at a concentration of at least 1 g per litre; or

  - fumigated with methyl bromide.

Fibre for testing

For fibre imported from countries which are not free of ticks of the genera *Ixodes, Boophilus, Hyalomma, Rhipicephalus, Haemaphysalis, Dermacentor, and Amblyomma*,

- Fibre must be moved to an approved transitional facility for testing, and after completion of testing, the fibre must be destroyed by incineration or treated as follows :

  - fumigation with methyl bromide; or

  - washing in water at a temperature of at least 65°C for at least 5 minutes in the presence of a non-ionic detergent at a concentration of at least 1 g per litre; or

  - Scouring

    - Scour must be operated at 60-70°C in partial flowback mode or full flow back mode; and

    - Solid and semi-solid scouring wastes must be disposed of by incineration.

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Don Knowles, USDA, Pullman, Washington, USA (scrapie and lentiviruses)
Jill McLaren, Hortresearch, Alexandra, NZ (mites)
Bernard Moss, National Institutes of Health, Maryland, USA (capripox)
Dermot O'Brien, Dept of Agriculture and Food, Ireland (sheep scab)
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