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Arthritis in Prime Lamb Sheep

A Review

Abstract

A series of surveys was undertaken to determine the incidence of arthritis in prime lamb sheep in Australia. Data was collected from AQIS and survey data was collected from a sample of sheep producers, veterinarians and diagnostic laboratories. In addition the current literature was reviewed.

Arthritis is sheep may be caused by any of three groups of organisms. These groups are *Erysipelothrix, Chlamydia* and pyogenic bacteria. Each group is responsible for approximately one third of the cases that are submitted for diagnosis.

The percentage of total condemnations of carcases as a result of arthritis is 0.017% in lambs and 0.019% in adult sheep at slaughter. Partial condemnations are 3.9 times higher than total condemnations. Sheep producers report that there is an average of approximately 0.63% of lambs affected with arthritis observed on properties with up to 70% of these either destroyed on the property or dying.

Two interesting findings were found in the abattoir data which require further investigation. The first is that the incidence in adult sheep is the same as that seen in lambs. The second finding was that the percentage of sheep condemned with arthritis in Victorian abattoirs was almost twice as high as that in any other state of Australia**.**

The economic loss to the sheep industry was calculated to be $18,000,000 annually. The losses were the result of total and partial condemnations at abattoirs, sheep destroyed on properties, the cost of lower feed conversion in affected sheep, the costs of treatments and preventative strategies, and the cost of additional meat inspection resources required to inspect carcases.

Very few cases of arthritis are submitted for definitive diagnosis. Most sheep producers have stopped attempting any treatment because of the low success rate. Several preventative strategies are employed which include the use of a vaccine against *Erysipelothrix*, and the use of antibiotics either as a preventative or for treatment of new clinical cases.

Although most cases of arthritis are associated with wounds in sheep such as occurs at marking or shearing, some cases do occur in sheep when concentrated around grain feeders. The requirements of good hygiene have not been defined, although this is the most common advice given to reduce the incidence of the disease.

Executive Summary

A review of arthritis in sheep has been undertaken using data collected from several sources, plus a review of the current veterinary literature. The sources from which data was collected includes export abattoirs throughout Australia, New South Wales Veterinary Diagnostic Laboratories, a sample of rural veterinary practices servicing sheep producers, and a sample of prime lamb producers. From the information collected an economic estimate has been made of the cost of the disease to the prime lamb industry.

The data collected from export abattoirs has shown that over the last five years 0.017% of carcases are condemned as a result of polyarthritis. The number of carcases that are partially rejected has not been recorded. It is interesting to note that the abattoirs in Victoria condemn approximately twice as many carcases as any other state. This may be the result of sheep being marked under wetter conditions as the states with lower rainfall have fewer condemnations. The other interesting finding from the abattoir data is that the percentage of adult carcases condemned with polyarthritis is almost the same as the percentage of lamb carcases. The abattoirs data did not distinguish between Merino carcases and prime lamb carcases.

The number of cases submitted to diagnostic laboratories is low. In the most recent five years since the introduction of charging for the analysis of samples the number of submissions has almost halved. The cases from which bacteria were isolated show an even spread across the three major causes. These are *Chlamydia pecorum, Erysipelothrix rhusiopathiae,* and the pyogenic bacteria such as staphylococci, streptococci, *Actinomyces pyogenes* and *Fusiformis* necrophorum.

Sheep producers that responded to the survey indicated that the incidence varied on properties from approximately 25% of properties with no identified cases, to properties with as many as 15% of lambs affected. Very few properties treated affected sheep as the response in previous years has been poor. The properties that believe they have seen a response to antibiotic treatment are those that inspect the susceptible animals regularly and treat affected sheep on the first day of observed clinical signs.

Veterinary involvement with sheep producers is scant Most practices are involved in dispensing antibiotics, but in most cases the course of treatment recommended was of insufficient length to be affective. Once the disease has been diagnosed on a property follow up investigation does not appear to happen. The submission of samples is much lower than would be expected if effective investigations were undertaken. The advice given to minimise the incidence of arthritis is generic and appears to lack specific detail.

The cost to the prime lamb industry was estimated using the data collected and analysed, plus current market prices at December 2006. The cost estimate was approximately $18,000,000. Arthritis affects sheep by causing ill-thrift which may result in death from predation or concurrent disease. Affected sheep are condemned at slaughter as a result or total or partial condemnation of the carcase, plus the cost of additional meat inspection staff to detect affected joints. On properties where the arthritis appears to be endemic there is the cost of regular surveillance of mobs of lambs, the cost of antibiotics for treatment and prevention, and the increasing use of vaccine.

The high number of sheep that are held on properties before they are destroyed is high. This has the potential to become an animal welfare issue. A set of guidelines have been developed which

can be used to assist sheep producers in determining the time when affected sheep should be destroyed.

There is a requirement for further investigation for the benefit of prime lamb producers. These include:

- the reasons for a higher incidence in Victoria compared to sheep slaughtered in other states
- the reason for the higher condemnation rate in adult sheep carcases
- the requirements for “clean” environmental conditions at lamb marking
- development of criteria for destruction of affected sheep
- the effectiveness and most appropriate vaccination programme to prevent *Erysipelothrix*
- the relationship between weight gain and establishment of infection
- the requirements at times of grain feeding to reduce the incidence of Chlamydial arthritis

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1 Background

A recent review of the more common diseases of sheep and the economic cost to the sheep industry was produced by Sackett & Holmes in 2006. This review suggested that arthritis was the eighth most significant disease in the sheep industry with an estimated annual cost of approximately $26,000,000.

This review has been borne from this data.

Arthritis in sheep is one of the most common causes of condemnation of carcases at slaughter. However it has always been suspected that abattoir condemnation is not a true indication of the losses to the sheep industry.

Many sheep are destroyed on the property as they will not be accepted for slaughter. Most producers do not treat affected sheep as experience has shown them that this has very little benefit.

Affected sheep invariably lose bodyweight and are ill-thrifty. Infection results in a permanent lameness which does have animal welfare implications for the sheep industry.

Arthritis is not seen on all properties that graze sheep, but there is a continual low incidence on most properties and on some properties there is a significant number of affected sheep that can affect the profitability of the enterprise.

This review therefore is timely.

2 Project Objectives

The objectives of the study were as follows:

1. Review the literature on arthritis in sheep.

2. Collect data to determine the incidence of arthritis in sheep in Australia. This data will be sourced from abattoir data, from a survey of prime lamb producers, and from data published on the incidence of the disease in Australia.

3. Estimate the cost of the disease to the prime lamb industry. These costs are to include the costs incurred on farm and at slaughter.

4. Make recommendations for further research into the understanding and reduction of the disease.

5. Make recommendations to sheep producers that have sheep affected with arthritis. As extension of information to sheep producers is scant, some guidelines are required to assist sheep producers in managing arthritis.

3 Methodology

This review comprised five components.

3.1 A literature review

A review was undertaken of the literature produced within Australia and overseas. These included reports on the pathology and epidemiology of arthritis, the incidence of the disease in case studies, with the morbidity and mortality. Only six of the references cited referred to data collected in Australia.

3.2 Collection of data from abattoirs

Animal Quarantine and Inspection Services (AQIS) in Canberra collect and collate data on carcase condemnations from export abattoirs. Data was available from export abattoirs for the last five years. This data included all sheep slaughtered. Although adult sheep and lambs were identified there was no differentiation into prime lambs and Merino lambs.

3.3 A survey of sheep producers

A survey form was distributed to 70 sheep producers known to the author as prime lamb producers. From the questionnaires sent out, twenty-six replies were received. The data analysed from these replies, although only estimates, gave an indication of the incidence of arthritis in lambs, plus the sheep producers method of handling infected lambs.

3.4 A survey of rural veterinarians

Eleven veterinary practices in eastern Australia that were in rural districts and service sheep producers were surveyed using a standard set of questions in a telephone survey. This data was analysed to determine the rural veterinary input into the treatment and control of arthritis in sheep.

3.5 Collection of data from New South Wales veterinary diagnostic laboratories

The New South Wales Department of Primary Industries based at Elizabeth Macarthur Institute in Menangle collect the data from all submissions of tissues for laboratory analysis in New South Wales. Data collected from the last ten years has been analysed as an indication of the incidence of the various bacteria associated with arthritis.

This information was then used to make the following comments:

3.6 An estimation of the cost of arthritis to the prime lamb industry

From the data collected an estimate was calculated of the cost of arthritis to the Australian sheep industry. The incidence of the disease was estimated from the data collected and costs were applied at current market values in December 2006.

3.7 Recommendations for further investigation

The literature review indicated that there are some aspects of the disease and its prevention and treatment that are not understood. This is particularly applicable in the Australian sheep scene. There is need for further research if effective recommendations are to be to sheep producers.

3.8 Recommendations to sheep producers with sheep affected with arthritis

One of the objectives of this review was to develop guidelines for sheep producers that would assist in the prevention and management of arthritis. From the knowledge available, a set of relevant guidelines have been recommended.

4 Literature review

4.1 Arthritis - The Disease

4.1.1 Joints

There are various joints in a sheep. The joints or articulations which are sites for arthritis are the synovial or diarthrodial joints. They are primarily the joints involving the limbs. These joints consist of a joint cavity, a synovial membrane lining and articulating plates at the ends of the bones that form the joint. Some synovial joints have ligaments while others may have menisci (stifle joint) or a cartilaginous rim (hip joint). The joint capsule and ligaments are attached to the bones and surround the joint capsule. They are composed of fibrous tissue, collagen and reticular fibres. These tissues have a poor blood supply. Because of this the joints show limited response to inflammation, and limited ability to repair. Ligaments and capsules contain proprioceptive organs and so respond to pain caused by arthritis.

The synovial membrane that lines the articular cavity is very vascular and has an outer layer and an inner layer that produces the essential synovial fluid. The synovial membrane is permeable in both directions with particulate matter, such as bacteria, being able to penetrate the joint (Angus, 1991). Particulate matter within the joint is removed by phagocytes. If large amounts of debris accumulate in the joint, as in arthritis, the synovial membrane stimulates fibrosis of the joint capsule which can result in swelling and fixation of the diseased joint. This accumulation of fluid in the joint cavity leads to increased pressure and pain.

Synovial fluid has two functions. It lubricates the joint and it nourishes the articular plates. Normal synovial fluid is viscous, clear and a slightly yellow colour. Synovial fluid is rich in nutrients and so provides a medium for bacterial multiplication once the joint has been invaded.

The articular cartilage in joints serves several purposes. The cartilage protects the subchondral bone from fracturing. It is elastic and can move to give an even distribution of pressure on the articular surface when the joint surface is stressed during movement. It is avascular and lacks nerve endings, and so shows little response to inflammation.

4.1.2 Description of Arthritis

Arthritis is inflammatory joint disease (Jubb et al., 1993). The discussion in this paper will be confined to the infectious causes of arthritis in sheep. The bacteria involved enter the sheep via a skin wound and enter the bloodstream. They then enter the diarthrodial joint from the blood and become resident in the joint. The resulting arthritis may range from minor changes in the joint fluid through to chronic damage to the joint and resulting ankylosis of the adjacent bones. Bacteria do not enter the joint from infection of surrounding tissues as the joint capsule is an effective barrier to organisms.

The haematogenous organisms may enter other tissues in the body such as bone marrow or joints in the spinal column and produce an inflammatory response in that area.

In adult ewes the bacterial infection may reach the joint from septicaemia as a result of mastitis or metritis (Smith et al., 1989).

Although arthritis may be caused by penetrating wounds, or from trauma, these cases are very rare in sheep and are not included in this discussion.

Some mild cases of arthritis will resolve, but most will progress to a chronic infection unless treated successfully. Sheep do not die as a direct result of arthritic infection, except for some lambs less than one month of age. However they may die from either subsequent misadventure or predation because of lack of mobility, or from internal parasites or other disease because of loss of body condition. Most chronic cases of arthritis are destroyed on the property for humane reasons.

4.1.3 Cause of Arthritis

The majority of cases of arthritis in sheep are infectious. The invading bacteria enter the body through broken surfaces such as surgical wounds imposed at lamb marking, shearing cuts, or via the navel. Some bacteria can enter the body through the oral route. Conjunctival infusion has lead to the establishment of bacteria in joints. The bacteria enter the bloodstream and are transported to the joints where they enter the joint via the porous synovial membrane. The synovial fluid is a medium rich in nutrients, and low in leucocytes, and encourages the multiplication of bacteria.

There are three groups of bacteria that can affect the joints. *Chlamydia* and *Erysipelothrix* are specific conditions, but the suppurative bacteria include most of the common bacteria found in the environment. The following bacteria have been incriminated in arthritis:

Erysipelothrix rhusiopathiae	Angus, 1991, Watkins, 1998
Chlamydia psittaci	Angus, Cutlip, 1972
Escherichia coli	Watkins, 1998
Actinomyces pyogenes	Watkins, 1998
Corynebacterium ovis	Angus, 1991
Fusobacterium necrophorum	Angus, 1991
Haemophilus agni	Angus, 1991
Mycoplasma spp.	Angus, 1991
Actinobacillus seminis	Angus, 1991
Streptococcus dysgalactiae	Watkins, 1998
Streptococcus uberis	Watkins, 1998
Streptococcus agalactiae	Watkins, 1998
Streptococcus sp.	Watkins, 1998
Pasteurella haemolytica	Watkins, 1998
Staphylococcus sp.	Watkins, 1998
Micrococcus sp.	Watkins, 1998
Lactobacillus sp.	Watkins, 1998
Staphylococcus	Angus, 1991
Maedi-visna	Angus, 1991

Watt et al., (1970) isolated *Actinobacillus seminis* from infected joints of lambs in three flocks. These sheep had either been recently dipped or marked. In one flock 25 of 280 lambs were affected.

In 1947 Marsh isolated *Corynebacterium ovis* from the joints of lambs in a feedlot. These lambs had been lambed and marked indoors prior to entering the feedlot. The sheep were lame, but the joints were not swollen. A greenish exudate was present in the joints from which *C. ovis* was isolated.

Watkins and Sharp (1998) cultured the joint fluid for 72 joint aspirates and 252 carcases of lambs less than three weeks of age, submitted with arthritis to Veterinary Investigation Centres in United Kingdom. Bacteria were cultured from 88% of the joints. 70% of the lambs examined and 80% of the joints yielding bacteria had *Streptococcus dysgalactiae* isolated. The other bacteria isolated were *Escherichia coli, Staphylococcus, Erysipelothrix rhusiopathiae* and *Actinobacillus pyogenes*. In 77 carcases examined, omphalitis was diagnosed. Cultures from the infected navels were predominantly *Streptococcus dysgalactiae, Actinobacillus pyogenes* and *Escherichia coli*. 16% of the lambs with arthritis also had omphalitis with *Streptococcus dysgalactiae* being the predominant bacteria. They concluded that throughout England and Wales 80% of the arthritis in young lambs is caused by *Streptococcus dysgalactiae*.

4.1.4 Incidence of Arthritis

Green et al., 1994 examined every lamb showing clinical signs of disease in two flocks in England. These lambs were housed and born indoors, housed through until weaning at 5 – 7 weeks of age and they were kept on straw bedding. In the two flocks there were 3.0% and 0.7% of the lambs diagnosed with joint ill. No samples were collected for bacteriological identification.

Farquharson (2000) analysed the data from submissions made to the New South Wales Department of Agriculture diagnostic laboratories in the years 1988 and 1989. In these years there was no charge for laboratory tests. The table below shows the morbidity and mortality rate from flocks affected with arthritis and according to the causative organism.

Diagnosis	Morbidity Rate (%)	Mortality Rate (%)	Total sheep at risk	Number of cases submitted
Chlamydia	3.88	0.35	11,627	21
Erysipelothrix	1.40	0.40	1,530	6
Actino. Pyogenes	2.00	0.79	25,632	4
Fus. necrophorum	3.21	2.53	14,732	10
Histophilus ovis	1.10	0.86	2,200	3
Staphylococcus	6.70	0	300	1
Streptococcus	*	*	*	1
No diagnosis	5.97	2.46	6,430	20
Total affected	814	1,916	62,451	66

Actino = Actinomyces
Fus. = Fusiformis
* = no statistics given

4.1.5 Predisposing Factors

The major predisposing factor to arthritis is wounds, through which bacteria can enter. The bacteria can also enter via the oral or conjunctival route. Initially in lambs it can occur at birth through the navel whilst it is still patent. Most bacterial invasion occurs during the lamb marking procedure. The tails of all lambs are docked. This may be by amputation using a knife or a hot knife, or by the application of an elastrator elastic rubber ring. The male lambs that are not kept as entires are castrated. This is performed by incision and drawing out the testicles or by applying an elastrator rubber ring to the neck of the scrotum. In addition the lambs are ear-marked when a distinctive pattern of ear is removed for permanent identification. Merino lambs that have wrinkled skin about the breech area are also mulesed. This procedure involves removing elliptical sections of skin from the breech so that the area once healed is devoid of wool and wrinkles are minimised.

The outcome of the marking procedures is that the young lambs are in pain and they tend to sit or lie down with the raw wounds being in contact with the ground. This gives an ideal entry for environmental bacteria.

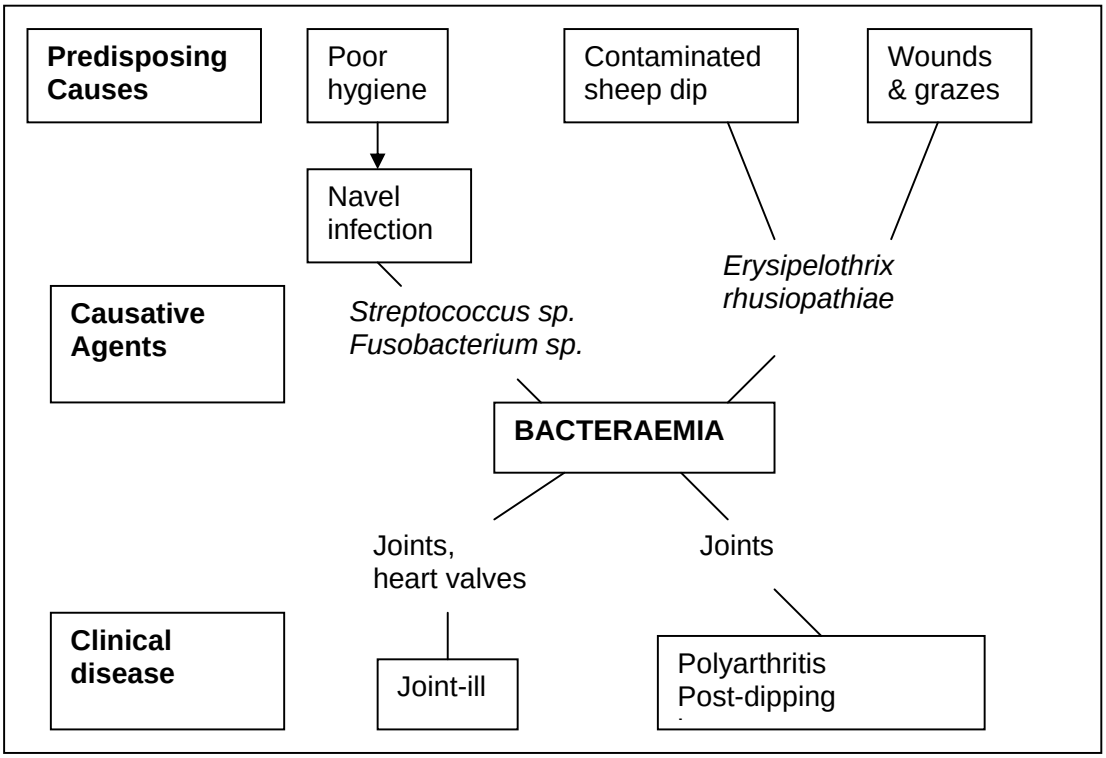
Flies are also a potential source of spread for infection (Ahrens, 1984). They can actively carry infection from an infected wound or the environment to a recent wound. Furthermore, the skin damage induced by flystrike exposes a wound to environmental bacteria.

In sheep beyond the marking age, shearing cuts are a potential source of entry. Most sheep are cut during shearing leaving open wounds which can become infected with skin bacteria, or can contact the ground when the sheep lie down. Barley grass and penetration of the skin by other seed material has also been incriminated as a source of entry of bacteria (Ahrens, 1984). Sheep that are dipped immediately after shearing can become infected with arthritis as the bacteria are able to multiply in the dip solution if it does not contain an effective active disinfectant.

Cutlip (1972) showed that the conjunctiva was a possible source of entry when he instilled *Chlamydia* in the conjunctiva of healthy sheep and subsequently arthritis developed. The bacterial species was later isolated from the joints.

Angus (1991) presented the following chart to show the factors that lead to infectious polyarthritis in lambs.

Diagram 1: Mechanisms of polyarthritis in lambs (after Angus 1991)



4.1.6 Types of Arthritis

Arthritis can be classified into four types based on the causative agent. These are

- Septic arthritis
- Chlamydial arthritis
- *Erysipelothrix* arthritis
- Exotic causes, such as Maedi-visna virus and tick pyaemia caused by *Staphylococcus*

4.1.6.1 Septic Arthritis

Septic arthritis is caused by the common pyogenic bacteria present in the environment. The bacteria that have been incriminated are listed on page 11.

The bacteria enter the sheep via a wound. Most cases occur after husbandry procedures such as marking and shearing when skin wounds are inflicted on the sheep.

On examination the sheep are lame in one or more joints; there is swelling of the joints which may be warm to touch. On aspiration the fluid removed may range from being cloudy and pale to purulent. It is often yellowish to green and purulent.

Septic arthritis is diagnosed clinically from the swollen joints, and the presence of purulent joint fluid. The causative organism can be isolated by culture of the joint fluid.

Penicillin or oxytetracycline is the preferred therapeutics to use, with a 5 day course of treatment.

4.1.6.2 Chlamydial Arthritis

This disease is caused by *Chlamydia pecorum*, which is different to *Chlamydia psittaci* that can cause abortion in sheep and also conjunctivitis (Clarkson and Philips, 1997). This bacterium has recently been renamed *Chlamydophila pecorum* (Everett, 2000). *Chlamydia psittaci* may infer some cross-immunity against *Chlamydia pecorum*. The organism is capable of multiplying in the synovial fluid. It is an obligatory intracellular organism. *Chlamydia* organisms exist in two states. The "elementary bodies" can be compared to bacterial spores and can survive for long periods in the environment. Once they enter the host the elementary bodies transform into "reticular bodies" which multiply by division. The elementary bodies released from the reticulate bodies can then invade further cells or be passed out of the body and contaminate the environment (Songer & Post, 2005).

This condition is seen mainly in lambs of between two and five months of age and is often encountered in lambs managed in feedlots. *Chlamydia* has an incubation period of 1 to 4 weeks (Songer & Post, 2005). Morbidity as high as 80% has been reported (Bulgin, 1986). *Chlamydia* could not be isolated from lambs less than 3 months of age, possibly because the lambs have acquired passive immunity from the ewe or they do not pick up the infection until they begin grazing (Clarkson & Philips, 1997).

The organism enters the body by ingestion or inhalation from bacteria shed in the faeces, urine or nasal or ocular discharge. The conjunctivae have been reported as a point of entry in experimental transmission and it has been suggested that lambs may show conjunctivitis prior to joint involvement. Once the bacteria are in the body they multiply, and if the infection persists, it becomes established in the joints. It appears to be more common in lambs with high growth rates, suggesting that when additional stress is applied to the joints, that the resulting trauma and inflammation allows the bacteria to multiply and produce arthritis. However it also occurs in Merino weaners which on most properties do not have high growth rates.

Increased body temperature is often the first change seen in affected lambs, with body temperature rising to between 39.0 and 42.0^{o}C. The lambs are first observed away from the mob, reluctant to eat or to drink. Lameness, often manifest as a shifting lameness, follows from one to three days later, frequently involving most limbs, resulting in a stilted gait. When a hind limb is involved the sheep will rest on the knees of the front legs to reduce weight on the hind legs and to minimise the pain involved. Feed intake is reduced as the affected lambs are reluctant to move, with dehydration also occurring. After about two weeks lambs may recover, some can die and in others the lesion will progress to a chronic lesion with fibrosis of the joint capsule (Cutlip et al., 1972). The major loss in affected lambs is the weight loss, and time required to recover weight and weight gain. There is also a significant cost in the supervision of weaners. Managers of properties in which the disease is endemic will generally inspect the mobs of weaners every day so that suspect cases can be removed and given treatment. This is a heavy time commitment.

On post-mortem of acutely affected joints there is a swelling of the joint capsule and excess synovial fluid. Fibrin is initially free in the synovial fluid but as the condition progresses the fibrin becomes attached to the synovial membrane. The joint fluid is a greyish-yellow colour, more viscous than normal fluid and may contain small clumps of fibrin, as the joint starts to recover and becomes organised. Microscopic changes seen include an increase in neutrophils, macrophages and lymphoid cells in the synovial tissues. The synovial membrane is proliferated with long fibrous villi extending into the joint space.

Chlamydial arthritis is differentiated clinically on the appearance of the joint fluid. The fluid is normal to turbid in appearance and consistency, and it does not contain fibrin.

Oxytetracycline is the antibiotic of choice, and treatment can be successful if implemented early in the course of the disease. However the treatment regime should deliver adequate concentrations of antibiotic in the blood for at least ten days (Hungerford, 1990).

It has been reported that vaccination of sheep with the chlamydial abortion vaccine (*Chlamydia psittaci*) will infer some cross-immunity, but this vaccine is not available in Australia. Removal of infected cases may reduce the spread and incidence of the condition. On some properties in which the disease is endemic, oxytetracycline has been incorporated in the grain whilst weaners are being supplementary fed, and this has reduced the incidence of arthritis.

4.1.6.3 *Erysipelothrix* Arthritis

Erysipelothrix rhusiopathiae is a ubiquitous organism. It is present in most species of animals and it survives in the environment. The organism is found in the faeces of infected and non-infected sheep (Lamont, 1979, Kaferstein et al., 1972). Kaferstein et al., (1972) also found *Erysipelothrix rhusiopathiae* in the lymph nodes of 8 out of 55 apparently healthy lambs aged between 3 and 8 months of age. It can survive up to 35 days in the environment in cool conditions, and will survive better in moist conditions compared to dry soil (Wood, 1972), provided it is in contact with organic material such as faeces. The organism is readily destroyed in washing soda (alkaline) solutions but appears to be less affected by solutions of alcohol, formaldehyde and phenol (McCulloch & Fuller, 1941). It appears to produce arthritis in sheep in every sheep-rearing country of the world. It can also be cultured from joints in sheep with no clinical abnormalities.

Experimental infection has shown that the organism can produce arthritis if administered through any of the following routes; oral and subcutaneously (Cornell & Glover, 1925), intradermal (Piercy, 1974), umbilical cord (Hopkirk & Gill, 1930), castration and docking wounds (Howarth, 1933), conjunctivae and fresh wounds (Murnane, 1938), shearing cuts (Whitten et al., 1948) and by placing newly castrated and docked lambs on straw bedding sprinkled with a broth culture of organisms. Post-dipping lameness is a manifestation that occurs after dipping sheep in contaminated (non-fresh) dip solutions whilst shearing wounds are still present (Whitten et al., 1948). The number of organisms required to induce arthritis was as low as 30×10^8 (Lamont, 1978), via the intravenous route.

Affected sheep may have an acute form of the disease which can progress into a chronic form. The acute form begins as a septicaemia and is characterised by high fever, then depression and lameness. The affected joints are swollen due to an increase in synovial fluid and are heated to touch. In some cases the joints may not be swollen, making diagnosis more difficult (Angus, 1991).

The degree of lameness depends upon the joints infected. In the chronic form there may be swelling and deformity of joints, and the sheep are unthrifty. On many properties *Erysipelothrix* arthritis occurs each year within one to two weeks of marking lambs.

The pathology of the joints shows an increase in fibrin in the joint and adherence to the joint cartilage. The synovial membrane is thickened and the joint fluid has an increased volume and has a turbid appearance due to the increased number of lymphocytes. The adjacent lymph nodes draining the infected joints may be enlarged. Microscopic examination shows an increase in the size of the villi on the synovial membrane.

Lambs that have suckled colostrum from ewes that have developed immunity after natural challenges to the organism are better equipped to localize the bacteria at the site of infection and prevent infection in the joints.

Erysipelothrix arthritis is diagnosed by culture of the bacteria from infected joints. The success in culturing bacteria is in direct relation to the age of the lesion. *Erysipelothrix* has been isolated from joints with a mixed infection containing also pyogenic bacteria and it was only after prolonged culture that *Erysipelothrix* was identified (SAC, 1997). Kaferstien was able to culture the bacteria from 40% of infected lesions or adjacent lymph nodes, and Lamont from about 27% of infected joints. There is an inverse relationship between the rate of isolation of bacteria and the duration of the disease (Nielsen, 1966). Agglutination titres are not consistent as non-infected sheep may have high titres from natural exposure to the bacteria. However this test may be of value in chronic cases. Histopathology of the joints can assist in the diagnosis.

Penicillin is the most cost-effective treatment *for Erysipelothrix* infection provided the sheep are treated early and the course of antibiotics is continued for five days.

An *Erysipelothrix* vaccine “Eryvac” is available in Australia. In flocks with an on-going problem ewes should be vaccinated on two occasions in the first year. This is at the end of mating and again about 4 weeks prior to the start of lambing. In outbreaks, vaccination of lambs in the face of the outbreak may protect lambs not yet exposed to the infection. Lambs require two doses for effective protection. Piercy, 1974 showed that lambs that had suckled colostrum from ewes with antibodies from two doses of vaccine were able to confine *Erysipelothrix* bacteria within the regional lymph nodes. In lambs that were colostrum-deprived, bacteria were isolated from lymph nodes, abdominal organs and synovial fluid. This observation validates the strategy of vaccinating ewes before lambing and ensuring lambs on endemic properties should have colostrum to attain passive immunity. On some properties that have seen the condition each year, all lambs are injected intramuscularly with a long acting dose of either penicillin or oxytetracycline as a preventive therapy. This has been effective, and is less costly than vaccination. A single dose of vaccine would cost the producer approximately 50 cents, whereas the cost of a single dose of long acting tetracycline would cost approximately 35 cents.

Paton (2003) in a trace-back study from abattoirs, found the incidence of arthritis in lambs in Western Australia to be an average of between 0.8 and 1.3%. Samples from infected joints in an abattoir isolated *Erysipelothrix rhusiopathiae* from 37% of joints, with one joint having a mixed infection with staphylococci present. No other organisms were isolated. A survey of farm management practices was carried out. There was a high correlation between mulesing and the incidence of arthritis and a high correlation between lamb shearing and the incidence of arthritis.

There was a seven times increase in arthritis cases in lambs that were mulesed compared to lambs that were not mulesed and a 4.3 times increases in the cases of arthritis in lambs that were shorn compared to lambs that were not shorn. It is interesting to note that marking lambs in temporary yards compared to permanent yards resulted in a higher incidence of arthritis. Similarly the use of disinfectants on the wounds had a higher incidence of arthritis than sheep in flocks that did not use a disinfectant.

Pfizer Animal Health market "Eryvac" vaccine. It is estimated that each year approximately 1,500,000 doses are sold for use in sheep (Sherman, pers. com.). The vaccine is sold through rural merchants so the vaccine regime recommended may vary. Some sheep may only receive a single dose of vaccine in face of an outbreak; some ewes may receive a single dose as an annual booster after receiving the requisite two doses as a maiden ewe. It has been recommended to some producers by their veterinarian to vaccinate lambs at marking and again at weaning, rather than vaccinate the ewe prior to lambing. This vaccination programme appears to be effective on properties that observed cases of arthritis later than marking. It is unknown whether the properties where the vaccine is used have ever had a definitive diagnosis of *Erysipelothrix*. The efficacy of the vaccine is suspected to be variable. Some properties do report a high reduction in cases observed whilst others have reported no effect. The latter are most likely to be properties that have not sought a diagnosis and the arthritis is the result of another organism, or the vaccine has been used in sheep already affected.

4.1.6.4 Exotic Causes of Arthritis

Two other organisms can produce arthritis in sheep, but they are not present in Australia. These are briefly discussed for completion of the topic. The two conditions are Maedi-visna and tick pyaemia.

Maedi-visna is a viral disease that is fatal. Very rarely sheep will develop arthritis, but if present it is primarily in the carpal joints. The joint becomes swollen and there is an acute lameness. In flocks where this disease is endemic the more typical signs of respiratory distress, weight loss and gait abnormalities of the hind limbs in adult sheep are more common than acute lameness.

Tick pyaemia produces an arthritis caused by staphylococci that are introduced into the body when the tick *Ixodes ricinus* begins to feed on the blood of lambs. In most cases the arthritis is septic, but also abscesses are produced in the body organs and sometimes on the spinal cord.

4.1.7 Pathology of Affected Joints

The first macroscopic changes seen in infected joints are the increased prominence of the villi as they become hyperaemic and oedematous. The synovial fluid is increased in volume and is turbid and mucinous. The synovial membrane may contain petechiae. As the lesion progresses there is fibrinous effusion into the joint. Fibrin may be seen on the articular cartilages and on the synovial membrane.

In advanced cases the fibrinous changes give way to fibrous deposition. Granulation tissue becomes deposited on the articular surfaces and on the proliferating perichondrium. It is at this stage that the joint may become sterile.

Once the joint is sterile the lesion may progress in one of three ways. First, the lesion may resolve. Second, the lesion may become organised and heal by fibrosis, resulting in a thickened fibrotic joint capsule. Third, there may be continued reaction in the joint leading to adhesions and finally ankylosis of the joint (Jubb et al., 1993).

4.1.8 Diagnosis of Arthritis

The clinical signs of arthritis are readily detected. The sheep are lame in one or more limbs. In some cases the sheep may exhibit a shifting lameness. It is important to examine affected sheep after resting as well as whilst moving, as on occasions the lameness can disappear after the sheep has been mobile. As the inflammation progresses the affected joints become swollen. The inflammation is painful and this begins to affect both the feed intake of the sheep and the efficiency of feed conversion.

Palpation of the joint may reveal an enlarged joint which initially is hot and soft. As the lesion progresses the mobility of the joint becomes restricted and extrusions of bone may be felt about the joint. In chronic lesions the joint may be ankylosed.

The cause of the inflammation may be determined by culture of a joint aspirate collected through sterilised skin from the joint capsule. In the case of chlamydial infection, serum antibodies may be detected with diagnosis confirmed from a rising titre in samples collected 21 days apart. It is not always possible to isolate bacteria from joints, especially if the lesion has been present for a period of time.

Examination of the joint fluid can assist in diagnosis. The following table presented by Jackson (1999) is useful.

Table 1: Guide to the features of joint fluid in sheep (after Jackson 1999)

Feature	**Normal Joint Fluid**	**Joint Fluid in Septic Arthritis**
Appearance	Clear and golden	Cloudy and pale yellow/white
Consistency	Viscous	Watery
Coagulation	No	Yes, on standing
Protein content	<20 g/litre	>60 g/litre
Cell count	<300 cells/µl	>10,000 cells/µl
Cytology	<10% polymorphs	>90% polymorphs, many degenerate

On opening joints the increased volume of fluid is seen. This fluid may be discoloured and even contain blood and fibrin. The synovial membranes are congested with larger villi giving a roughened appearance and the cartilages on the joint surfaces may be eroded and ulcerated (Angus, 1991).

Macrae and Scott (1999) examined normal and infected joints of sheep using ultrasonography. They foresee the benefits of this technique in assessing the prognosis of chronic lesions based on the changes in the synovial membranes and joint capsule. The technique is quicker and cheaper

than aspiration of joint fluid and culture. Again this technique may have limited use in valuable individual animals.

In the laboratory there is a protocol that will give optimal probability of diagnosing arthritis and of isolating the causative organism. Affected joints should be submitted to the laboratory intact. At the laboratory an aspirant is taken from the joint under sterile conditions and immediately cultured on to both blood agar plates and selective media to isolate the infected bacteria. Samples of the synovial membrane can be macerated, grown up in an enrichment broth and the suspension poured on to plates to increase the chances of growing *Erysipelothrix rhusiopathiae*. The joint should be opened and the synovial fluid examined, and the synovial membrane and joint surfaces examined for gross changes. Samples of the synovial membranes can be collected for histopathological examination.

4.2 Chlamydia

Chlamydia organisms need to be enriched in chicken embryos to get adequate numbers for PCR identification. The organisms are labile so the samples need to be processed within 24 hours of collection. The intact joint should be kept under refrigeration during transportation to the laboratory.

Paired sera can be collected from infected sheep to assess chlamydial titres. A four-fold increase in antibody titre from the acute stage to the convalescent stage three weeks later is indicative of chlamydial infection.

4.3 Limitations in Diagnosis

Isolation of the causative organism is the biggest impediment to diagnosis. Many of the arthritic sheep presented are chronic, and the bacteria are no longer present in adequate numbers for culture. Often some of the sheep have already been treated with an antibiotic. The pyogenic bacteria are easy to culture.

*Chlamydia*e are the most difficult of the common arthritis organisms to isolate. The organism is fragile and needs to be held in a cool environment whilst being transported to the laboratory. Recent culture techniques and the use of PCR identification may increase the number of cases identified.

There is always the possibility of mixed cultures being present in the joint. As *Chlamydiae* are more difficult to diagnose, the organism may be missed and yet it could be the primary causative bacteria.

The culture of organisms is not always diagnostic, as most organisms can be cultured from joints that show no gross or microscopic changes. A pathological change in the tissues of the joint must accompany bacterial culture.

4.4 Effects of Arthritis

The effects of arthritis on sheep are severe. Most cases result in poor productivity and the animal is destroyed. The losses occur both on-farm and at sale or slaughter.

Sheep carcases detected with arthritis at slaughter are condemned. If the infection is confined to one joint then the affected area is removed from the carcase, prior to the carcase weight being recorded, and the carcase can only be used for domestic consumption. If more than one joint is infected, or if systemic infection is present then the carcases is classified as polyarthritis and it is totally rejected.

At saleyards, if arthritic sheep are seen in a sale mob, the purchaser will reduce the price offered for that line of sheep.

On sheep properties, sheep infected with arthritis will have a lower average weight gain depending on the severity and longevity of the disease. Joints that have been damaged may sustain permanent detrimental effects on productivity. These effects include growth rate, carcase composition, lambing percentage and wool growth. Some sheep will die from starvation, secondary disease such as internal parasitism, flystrike, or predation.

The welfare of infected animals is compromised. It is difficult for the sheep producer to assess the pain and suffering of infected sheep. Most producers treat infected sheep with antibiotics in the hope of cure, but often as an obligation that they are trying to assist the sheep by alleviating the condition. If infected sheep are destroyed on the property there are no cardinal signs to determine the most appropriate time. Often they are destroyed at the end of the season when the last shipment of lambs has been sold.

Mobs of sheep that contain sheep affected with arthritis will require additional time to muster. As the affected sheep tend to lag behind the mob they are often subjected to further stress as they are encouraged to move at a faster pace.

Concerned sheep producers can spend many hours, often each day, in observing the mobs of young sheep that are susceptible to arthritis. They know that if infected sheep can be treated with antibiotics as soon as the clinical signs appear the infection can be cured. This is particularly important to stud breeders where individual animals have a high commercial value.

The cost of treatment can be high. A course of antibiotics can be as high as $5.00 per sheep treated. There is also the cost of the time to identify, isolate and treat the infected sheep.

Properties that incur significant cases of arthritis every year often attempt to prevent lambs becoming infected. They may use the Eryvac vaccine at lamb marking at a cost of 50 cents per head, or they may vaccinate the ewe with two doses of vaccine, the second dose being administered prior to lambing. On some properties the producers are administering a dose of long-acting oxytetracycline to every lamb at lamb marking to prevent *Erysipelothrix rhusiopathiae* or the pyogenic bacteria becoming established through wounds imposed at lamb marking. Some veterinarians are considering the use of soluble tetracycline incorporated in the feed supply for lambs in feedlots or on a diet of supplementary feeding.

4.5 Treatment of Arthritis

Treatment of infected joints has varied outcomes. In the majority of cases the lesion has been established for a long period of time and the inflammatory changes have already altered the architecture of the joint. In addition the fibrous tissue laid down in the joint capsule reduces the blood supply to the joint and so it is difficult to get adequate concentrations of antibiotic or therapeutic into the joint.

Infected sheep should be treated with antibiotic, with a course of at least five-days. These include penicillin as an intramuscular injection at a rate of 20 mg/kg daily for five days, or with a five-day course of intramuscular injection of oxytetracycline at a rate of 12 mg/kg liveweight.

The use of corticosteroids in contraindicated as it may result in further erosion of the joint cartilage (Smith et al., 1989). Other groups of anti-inflammatory drugs are not appropriate as none of them are registered for use in sheep.

More radical adjuncts to treatment such as aspiration and irrigation of joints, and injection of antibiotic directly into the joint are rarely used. However these latter strategies may be employed when treating valuable elite animals.

The success rate of treatment on most commercial properties is poor as most animals are not treated until the time when they yarded at the next husbandry procedure, and the lesion has become chronic and the joint integrity has been altered. However on properties that have had chlamydial arthritis diagnosed, treatment with oxytetracycline as soon as lameness is observed appears to be successful.

Green et al, 1998 conducted weekly examinations on individual lambs from birth until one week prior to slaughter on two properties. Any lambs showing clinical signs of disease were treated on diagnosis. Each lamb was followed through to slaughter and identified at time of carcase inspection. Of the lambs diagnosed with arthritis and treated during routine clinical examination, 5 of the 23 (22%) treated had arthritic lesions at slaughter. In comparison lambs that did not show evidence of arthritis at routine clinical examination, 3 of the 646 lambs had arthritic lesions at slaughter. Therefore even with diligent regular clinical examination and immediate treatment, only 78% of lambs showed no evidence of lesions at slaughter as a result of either antibiotic treatment, self-cure or both.

4.6 Prevention of Arthritis

Effective prevention of arthritis requires a definitive diagnosis being made with the incriminating organism being identified. The timing of the implementation of the preventive method needs to be appropriate. Various methods are used.

Adams (1983) and Angus (1991) have both recommended the benefits of colostrum in which *Erysipelothrix* is endemic in the flock. This may not be appropriate to most Australian sheep flocks, but it is applicable to a flock with sheep of high individual value and where lambs are either fostered or mothered on to surrogate ewes.

On some properties the pyogenic bacteria can enter the navel shortly after birth, especially if the lamb is delivered on to wet or muddy ground. On stud properties where lambs are often identified and ear-tagged at birth, an iodine solution may be applied to the navel to sterilise the area. As some producers are starting to lamb ewes in feedlots when there is no pasture available, such a procedure may be used.

Sheep producers report that most arthritis in lambs is seen after lamb marking. Therefore sheep producers and marking contractors endeavour to practice hygienic procedures at lamb marking to decrease the incidence of arthritis. These practices include the use of temporary yards with unsoiled pasture to minimise contact of the marking wounds with faeces or soil and the disinfection of instruments used in the surgical procedures. Some producers use plastic sheeting for the lambs to drop on to after marking to reduce contact with the soil. Most producers try to mark in mobs of about 400 lambs, which is often the size of a lambing mob, so the lambs can be moved back to their lambing paddock as soon as possible. This may be more difficult when marking contractors are used as they prefer to mark at 1,500 lambs each day and so prefer larger mobs.

At marking times properties on which arthritis is endemic may either vaccinate or treat each lamb with antibiotics.

4.6.1 Eryvac Vaccine

Pfizer Animal Health market in Australia a vaccine that induces animals to develop antibodies against *Erysipelas rhusiopathiae.* This vaccine was originally developed for use in pigs, and has been shown to be effective in sheep. It was approved for registration for use in sheep in December 2005. It is used to control arthritis in lambs caused by *Erysipelothrix rhusiopathiae.*

It is difficult to obtain figures on the use of the vaccine as sheep and pig sales are combined. However there does appear to be an increase in the use of the vaccine. In the survey of sheep producers conducted for this review, three of the 26 properties have used the vaccine.

4.6.1.1 Instructions for use

The recommended course of vaccination is to vaccinate naïve ewes at mating and then administer a second dose approximately 4 weeks prior to the start of lambing. In ewes that have previously been vaccinated, they are given a single dose of vaccine approximately 4 weeks prior to the start of lambing. This vaccination should allow the ewe to pass immunity across to her lambs via the colostrum. Lambs should be protected by this passive immunity for the first 6 to 8 weeks of life.

4.6.1.2 Availability and distribution of vaccine

Eryvac vaccine is sold by Rural Merchants. There is no control on its use or the recommendations given to producers. The author has observed the vaccine being promoted by rural merchants as an arthritis vaccine. The vaccine should not be recommended unless a definitive diagnosis of the causative organism has been obtained.

5 Export Abattoir Survey

5.1 Methodology

Australian Quarantine and Inspection Service has been collecting data on condemnation of carcases at slaughter from 1st July 2000 through to 30th June 2006. The various causes of carcase rejection have been listed.

Statistics are available for both lambs and adult sheep (see tables below). However they are not identified according to breed so Merino sheep are not separated from the cross-bred and British breeds.

It should be noted that the arthritis condemnations are defined as "polyarthritis". This is defined as more than one joint affected, or when one joint is affected and there is evidence of systemic involvement. When only one joint is affected and there is no evidence of systemic infection, that joint is rejected with the remainder of the carcase passed for human consumption. These cases are categorized as arthritis and are not included in the condemnation data. They are partial condemnations as the infected joint is removed from the carcase.

5.2 Results- National

Table 2.1: Condemnation of Lamb Carcases Slaughtered at Export Abattoirs in Australia from 1st July 2000 to 30th June 2006

Year	Total slaughtered	Total condemned	% condemned	Total polyarthritis	% polyarthritis	% of condemnations
2000-2001	8,585,708	9,044	0.105	1,719	0.020	19.0
2001-2002	8,414,094	8,395	0.100	1,677	0.019	20.0
2002-2003	8,092,294	7,717	0.095	1,509	0.019	19.6
2003-2004	8,760,565	8,495	0.097	1,725	0.020	20.3
2004-2005	9,993,777	8,872	0.088	1,604	0.016	18.1
2005-2006	11,645,316	12,346	0.106	1,925	0.017	15.6

Table 2.2: Condemnation of Adult Sheep Carcases Slaughtered at Export Abattoirs in Australia from 1st July 2000 to 30th June 2006

Year	Total slaughtered	Total condemned	% condemned	Total polyarthritis	% polyarthritis	% of condemnations
2000-2001	11,325,268	92,560	0.817	2,713	0.024	2.93
2001-2002	9,750,880	76,483	0.784	1,986	0.020	2.60
2002-2003	9,611,984	94,441	0.983	1,858	0.019	1.97
2003-2004	7,182,759	41,281	0.575	1,211	0.015	2.93
2004-2005	7,899,646	53,159	0.673	1,232	0.016	2.32
2005-2006	8,429,813	63,623	0.755	1,453	0.017	2.28

In the carcases condemned, not all are as the result of disease. Condemnations include ante-mortem inspections condemnations, bruising, dog bites, gross contamination, and company condemnations. The latter includes those carcases that have become contaminated as they fell off the processing chain during the slaughter process. None of these carcases would have been inspected for arthritis.

5.3 Results – state comparisons

When the data is categorised into states of Australia the following results are shown:

Table 2.3: Condemnation of Lamb Carcases Slaughtered at Export Abattoirs in the Respective States of Australia from 1st July 2000 to 30th June 2001

State	Total slaughtered	Total polyarthritis	% polyarthritis
NSW	1,546,480	584	0.038
QLD	666,313	27	0.004
SA	2,371,172	121	0.005
TAS	85,157	6	0.007
VIC	3,056,006	925	0.030
WA	860,580	56	0.007
National	8,585,708	1,719	0.020

Table 2.4: Condemnation of Lamb Carcases Slaughtered at Export Abattoirs in the Respective States of Australia from 1st July 2001 to 30th June 2002

State	Total slaughtered	Total polyarthritis	% polyarthritis
NSW	1,856,864	614	0.033
QLD	273,141	20	0.007
SA	2,543,113	105	0.004
TAS	136,585	24	0.018
VIC	2,449,024	821	0.034
WA	1,155,367	93	0.008
National	8,414,094	1,677	0.020

Table 2.5: Condemnation of Lamb Carcases Slaughtered at Export Abattoirs in the Respective States of Australia from 1st July 2002 to 30th June 2003

State	Total slaughtered	Total polyarthritis	% polyarthritis
NSW	1,709,165	489	0.029
QLD	42,960	5	0.012
SA	2,204,590	102	0.005
TAS	125,444	19	0.015
VIC	2,653,403	814	0.031
WA	1,356,732	80	0.006
National	8,092,294	1,509	0.019

Table 2.6: Condemnation of Lamb Carcases Slaughtered at Export Abattoirs in the Respective States of Australia from 1st July 2003 to 30th June 2004

State	Total slaughtered	Total polyarthritis	% polyarthritis
NSW	1,588,807	127	0.008
QLD	18,653	0	0.0
SA	2,532,596	123	0.005
TAS	139,179	14	0.010
VIC	2,699,715	1,316	0.049
WA	1,781,615	145	0.008
National	8,760,565	1,725	0.020

Table 2.7: Condemnation of Lamb Carcases Slaughtered at Export Abattoirs in the Respective States of Australia from 1st July 2004 to 30th June 2005

State	Total slaughtered	Total polyarthritis	% polyarthritis
NSW	1,816,843	45	0.002
QLD	36,857	0	0.0
SA	2,986,373	106	0.004
TAS	146,490	23	0.016
VIC	3,161,876	1,320	0.042
WA	1,845,338	110	0.006
National	9,993,777	1,604	0.016

Table 2.8: Condemnation of Lamb Carcases Slaughtered at Export Abattoirs in the Respective States of Australia from 1st July 2005 to 30th June 2006

State	Total slaughtered	Total polyarthritis	% polyarthritis
NSW	2,173,304	85	0.004
QLD	7,216	0	0.0
SA	2,973,546	146	0.005
TAS	187,897	25	0.013
VIC	4,082,062	1,422	0.035
WA	2,221,291	247	0.011
National	11,645,316	1,925	0.017

Table 2.9: Condemnation of Lamb Carcases Slaughtered at Export Abattoirs in the Respective States of Australia from 1st July 2000 to 30th June 2006

State	Total slaughtered	Total polyarthritis	% polyarthritis
NSW	10,691,463	1,944	0.018
QLD	1,045,140	52	0.005
SA	15,611,390	703	0.005
TAS	820,752	111	0.014
VIC	18,102,086	6,618	0.037
WA	9,220,923	731	0.008
National	55,491,754	10,159	0.018

Table 2.10: Condemnation of Adult Carcases Slaughtered at Export Abattoirs in the Respective States of Australia from 1st July 2000 to 30th June 2001

State	Total slaughtered	Total polyarthritis	% polyarthritis
NSW	4,558,634	808	0.018
QLD	1,237,043	219	0.017
SA	1,299,723	113	0.009
TAS	48,364	7	0.014
VIC	2,228,817	1,017	0.046
WA	1,952,687	549	0.028
National	11,325,268	2,713	0.024

Table 2.11: Condemnation of Adult Carcases Slaughtered at Export Abattoirs in the Respective States of Australia from 1st July 2001 to 30th June 2002

State	Total slaughtered	Total polyarthritis	% polyarthritis
NSW	4,300,964	790	0.018
QLD	1,124,757	117	0.010
SA	921,880	146	0.016
TAS	68,530	16	0.023
VIC	2,101,665	686	0.033
WA	1,233,084	231	0.019
National	9,750,880	1,986	0.020

Table 2.12: Condemnation of Adult Carcases Slaughtered at Export Abattoirs in the Respective States of Australia from 1st July 2002 to 30th June 2003

State	Total slaughtered	Total polyarthritis	% polyarthritis
NSW	3,953,655	669	0.017
QLD	948,335	49	0.005
SA	1,331,716	306	0.023
TAS	110,163	20	0.018
VIC	2,120,874	671	0.032
WA	1,147,241	143	0.012
National	9,611,984	1,858	0.019

Table 2.13: Condemnation of Adult Carcases Slaughtered at Export Abattoirs in the Respective States of Australia from 1st July 2003 to 30th June 2004

State	Total slaughtered	Total polyarthritis	% polyarthritis
NSW	2,429,683	237	0.010
QLD	715,860	23	0.003
SA	696,351	83	0.012
TAS	100,383	30	0.030
VIC	1,951,145	660	0.034
WA	1,289,337	178	0.014
National	7,182,759	1,211	0.017

Table 2.14: Condemnation of Adult Carcases Slaughtered at Export Abattoirs in the Respective States of Australia from 1st July 2004 to 30th June 2005

State	Total slaughtered	Total polyarthritis	% polyarthritis
NSW	2,759,783	302	0.011
QLD	695,592	16	0.002
SA	726,438	104	0.014
TAS	106,583	17	0.016
VIC	1,939,844	586	0.030
WA	1,671,406	207	0.012
National	7,899,646	1,232	0.016

Table 2.15: Condemnation of Adult Carcases Slaughtered at Export Abattoirs in the Respective States of Australia from 1st July 2005 to 30th June 2006

State	Total slaughtered	Total polyarthritis	% polyarthritis
NSW	2,980,336	387	0.013
QLD	709,289	12	0.002
SA	823,736	101	0.012
TAS	105,390	20	0.019
VIC	2,235,469	600	0.027
WA	1,575,593	333	0.021
National	8,429,813	1,453	0.017

Table 2.16: Condemnation of Adult Carcases Slaughtered at Export Abattoirs in the Respective States of Australia from 1st July 2000 to 30th June 2006

State	Total slaughtered	Total polyarthritis	% polyarthritis
NSW	20,983,055	3,193	0.015
QLD	5,430,876	436	0.008
SA	5,799,844	853	0.015
TAS	539,413	110	0.020
VIC	12,577,814	4,220	0.034
WA	8,869,348	1,641	0.019
National	54,200,350	10,453	0.019

Of the condemnations resulting from a specific diagnosis of disease in lambs, polyarthritis was the most common in most years.

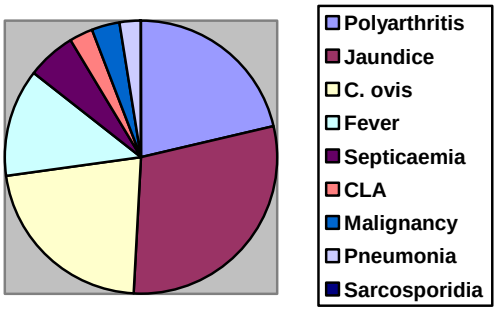


Figure 2.1: Proportion of Lamb Carcases Condemned from Disease Causes from 1st June 2000 to 31st July 2006

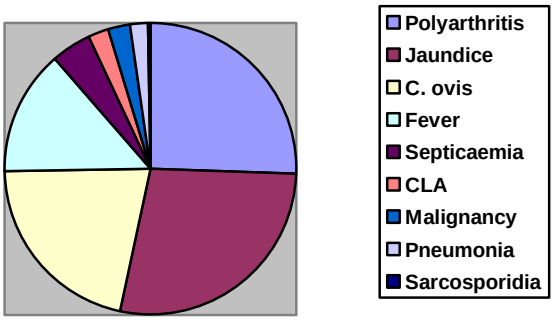


Figure 2.2: Proportion of Adult Carcases Condemned from Disease Causes from 1st June 2000 to 31st July 2006

Reviewing the abattoir data for carcases condemned as a result of a disease episode the following results were shown. Physical damage, ante-mortem rejection, company condemnation, gross contamination, and emaciation have not been included.

Table 2.17: Incidence of Lamb Carcase Condemnation as a Result of Disease from 1st June 2000 to 31st July 2006

Cause	Number	Percentage
Polyarthritis	10,159	25.6
Jaundice	11,072	27.8
Caseous Lymphadenitis	894	2.2
Fever	5,535	13.9
Septicaemia	1,728	4.3
Septic Pneumonia	772	1.9
Malignancy	1,012	2.5
Cysticercus ovis	8,488	21.3
Sarcosporidia	101	0.3
Total	39,761	

Table 2.18: Incidence of adult carcase condemnation as a result of disease from 1st June 2000 to 31st July 2006

Cause	Number	Percentage
Polyarthritis	10,453	6.8
Jaundice	19,098	12.5
Anaemia	671	0.4
Caseous lymphadenitis	41,948	27.4
Fever	31,223	20.4
Septicaemia	14,549	9.5
Pyaemia	378	0.2
Septic Pneumonia	7,951	5.2
Peritonitis	1,105	0.7
Malignancy	44,950	29.3
Cysticercus ovis	9,682	6.3
Hydatids	136	0.1
Sarcosporidia	11,624	7.6
Total	153,268	

In Britain 0.5% of lamb carcases are condemned at slaughter from arthritis (Watkins & Sharp, 1998).

5.4 Comparison with 1984-1985 Abattoir Data

As there has been only scant data collected from abattoirs, it is worthwhile comparing the data from Export Abattoirs in 2004-2005 with data collected from New South Wales Abattoirs in 1987 to 1990 by Butler (1993). The total condemnation rate for adult sheep and lambs combined was 0.48%. These values from the various meat processors ranged from no recorded condemnations (from any condition) to 0.137% of total condemnations.

Further information was collated by Butler (1993) in New South Wales from 1984 and 1985. The table below shows the results:

Table 2.19: Arthritis Condemnations in Sheep Slaughtered in New South Wales in 1984 and 1985 (Butler, 1993)

Processor & Year	Total kill	% Arthritis Condemnations		% All Arthritis	Ratio partial to total
		Total	Partial		
All centres – 1984	7,406,306	0.045	0.175	0.220	3.90
All centres – 1985	8,656,678	0.041	0.159	0.200	3.91
Export Abattoirs – 1984		0.076	0.096	0.173	1.26
Export Abattoirs – 1985		0.070	0.113	0.174	1.61
Slaughterhouses – 1984		0.013	0.198	0.211	15.47
Slaughterhouses – 1985		0.014	0.199	0.213	13.82

The above data (see Table 2.19) shows that there has been little change in the incidence of total condemnations as a result of arthritis over the last twenty-two years. The data from Butler also suggests that the export abattoirs are more stringent in their criteria for total condemnation as the combined sum of total and partial condemnations are similar in both years and between export abattoirs and slaughterhouses. However the total condemnations at export abattoirs are 4.5 times higher.

Comparison of the total condemnations against the partial condemnations shows that there are 3.9 times as many partial condemnations as total condemnations.

5.5 Discussion

This data indicates that in export abattoirs over the last 6 years an average of 1693 lamb carcases and 1742 adult carcases were total condemnations. This represents 0.0185% of all lambs slaughtered or 1.85 carcases per 10,000 lambs submitted for slaughter. In the adult sheep this represents 0.0183% of all adults slaughtered or 1.83 carcases per 10,000 adult sheep submitted for slaughter. There was little variation between the six years.

The condemnation rate in lambs and adult sheep are similar. This suggests that either sheep are developing arthritis after they are one year of age, or they have been carrying the infection for most of their lives. The latter implies that sheep growth rates and production are minimally compromised with a mild infection, or sheep are being carried when obviously infected, or they have recovered clinically but joint damage remains.

Between the different states of Australia there is a large variation in condemnation rate. However the state of slaughter does not indicate the property of origin as lambs and adult sheep at abattoirs are drawn from a large area of Australia, even from Western Australia, into the south-eastern states. Victoria has at least twice as many lamb carcases and ewe carcases condemned than any other state. New South Wales and Tasmania have an average number of condemnations whilst Western Australia, South Australia and Queensland are low. Various factors may contribute to these differences. These may include sheep breeds, husbandry procedures, climate, sheep stocking density, selection of sheep for slaughter, or diligence of meat inspection or adherence to meat inspection standards.

Table 2.20: Condemnation of Lamb Carcases Slaughtered at Export Abattoirs in the Respective States of Australia from 1st July 2000 to 30th June 2006

State	Total slaughtered	Total polyarthritis	% polyarthritis
NSW	10,691,463	1,944	0.018
QLD	1,045,140	52	0.005
SA	15,611,390	703	0.005
TAS	820,752	111	0.014
VIC	18,102,086	6,618	0.037
WA	9,220,923	731	0.008
National	55,491,754	10,159	0.018

Table 2.21: Condemnation of Adult Carcases Slaughtered at Export Abattoirs in the Respective States of Australia from 1st July 2000 to 30th June 2006

State	Total slaughtered	Total polyarthritis	% polyarthritis
NSW	20,983,055	3,193	0.015
QLD	5,430,876	436	0.008
SA	5,799,844	853	0.015
TAS	539,413	110	0.020
VIC	12,577,814	4,220	0.034
WA	8,869,348	1,641	0.019
National	54,200,350	10,453	0.019

6 Sheep Property Survey

6.1 Methodology

A questionnaire was mailed to approximately 70 sheep producers requesting information about arthritis on their properties. The properties targeted were identified by the author as prime lamb producers. The questionnaire is in Appendix 1.

6.2 Results of Survey

The response was not high with 26 producers responding. The properties responding were located in either West Australia, South Australia, Victoria, New South Wales or Tasmania. None of the producers had actual data of numbers of sheep affected, but they did give an estimate of the numbers affected.

The prime lamb properties surveyed marked between 822 and 7,000 lambs each year. Over the last five years there was an average of 0.63 % of arthritic sheep estimated. On seven properties were no cases of arthritis reported over the last five years. The annual average variation between 2001 and 2005 ranged from 0.51 and 0.85. Of the approximately 288,000 lambs marked there was an estimated 28 lambs known to be condemned at slaughter. Of the remainder, 73 were sold and the rest were destroyed on the property. Only three properties reported treating affected lambs. It is interesting that one producer stated that having five cases per thousand was not a concern.

Over the last three production years, 2003/04, 2004/05, 2005/06, producers stated that there were 510 lambs affected, 17 of which were treated, 74 were sent to abattoirs, 74 were sold, 40 died and 322 were destroyed.

The breeds and cross-breeds of the flocks involved varied, but there was no particular breed of ewe with a higher incidence. One breeder of Dorset rams did report that arthritis was a concern to Dorset breeders, whilst another reported that arthritis was more common in Hampshire cross lambs.

The husbandry techniques employed at marking showed no significant differences. Almost every producer used rings for castration, tails were docked with either a knife, rings or a gas knife, and all producers vaccinated and earmarked or ear-tagged their lambs. It is interesting that 25% of the participants still mules the ewe lambs that are intended for flock replacements.

Most producers reported that the clinical signs observed were lameness, swollen joints and ill-thrift in affected lambs.

Of the 26 properties that responded, only three stated that they used antibiotics as a treatment, two of which reported some success if the cases were treated early. Three properties have been using the Eryvac vaccine over the last three years and they reported a reduction in the number of cases seen. However some producers also stated that the incidence was reduced in latter years because of the drier conditions over marking. Most producers stated that they just destroyed affected lambs.

It is interesting to note that no producers commented on arthritis in adult sheep.

The table below summarises the results of the incidence of arthritis from properties that responded to the producer survey.

Year	Total lambs marked	Incidence of arthritis (%)	Abattoir condemnations
2001	47,500	0.70	0
2002	45,300	0.85	0
2003	61,500	0.53	5
2004	66,300	0.60	10
2005	74,600	0.51	13
Total	288,300	0.63	28

6.3 Discussion

The information received from the responding producers were estimates of the incidence of arthritis. Experience suggests that these estimates are conservative and may understate the incidence by up to a half.

The incidence of arthritis was less over the latter three years compared to 2001 and 2002. These years with the lower incidence had lower rainfall than the earlier years, suggesting that wet conditions at marking time may predispose to infection. Comments to this affect were made by some producers.

It is apparent that producers are accepting of the condition and many expect to get some cases every year. The treatment courses they have been using with antibiotics have not been successful in the past so they have stopped any treatments and tend to destroy the sheep on the property. However on properties that are vigilant and are able to identify and treat sheep within 48 hours of the onset of clinical signs appear to getting a good response to antibiotic treatment. In these cases the first clinical sign observed is sheep being away from the mob and it is not until they are moved that lameness is observed. This type of intensive surveillance is time consuming.

Most producers reported the typical clinical signs of lameness and swollen joints and many stated ill-thrift. This latter finding indicates that properties are carrying chronic cases which probably should have been destroyed. This is an animal welfare issue. Therefore guidelines need to be produced to indicate to producers when affected sheep are beyond treatment and should be destroyed.

Comments were made regarding the heavier terminal breeds of sheep, Dorset and Hampshire. This may be the result of high growth rates that are imposing greater stress on an immature joint, or it may be the concentration of sheep about grain feeders as the producers seek high growth rates, and the spread and uptake of *Chlamydia* organisms. These aspects do require further investigation.

7 Veterinary Practice Survey

7.1 Methodology

A total of eleven veterinary practices in New South Wales, Victoria, South Australia and Tasmania were surveyed using a telephone interview. They were selected on the basis of having experienced veterinarians and servicing areas with a high sheep population. The questions asked are shown in Appendix 1.

7.2 Results

The number of cases seen over the last five years varied between zero and 60. Many consultations with clients were telephone consultations discussing the cases, the treatment and prevention in future years. The trigger point for a response from the sheep producer was when approximately 5% of the mob showed signs of lameness, or if several carcases had been condemned at slaughter. The flock size did not appear to initiate a response from the sheep producer. Most infections in lambs occurred after marking, although cases were seen in weaners up to 12 months of age.

The clinical signs reported or seen were both lameness and swelling of the affected joints, and with *Chlamydia* it was a rapid loss of condition. A low percentage of cases were sampled for laboratory diagnosis of the causative organism. Some practitioners took swabs from aspirated joint fluid, some took serum when *Chlamydia* was suspected. Only two practices submitted affected joints to the laboratory, but in both of these practices the cost of the laboratory examination was subsidised by state governments. Many depended on clinical signs for diagnosis.

Various laboratories were used to process samples, all of which were familiar with processing samples from sheep. The practices that submitted affected joints appeared to get a higher percentage of definitive diagnoses.

The treatment recommended and dispensed was either long-acting oxytetracycline or procaine penicillin. When cases were treated within two or three days of onset, the cure rate was as high as 80%. Often in chronic cases no treatment was recommended as a poor response was predicted. In two practices a five day course of procaine penicillin was recommended and these practices appeared to get a higher cure rate.

All of the practices that were approached for information gave recommendations to minimise the rate of infection. All were based on hygiene. The measures included iodine on navels at birth, using temporary grassed yards at marking, moving lambs back to pasture as soon as possible after marking, reducing dust during marking, hygiene at shearing and avoiding dipping off-shears if *Erysipelothrix* was incriminated. With the increase in hand feeding of sheep, some veterinarians recommended that the lambs were fed in feeders off the ground to minimise the contact with dust. On properties where *Erysipelothrix* has been diagnosed and the incidence is greater than 20%, the use of intramuscular oxytetracycline at marking to all lambs has been recommended. On one property it has been recommended that oxytetracycline powder is incorporated in the concentrate feed after *Chlamydia* has been isolated from infected lambs.

7.3 Discussion

This survey suggests that rural veterinarians see very few cases in any year and that sheep producers are very accepting of a low percentage of cases. Veterinarians are reluctant to submit cases to the laboratory to isolate the causative organism, because of cost and of the low rate of isolation of bacteria.

The cost of a laboratory investigation is not high in relation to the value of the animals. The cost of an examination of the joint surfaces plus bacteriology of joint fluid and serum agglutination is approximately $140.00 (Ross, pers.comm.) The laboratories prefer and recommend that intact joints from recent cases are submitted along with sera. Bacteria on swabs and from joint aspirates do not survive well in transit.

The success rate of antibiotic treatment varies. Veterinarians surveyed reported that success in recently infected cases appears to be greater than 50%, but chronic cases have poor success rate and probably should not be treated. The course of treatment should be for five days as the curative rate appears to be higher than a shorter course of three days. In human cases the course of treatment for septic arthritis is for ten days. Affected sheep that are treated with parenteral antibiotic should be confined close to the sheep yards, and the date of the initial treatment marked on the sheep. This gives a greater likelihood for them to be treated for five days, or if long-acting preparations to give a second dose after three days.

The preventative advice given to producers appears to be generic. The use of temporary yards for marking is a good practice, but after the survey conducted by Paton (2003), it should not be assumed that temporary yards offer any better conditions than permanent yards. Definitive work is required to determine the most appropriate facilities and procedures for marking lambs to minimise arthritis.

The apparent increase in the incidence of *Chlamydia* in older weaned lambs whilst being fed concentrate feeds requires further investigation to isolate the predisposing factors, and the most effective way of preventing the infection.

The veterinary profession needs to be made aware of the true incidence of arthritis in sheep. It also needs to have a standard protocol for submission of samples to laboratories to give the greatest opportunity to isolate the incriminating organisms.

8 Diagnostic Laboratory Survey

8.1 Methodology

Information was sought form veterinary diagnostic laboratories regarding the results of submissions of samples to establish a diagnosis of arthritis. In New South Wales Elizabeth Macarthur Agricultural Institute collected submissions for their database that includes all Department of Primary Industries laboratories in New South Wales. Victoria was unable to supply any results. The results are tabled below.

8.2 Results

Table 2.22: Number of cases submitted, the diagnosis, the age of the sheep and the breed of the sheep to laboratory diagnosis in NSW in 1994-1999.

Organism	**Merino**	**Non-Merino**	**Total**
Chlamydia	9	18	27
Erysipelothrix	21	6	27
A. pyogenes	6	2	8
F. necrophorum	4		4
Histophilus ovis	2	1	3
Proteus	1		1
Histophilus somnus	1		1
Pasteurella multocida	1	2	3
Streptococcus	1	1	2
Micrococcus		1	1
E. coli		1	1
Staphylococcus	1	1	2
No diagnosis	31	27	58
Total	**78**	**60**	**138**
< 12 months of age	50	41	91
Adult sheep	14	5	19
Age unknown	14	14	28

Total *Chlamydia* = 27/138
Total *Erysipelothrix* = 27/138
Total septic arthritis = 26138

Table 2.23: Number of cases submitted, the diagnosis, the age of the sheep and the breed of the sheep to laboratory diagnosis in NSW in 2000-2005.

Organism	**Merino**	**Non-Merino**	**Total**
Chlamydia	3	17	20
Erysipelothrix	4	2	6
A. pyogenes	3	1	4
F. necrophorum	7		7
Histophilus somnus	1	1	2
Pasteurella multocida	1	2	3
Staphylococcus	1		1
No diagnosis	7	10	17
Total	**27**	**33**	**60**
< 12 months of age	13	20	33
Adult sheep	10	5	15
Age unknown	4	8	12

Total *Chlamydia* = 20/60
Total *Erysipelothrix* = 6/60
Total septic arthritis = 17/60

Table 2.24: Number of cases submitted, the diagnosis, the age of the sheep and the breed of the sheep to laboratory diagnosis in NSW in 1987-1989 (Butler, 1993)

Organism	**Number**
Chlamydia	17
Erysipelothrix	6
A. pyogenes	1
F. necrophorum	11
Histophilus ovis	2
Streptococcus	1
Staphylococcus	1
Mixed infection	4
No diagnosis	22
Total	**65**

Total *Chlamydia* = 17/65
Total *Erysipelothrix* = 6/65
Total septic arthritis = 20/65

8.3 Discussion

The cases submitted to NSW Department of Agriculture Veterinary Diagnostic Laboratories are separated into two groups: 1994-1999 when there were no charges for laboratory submissions, and 2000 – 2005 when charges were made for all samples analysed. Once charging for samples was introduced, the number of submissions was halved. However in those cases submitted by Rural Lands Protection Boards veterinarians, often no charge was made.

These cases do not necessarily represent a cross section of cases across the state. They may indicate the enthusiasm of the submitting veterinarian, the group of concerned producers, or only cases where the incidence is high in a particular year. One case reported that 800 lambs from a mob of 1,200 were affected with arthritis. In many situations, once a diagnosis has been made on a property, no further diagnostic work is undertaken, irrespective of the number of cases in subsequent years.

In many cases no cause could be established. In some cases, bloods only were submitted which limited the diagnosis to *Chlamydia*, or the lesions may have been chronic and so no organism could be cultured.

However the data does show that the number of cases of the three classifications of *Chlamydia, Erysipelothrix* and septic arthritis are similar.

Over the last five years more cases have been submitted from non-Merino breeds indicating the value of the animals and the potential lost income.

The data collected by Butler (1993) from the same laboratory but covering the years 1987 – 1989 has shown similar ratios between the three classified groups of causes.

The laboratories are important in helping to seek a definitive diagnosis. The appropriate samples need to be submitted under appropriate transport conditions. The preferred samples are unopened joints. This allows the organisms to survive for longer, and it prevents the invasion of contaminating bacteria that may occur in collecting and handling joint aspirates. *Chlamydia* are fastidious organisms requiring the joint aspirate to be inoculated into embryonated chick eggs within a few hours of collection. Many veterinarians rely on serum titres for the diagnosis of chlamydia. A PCR (polymerase chain reaction) test is currently being developed at Elizabeth Macarthur Agricultural Institute in New South Wales which should assist in the diagnosis of *Chlamydia*.

Pfizer Animal Health manufactures and distributes the “Eryvac” vaccine to protect sheep against *Erysipelothrix rhusiopathiae* infection. They are currently developing an ELISA test which should improve the diagnosis for *Erysipelothrix* infection at a lower cost and within a shorter time period.

9 Economic Loss from Arthritis

When discussing the significance of arthritis to the sheep industry it is essential that the economic loss caused by the disease is evaluated.

The values used are from the survey data collected, or from conservative market values. The loss of carcase weight from a partially condemned carcase has been estimated at 3.0 kilograms. It has been estimated that if arthritis did not occur in carcases at abattoirs then the number of meat inspectors could be reduced by 5%. The national sheep numbers are taken from ABARE data.

9.1 Estimate of losses from arthritis

The losses from arthritis include the following:

1. Loss of carcase at slaughter
2. Partial loss of carcase at slaughter
3. Destruction of affected sheep on property
4. Treatment of affected sheep on property
5. Employment of additional meat inspectors

Using the data collected in the various surveys, an average annual loss would include:

0.0185 % of lambs submitted for export slaughter
0.0185 % of adult sheep submitted for export slaughter
0.0722 % of partial condemnation of lamb carcases
0.0722 % of partial condemnation of adult sheep carcases
5% reduction in meat inspectors
0.63 % of sheep destroyed on property
4/260 x 0.84% of sheep treated on property
Cost of vaccine used on *Erysipelothrix*-infected properties

Using the assumptions based on ABARE data and on survey data

Total lambs slaughtered	16,000,000
Total adult sheep slaughtered	12,000,000
Partial lamb condemnations	3.90 x total condemnations
Partial adult sheep	condemnations 3.91 x total condemnations
Adult sheep total condemnations	0.019%
Lamb total condemnations	0.018%
5% meat inspectors	
Sheep destroyed on property	0.63 %
Sheep treated on property	0.75% of affected sheep
Cost of vaccine	50 cents per dose

Using the following values

Lamb carcase at 23 kg @ $3.50/kg
Ewe carcase at 25 kg @ $1.60/kg
Meat inspector salary and on-costs $100,000
Sheep value on property $60.00
Cost of treatment $5.00/head
Cost of vaccination $1.20/head

9.2 Calculation of losses based on sheep numbers

Losses

Lamb loss = 16,000,000 x 0.018 @ 80.50 =	231,840.00
Adult loss = 16,000,000 x 0.019 @ 40.00 =	121,600.00
Partial lamb loss = 16,000,000 x 0.018 x 3.90 x 3 x 3.50 =	117,936.00
Partial adult loss = 16,000,000 x 0.019 x 3.91 x 3 x 1.50 =	53,488.80
Property lamb losses = 0.63% x 16,000,000 x 60.00 =	6,048,000.00
Property adult losses = .5% x 16,000,000 x 40 =	3,200,000.00
Reduction in meat inspectors = .05 x 400 x 100,000	2,000,000.00
Cost of treatments = 4/300 x 0.83 x 16,000,000 x 5.00	8,853.30
Cost of vaccination =2.3m doses x 0.50	1,150,000.00
Total annual loss	**$12,716,105.50**

The cost of labour required for additional surveillance inspecting mobs of weaners has not been factored in as it is not known how many properties are involved in this activity.

Green et al. (1994b) found that lambs with arthritis took an additional 27 days to attain slaughter weight. If a lamb utilises 2.0 kilograms of pasture daily at a cost of 10 cents per kilogram, for pasture, then these lambs would cost an additional $5.40 to get to slaughter weight. This cost does not include the additional time required by the flock manager in drafting out and re-mustering these sheep. A total of 16 million lambs slaughtered with 0.018% as total condemnations and 0.054% partial condemnations gives an additional cost to sheep producers of

$$16,000,000 \times (0.018 + 0.054) \times 5.40 = \$6,220,800.00$$

This cost does not appear to be high, but to individual producers with a high incidence of arthritis the cost is significant.

9.3 Overall total estimate

The overall total estimate of the cost of arthritis in the prime lamb industry is

$ 12,716,105.50
+
$ 6,220,800.00
=
$ **18,936,905.50 (Total)**

This figure is comparable to the estimate provided by Sackett et al (2006) in MLA AHW.087 of approximately $26 million, based on the entire Australian sheep flock including Merinos. Paton (2003) estimates the cost of arthritis to the national flock at approximately $30 million.

10 Recommendations for Further Investigation

The data collected from various sources yields some valuable information. The abattoir condemnation data is a true count of the condemnations at export abattoirs. The data collected from the sheep producer survey is probably conservative, but it does indicate that the number of lambs destroyed on properties is high. The data collected from the laboratories and from veterinarians is only a sample and although the data may not accurately reflect the incidence of the disease and the various causes, it does show the range of causative organisms that occur. It is suspected that once the causative organism has been identified, a preventative or treatment strategy is recommended, but no further diagnostic work is undertaken.

Therefore it is recommended that more accurate information is collected from properties using trace-back from abattoir condemnations. The information required would be isolation and identification of organisms involved, the incidence of the disease and husbandry information. The husbandry data would include a description of the procedures and facilities used at lamb marking, crutching and shearing, the climatic conditions at these times, the age, gender and breeds of the animals affected. Additional data should be collected on the total number of lambs and sheep affected, and any prevention and treatment strategies employed. The diet and the feeding system used should also be recorded. On these properties either joint aspirates from a sample of affected sheep, or the joints from sacrificed sheep should be collected and submitted for laboratory diagnosis.

The clinical and subclinical effects of the disease have never been measured accurately. Up to ten properties which include each of the three categories of arthritis, with an incidence of greater than 5% each year over the last 5 years should be identified and their cooperation sought. On these properties a sample of uniquely identified lambs destined for slaughter should be regularly weighed and inspected. Lambs with arthritis could then be followed through and compared with unaffected lambs to measure their average daily growth rates, the time to reach slaughter weight, and their response to any treatment imposed. The fate of the affected lambs may indicate the actual loss incurred by producers.

The veterinary profession is not actively involved with sheep producers. The advice given to producers is scant and may not be appropriate. This underscores the need for accurate extension to the veterinary profession as peak providers of advice and training in animal health and welfare. In most cases veterinarians are dispensing antibiotics without any identification of the causative organism. The recommendation on length of treatment varies and it is suspected that the response to treatment may be poor. A benefit-cost analysis needs to be presented to the veterinary profession about the disease to show the benefit of a laboratory diagnosis, the importance of collecting appropriate samples at the appropriate time, and the most appropriate preventative and treatment strategies.

If antibiotics are to be used either as a treatment or a prevention antibiotic sensitivities should be conducted at the laboratory to ensure affective antibiotics are dispensed.

Veterinarians and sheep producers are not aware of the incidence and importance of arthritis. Therefore an effective reporting system should be developed so sheep producers are given feedback on the number of sheep that are totally condemned plus those partially condemned. This data should be collated in a format for use by veterinarians in sheep-producing areas to make them aware of the incidence.

Currently Veterinary Diagnostic Laboratories can accurately isolate and identify *Erysipelothrix rhusiopathiae*. The diagnosis of *Chlamydia* is not as certain. The organism is fastidious and requires careful management during transport to the laboratory to increase the possibility of isolating the bacteria. A PCR test is being developed at Elizabeth Macarthur Agricultural Institute. This test needs to be validated under various conditions to know the limits of its accuracy and sensitivity.

The author of this report is not aware of any antibiotic sensitivity undertaken on organisms isolated from infected joints. This work should be undertaken at regular intervals to ensure that the antibiotics being recommended are in fact efficacious as veterinarians have a limited number of antibiotics that are registered for use in sheep.

Chlamydial arthritis appears to be a major concern with some Dorset breeders. This may be a result of the high weight gains in these sheep and the effect of the weight on an immature joint. It may be the result of sheep congregating around lick feeders from which sheep are offered concentrate feeds of cereal grains. Chlamydial bacteria can be spread through various sources including inhalation and ingestion, and the feeding system and the local environment of the feeders may be incriminated.

As the incidence of Chlamydial arthritis is identified it may be warranted to develop a vaccine to prevent lambs becoming infected. Most cases tend to occur after lamb marking, so the vaccine could be administered at lamb marking.

Sheep producers in Victoria suggest that the incidence of arthritis is higher in the wetter years, especially if lambs are marked under muddy conditions. It is interesting to note that the survey reported by Paton (2003) showed a higher incidence of arthritis in lambs marked in temporary yards compared to permanent yards. This could suggest that any dirt or mud has the potential to infect, rather than the amount present. Contact with mud or dirt may be related to the attitude of the lambs after marking. The use of a local anaesthetic agent such as “Trisolfen” should be explored in a controlled study to determine whether a difference in incidence of arthritis does occur. At the same time the use of a plastic sheet, regularly cleaned, and placed at the end of the marking cradle could be assessed to measure any effect on the incidence of arthritis.

Priority areas for trialling

- Temporary yards
- Local anaesthetic (“Trisolfen”)
- Disinfectant
- Plastic sheet
- Vaccine

Anecdotal information suggests that the *Erysipelothrix* vaccine is being used in lambs. It is of concern that this vaccine is being sold by some rural merchants as an arthritis vaccine rather than as an *Erysipelothrix* vaccine. This suggests that the cause of the arthritis is not being identified. Anecdotal information also suggests that the vaccine may be effective on only about one third of the properties that have used it. As *Erysipelothrix* has been identified in approximately one third of cases submitted to laboratories, perhaps flocks are being vaccinated without a diagnosis being established. When sheep producers get a poor response from the use of vaccine, it is difficult to encourage its appropriate use.

One interesting piece of information in the abattoir data was the similar incidence of total condemnations as a result of arthritis in adult sheep and lambs. This may be the result of chronic infections carried through from a young age, from cured infections, or the adult sheep may be contracting arthritis in their adult years, from shearing wounds or from skin wounds from other causes. These total condemnations need to be further examined after condemnation to collect joint aspirates for culture and to assess the chronicity and activity of the lesions. It is suspected that many of the lesions are chronic as many producers will retain lame sheep as long as they can keep up with the mob at mustering and retain body condition. If the arthritis does occur in adult life, then a whole new set of studies will be required to try to elicit the causes.

11 Recommendations to Sheep Producers

This review has highlighted some aspects of management that should be implemented to reduce the incidence of arthritis in their flocks. They are particularly important in flocks in which cases of arthritis seen every year.

1. Diagnosis

It is imperative that properties that see cases of arthritis that a definitive diagnosis is obtained. This should ensure that the most effective preventative and treatment strategy is put in place. A laboratory diagnosis can be established if samples from recent cases are submitted. The preferred sample is an unopened joint transported to the laboratory in a chilled state. The cost of bacteriology of joint aspirate plus histopathology of the joint membrane would cost approximately $150.00. This is a low cost compared to the benefit of animals saved and in the reduction in the cost of ineffective treatment.

2. Early Intervention

If sheep are to be treated effectively the course of antibiotic treatment must commence as soon as possible and before any scar tissue has been laid down in the joint.

3. Hygiene at Marking

Although hygiene is always mentioned is a preventive strategy it is rarely specified. When conducting surgical procedures the equipment used should be clean and carry minimal number of bacteria. Disinfection takes time so more than one set of instruments should be available to give time for the resting set to be sterilised. The disinfectant should be one containing chlorhexidine (Hibitane) as phenol-based disinfectants break down in the presence of organic matter such as blood.

Infection is more likely to occur if wounds are contaminated with mud or faeces. The amount of mud is not the issue; it is the presence of mud. Therefore clean grassed areas should be used for marking lambs, and the lambs left in that area for a minimal amount of time. Plastic sheets on the ground should assist in keeping lambs clean before they regain their feet.

Lambs should not be marked in muddy conditions.

4. Hygiene at Shearing

The wounds incurred by sheep at shearing are a source of entry for bacteria. Therefore contamination of wounds should be kept to a minimum by moving sheep out of the catching pens and the sheep yards as soon as possible after shearing.

5. Dipping Off-Shears

Dipping sheep off-shears allows lice treatments to be most effective. However any wounds received at shearing are a source of infection. Therefore if sheep are to be shorn off-shears the dip solution must be freshly prepared that day, or if retained overnight it should have a proprietary disinfectant added.

6. Feeding sheep in feedlots

The dust around feed bins and the close contact of sheep at feeding allow bacteria, especially *Chlamydia* organisms to spread readily. The source of entry may be by ingestion, inhalation, via the conjunctiva or through wounds. Consideration should be given to the placement of feed bins and the allocation of the number of sheep to each bin. An impermeable base may have to be placed under the feed-bin to reduce the generation of dust.

7. Preventive Strategies

There are several strategies that can be employed to reduce the opportunity for the bacteria to become established. However to recommend the most effective strategy a definitive diagnosis should be obtained.

Vaccination against *Erysipelothrix* has been shown to be effective on some properties. Two strategies are currently being recommended. When *Erysipelothrix* arthritis occurs at or with 14 days of marking, the ewes should be vaccinated to allow passive immunity to be obtained via the colostrum. When the arthritis occurs more than 14 days after marking, the lamb would be better protected by a vaccination at marking and then a second dose of vaccine at weaning.

Antibiotics have been recommended as a preventive strategy either by injection or as a powder incorporated in feedstuffs. The most appropriate strategy requires a definitive diagnosis. The antibiotic will only be effective if there are adequate concentrations of antibiotic in the blood at the time of infection.

8. Treatment

Producers do report successful treatment of affected sheep with antibiotics provided the antibiotic is administered early in the course of the disease. Once scar tissue has developed in the joint capsule treatment will have little effect. The length of treatment should be at least five days in every case. Therefore if long-acting products are used, a second treatment will be necessary.

Sheep that have been treated with antibiotic should be identified. The identification should indicate that the animal has been treated, but it should also incorporate a number relative to the day of treatment. This is important to indicate the day of the second treatment and also to indicate when the withholding period has expired and the sheep can be sold.

Both penicillin and oxytetracycline are effective against the bacteria that cause arthritis in sheep and both compounds are registered for use in sheep. The antibiotic should be used prior to the expiry date and it must be stored in a refrigerator as the antibiotic is destroyed under warm conditions.

9. Antibiotic Withholding Periods.

Antibiotics have withholding periods that need to be observed. Long-acting antibiotics have a longer withholding period than short-acting (24 hours) antibiotics.

The withholding periods of the respective antibiotics at the time of publication are as follows:

Short-acting oxytetracycline	14 days

Long –acting oxytetracycline	42 days
Short-acting penicillin	5 days
Long-acting penicillin	30 days
Oxytetracycline soluble premix	7 days

10. Submission of affected sheep for sale and slaughter

Sheep affected with clinical or chronic arthritis are not saleable as they will be condemned at slaughter. They should be destroyed.

11. Criteria for Destroying Affected Sheep

Sheep with chronic arthritis will not respond to antibiotic therapy and should be destroyed. Many sheep with arthritis are retained in a flock provided they do not inhibit the time required to muster the flock. Many other affected sheep are held in a "hospital" paddock until they are destroyed along with the other affected sheep in that group. Most of these sheep are losing bodyweight, are lame and most probably always in pain. On animal welfare grounds these sheep should be destroyed as soon as practicable.

The criteria recommended is that as soon as an affected joint is firm to the touch from scar tissue being laid down on the joint membrane, they are beyond treatment and should be destroyed.

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13 Appendices

13.1 Appendix 1

Questionnaire to Veterinarians

Veterinary Practice Questionnaire

How many properties did you diagnose arthritis in sheep in last year
in last 5 years

Number affected

Size of mob

Age of sheep

Clinical signs

Diagnostic samples

Which laboratory

Laboratory Results

Treatment regime

Success

Recommendations to client

13.2 Appendix 2

Questionnaire to Sheep Producers

Arthritis Questionnaire

Property Name:

District:

Owner/Manager:

Date:

Year	No. lambs marked	No. arthritis on farm	No. abattoir condemnation	Comments
2001				
2002				
2003				
2004				
2005				
Total				

Data or Estimate:
(circle one)

Ewe Breed: No.: Ram breed:

Clinical signs of arthritis:

Age of affected lambs:

Production affects:

Treatments:

Success rate:

Suspected potential cause:

Fate of affected lambs:

	2003/04	2004/05	2005/06
No. affected			
No. treated			
No. to abattoir			
No. sold			
No. destroyed			
No. kept			

Age at marking:

Castration: knife ring

Docking tail: knife ring gas knife

Ear mark: yes / no

Vaccinate: yes / no

Mulesing: yes / no

Age of lambs at mulesing:

Contractor or owner:

Lambs shorn prior to slaughter: yes/no

Length of mating:

Veterinary diagnosis(if submitted):

Erysipelothrix vaccination: yes / no

Vaccination programme:

Results after vaccination:

Comments:

Signed: