

DYNAMICS AND SIGNIFICANCE OF MASTITIS IN SHEEP

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Most of the research conducted to study the impact of mastitis in the livestock industry has focused on dairy cattle. However, mastitis also exists in the sheep industry and only recently have researchers begun to evaluate the extensiveness and significance of this problem.

It is well documented that there is a high relationship to amount of milk produced and consumed and preweaning lamb growth performance. Subclinical and clinical cases of mastitis may reduce milk production, and therefore reduce lamb performance, as well as ewe longevity. With the price differential between breeding and cull ewes, a reduction in mastitis problems would increase ewe longevity and decrease culling losses. Curtailing mastitis problems would also reduce the need for cross fostering or artificial rearing of lambs which increases costs, labor, and management inputs.

Objectives of this paper and presentation are to 1) present basic essential facts about mastitis 2) discuss ways to detect mastitis, and 3) discuss control and treatment strategies for this disease.

MASTITIS - BACK TO THE BASICS

Many producers try to control, treat, or attack mastitis without some basic understanding of how the disease works. Others simply neglect mastitis due to lack of awareness of subclinical mastitis and economic losses. These general principles are essential to developing sound mastitis control programs.

Economics

The first important basic fact is mastitis costs money and is a major cause of economic losses to the sheep industry. In 1985, a Sheep Industry Development Report estimated that mastitis cost the U.S. Sheep Industry \$20-25 million annually. These losses can be attributed to death or loss of ewes, replacement costs of ewes, lamb mortality and/or morbidity, labor cost, feed costs for orphans, and veterinary costs.

A major loss of mastitis is decreased milk production as a result of udder damage. Mastitis in ewes (based on CMT scores) has been shown to reduce milk production by 12% and 58% with one or both udder halves infected, respectively. In another study, lambs nursing ewes with both udder halves CMT positive weighed 16.7 lbs less at weaning than lambs nursing uninfected ewes. Research at Iowa State from 1988-1990 showed a significant decrease in ADG (11%) during 1989 in lambs nursing mastitic ewes but no significant ADG decreases in 1988 and 1990 (trend towards lower ADG both years, Table 1). Creep feed intake was poor in 1989 compared to 1988 and 1990. The ability to get lambs on creep feed and make feed a major part of their gain rather than milk may compensate for reduced ewe milk production due to mastitis. This has also been shown by Hueston in an Ohio study. Time and duration of infection affect ADG. During the 1989 ISU trial, lambs nursing ewes that were infected at weaning sample only had 7% lower ADG while lambs with ewes infected at lambing sample only had 19% lower ADG. Lambs nursing ewes infected at both periods showed a 24% lower ADG (Table 2).

In addition to decrease in lamb gains, mastitis may be a causative factor of lamb mortality prior to weaning. Moule (1954) reported lamb mortality to be 34.6% in Australia, with 23.6% of dead lambs having ewes with unsound udders. In a study by Gross et al. (1978), ewes with a CMT score of 3 at lambing weaned 45% of lambs born as twins. Ewes with CMT \geq 1 weaned 89% of lamb singles and 69% of lamb twins.

Since the result of mastitis is economic burden, we are challenged to understand causes, times of high incidence, detection methods, treatment strategies, and most importantly, how to prevent it.

What is mastitis?

Mastitis is an **inflammation of the mammary gland** where the inflammation is a reaction to tissue injury or damage. Inflammation can be characterized by any or all of these 5 symptoms: 1) heat; 2) swelling; 3) redness; 4) pain; and 5) loss of function.

Types of mastitis

Mastitis can be characterized into various types based on the ability to detect changes in the udder itself, as well as abnormalities in the milk. Clinical mastitis is characterized by observable abnormalities in the milk. **Clinical mastitis** is characterized by observable abnormalities of the udder and/or milk secretions. The degree of abnormality and severity depends, in part, on the type of microorganism involved. Within clinical mastitis, there are two types: 1) **subacute**: changes in milk such as flakes, clots, with only slight or absence of swelling and sensitivity, and 2) **acute**: rapid onset of swelling, heat, hardness, and sensitivity. Milk appears abnormal and yield is usually depressed. Often systemic signs such as fever (105 - 107° F), loss of appetite, weakness, depression, and occasionally death are present.

Subclinical mastitis is mastitis where there are no readily detectable changes in the udder itself and no visual milk abnormalities. However, microorganisms can usually be found by microbiological culture, and inflammatory changes in milk can be detected by special tests, such as the California Mastitis Test (CMT) which is a ewe -side test to subjectively evaluate white blood cell or body defense - disease fighting cell concentration in milk. In many flocks, this type of mastitis is the most prevalent and causes the greatest overall economic losses due to lowered milk production or “loss of function” without the other clinical inflammatory signs.

Chronic mastitis is mastitis of long duration. Milk appearance is variable, usually alternating between subclinical and clinical stages. Systemic signs are usually not apparent, but fibrosis of the udder is evident and can many times be detected by udder palpation. Milk yield is usually decreased, as is lamb performance.

What causes mastitis?

Mastitis can be caused by microorganisms or bacteria and trauma. Inflammation as a result of trauma is mainly due to aggressive nursing habits of lambs, which includes head butting of udders or traumatized teat ends due to excessive biting. The latter, by causing trauma and teat end damage, predisposes that teat to secondary bacterial invasion. Bacteria are the primary cause of ovine mastitis. There are many different types of organisms involved but only a few of major prevalence or concern.

Pasteurella hemolytica is a common inhabitant of the upper respiratory tract of normal sheep and lungs of pneumonic sheep. It is commonly associated with “blue bag” mastitis. Transmission is probably by mechanical means, such as with indiscriminate nursing and possibly insects or flies. It is a predominant organism in range sheep, and very minimal under intensive management operations.

Staphylococcus aureus is a very contagious mastitis organism. It can be associated with acute gangrenous mastitis (bloody milk, air in udder) but is usually associated with subclinical mastitis of long duration (chronic mastitis), and milk clinical signs in times of severe stress. The primary reservoir is the milk of an infected udder. It is a very invasive organism and is hungry to adhere to teat ends, especially after being damaged by nursing. Once inside the udder, Staph aureus will invade the milk tissue, causing massive scarring and fibrosis, many times causing lumps or cysts which can be detected by udder palpation.

E. coli and Streptococcus species are organisms commonly found in the environment and considered opportunists. E coli can be associated with a very hot watery mastitis with toxic signs. Streps tend to be mainly subclinical and can be of long duration. However, recent observations on mild clinical mastitis at or near lambing show environmental streps to be a primary causative agent.

Coagulase negative staphylococci (CNS) are primarily organisms that inhabit the skin in high populations. They are mainly associated with subclinical mastitis and minor inflammation (elevation of somatic cell counts). They are the most prevalent cause of infection in well managed flocks usually accounting for >90% of all infections. The sensitivity of detection of these by the CMT test is not as good as the other organisms, due to the nature of minor, variable inflammation and somatic cell elevation. Two important factors which are not clear and need to be researched are: 1) does the milk inflammation that CNS causes lead to lost milk production, and if it does; 2) how do we decrease the prevalence of this mastitis when the organisms continually harbors the udder and teat surfaces in large numbers?

Contagious ecthyma: Occurs in every flock as a primary infection and can lead to major secondary infections with mastitis. The virus is transmitted by both direct and indirect contact. It can contaminate equipment, fences, manure, bedding, and feed. The virus can remain viable on wool of recovered animals for extended periods. Problems exist when the nursing lamb gets this and develops sore mouth or lesions in the mouth. This allows for transfer to ewes’ teats. The key is to provide protection for the ewe, as well as other animals through proper vaccination.

- vaccinate ewes annually or bi-annually prior to breeding
- vaccinate replacement lambs and expose to ewes (ewe challenge)
- vaccinate rams
- **BE CAREFUL WHEN VACCINATING!** This is a live virus which can cause human problems.

How much mastitis is in my flock?

This, of course, differs between flocks based on management strategies, sanitation, breed, etc., but many producers grossly underestimate the extent of mastitis in their flock. Results of previous ISU studies using three flocks and four lambing periods showed 29% of ewes and 16% of halves were infected at lambing, and 21% of ewes and 11% of halves infected at weaning,

with over 40% of lambing infections persisting to weaning. ISU research from the McNay Research Farm for 1988-1990 is shown in Table 3. Overall, 13-25% of ewes and 9-17% halves were infected at lambing and 15-22% of ewes and 8-14% of halves were infected at weaning with 32% of infections persisting from lambing to weaning. Predominant organism in all flocks was CNS. Infection rates in ewe lambs were much lower than aged organism in all flocks was CNS. Infection rates in ewe lambs were much lower than aged ewes. Similar results have been shown in studies in Ohio, Missouri, Virginia, and Israel.

When does most mastitis occur?

Most sheep mastitis is contracted during two time periods: 1) first few weeks post weaning and 2) last 2 weeks pre lambing up to 2-3 day post lambing. (Figure 1) These are the periods of highest susceptibility to mastitis in sheep, as well as dairy cattle and probably other mammalian species. ISU research showed that 50% of new infections occur during each of these periods during the non-lactating period. The reasons for this high susceptibility during these periods include:

- 1) Milk accumulation which serves as a great media for organisms
- 2) increased mammary pressure which can cause teats to shorten and possibly open the streak canal, allowing for each bacterial entrance
- 3) lack of nursing or flushing effects
- 4) white blood cells are in very high numbers, but preoccupied by engulfing and eating milkfat, protein, and cellular debris. This makes them less efficient at destroying bacteria.

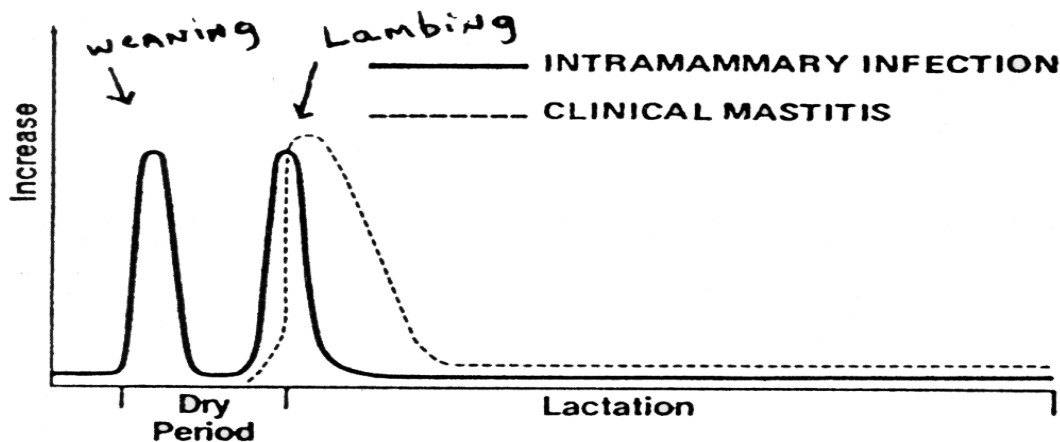


Figure 1. Incidence of new infections during the dry and lactation periods.

During the time between these two periods, the teat becomes plugged with keratin. This forms both a physical and chemical barrier to bacterial entrance. Also, inside the udder, there are large numbers of white blood cells and other immune components which are highly functional. During lactation the glands are continually nursed out. This helps to keep bacterial numbers and/or toxins low or negligible, and also serves to continually recruit new white blood cells.

MASTITIS DETECTION

The ability to detect mastitis is crucial to knowledge of the extent of mastitis problems within a flock. The key to success is early detection. Some methods of detection are listed below:

- *1) Visual observation of ewe, lamb, and possibly milk: Observing the ewe for any udder or systemic signs is important. Lameness or stiff-legged walking may signify a sore udder. Also, observations on lambs showing unthriftiness or lack of weight gain should lead to examination of her ewe's milk. Use a thermometer routinely if mastitis signs occur.
- *2) Udder palpation: This is a recommended practice for all ewes within a flock. It can help in diagnosing chronic mastitis where scarring has left fibrotic lumps or cysts within the udder. Routine palpation should be conducted following weaning, prior to breeding, and prior to or at lambing.
- *3) CMT: This is an easy to use, cheap, rapid, ewe-side test which subjectively evaluates white blood cells and can detect subclinical mastitis. The test consists of adding a milk sample to a solution of sodium alkyl-aryl sulfonate with bromcresol purple and subjectively scoring the degree of gelling (higher gelling means higher white blood cells). This is very sensitive for detecting infections where there is a high degree of inflammation, but loses some sensitivity when evaluating CNS.
- 4) Bacterial isolation and antimicrobial sensitivity: This may be extremely useful when faced with major problems, or clinical mastitis. It can help pinpoint the potential source of infections, and offer suggestions for treatment. However, it is time consuming and costly, and thus not practical or economical on a prophylactic basis.
- 5) Somatic cell counting: White blood cells can be counted by electronic methods such as Coulter or Foss Counters. This permits large numbers of samples to be assessed rapidly. However, samples would need to be collected, and transported to an appropriate laboratory. This testing is not ewe-side.

*Recommended for routine use

MASTITIS CONTROL PROGRAMS

Mastitis can be summed up in a simple equation.

$$\begin{array}{ccccccc} \text{Organic Exposure /} & + & \text{Animal Susceptibility /} & = & \text{Risk of Mastitis} \\ \text{Teat end trauma} & & \text{stress} & & \end{array}$$

Increased trauma or organism exposure to teat ends and/or times of high susceptibility or stress lead to increased risks of mastitis. Your goals should be to minimize both of these. However, there are times when animals are heavily stressed, or exposure does increase. At these times, attention to minimizing the other component of the equation is crucial. The goals of mastitis control are in order: 1) PREVENT NEW INFECTIONS; and 2) Eliminate existing infections. Primary emphasis should be on PREVENTION, since treatments are after the fact.

PREVENTION

MINIMIZE EXPOSURE

To cause mastitis, organisms must get on and into the teat. The goal, then, is to minimize organism loads on teat ends, with particular emphasis during high stress periods postweaning, prelambling, and at lambing. Keys to this are:

- 1) Provide **adequate space** for number of animals in the flock
 - 12-16 sq. ft./ewe and lambs open front shed
 - 25-40 sq. ft./ewe and lambs lots
- 2) Provide a **CLEAN, DRY, COMFORTABLE** environment.
 - A) **Clean and dry:** Organisms need 3 things for growth: 1) food; 2) moisture; and 3) temperature (heat). Attention should be focused on minimizing all or at least one of these.
 - i) **Food:** Bacteria, like humans, utilize organic matter for food. This includes bedding as well as fecal materials, so food is always present. Continual sources of fresh bedding and removal of contaminated bedding are important. In winter, however, this bedding pack can serve as a needed insulator from cold ground and concrete. Fresh bedding should continually be added to minimize teat and exposure. Potentials for other bedding materials that support lower bacterial growth such as chopped newspaper, sand, etc. need to be investigated.
 - ii) **Moisture:** Minimum exposure to wet, damp lots and buildings.
 - Avoid total building closure in winter. This keeps in heat but also traps excess moisture which can condensate, increasing risks of respiratory problems and mastitis. Provide adequate insulation as well as ventilation for moisture removal.
 - iii) **Temperature:** Organism growth increases logarithmically as temperature increases. Fortunately, at most lambings, temperatures are colder and organism growth is slower. However, sealed buildings in winter can lead to higher temperatures and humidity, both conducive to organism growth.
 - B) **Comfortable:** Facilities need to be comfortable. Clean and dry are part of this, but consideration should also be given to draftiness, ventilation, wind, bedding comfort, etc.
3. **Blocking exposure:** Barrier type teat dips are used in dairy cattle to provide a physical/chemical barrier against bacterial penetration. Most commercial barrier products have been shown not to persist 24 hrs in dairy, but this option has not been explored in sheep. Current ISU research to develop a 3-5 day persistent barrier type teat dip product for dairy may also be useful for sheep and other farm species.

MINIMIZE ANIMAL STRESS AND SUSCEPTIBILITY

The aforementioned areas of proper space and clean, dry environment are important for animal comfort. Sound management practices throughout the ewes' lambing cycles are very important, especially at weaning/postweaning and late gestation/lambing periods (high mastitis susceptibility). Feeding management at these 2 periods is crucial.

1) **Weaning and dry off preparation:** Successful prevention of post weaning infections starts with preparing the ewe to dry up by reducing milk production. Reducing production will decrease intramammary pressure, chances of leaking, and udder stress. Keys to this are:

Achieve low production by feeding management and dry off abruptly. Some producers allow lambs to nurse after 24, then 48 hrs, etc. This can work but increases labor of handling and separating lambs. Also, aggressive nursing habits of hungry lambs may lead to udder and teat trauma. Finally, ingestion of large abnormal volumes of milk by lambs may lead to potential digestive problems.

Early weaning (45-60 days) may also be important to lower mastitis risks. Ewes are long past peak lactation and production is low. Lambs should be on creep. Aggressive nursing of low production udders increases chances for enhanced teat end trauma.

2) **Late gestation/Lambing:** During late gestation and lambing is a high period of new infections. Fetal growth the last four weeks is rapid and great, and requires sound nutrition management. Compared to maintenance and gestation, ewes need to consume 60% more dry matter, 86-89% more energy and protein, and higher levels of vitamins (33% more Vitamin E) and minerals (80% more Ca and P) to support fetal growth, subsequent lactation, and maintain proper animal health. Extreme care should be taken to properly analyze feedstuffs, balance rations, and evaluate feeding habits. Special interest has been placed on Vit E - Selenium. Adequate Vit E-Se are essential for proper immune function. Research in dairy cattle has shown animals deficient in Vit E-Se have increased incidence of mastitis and reproductive problems at calving and early lactation. Sheep data on these is limited. A trial to evaluate this has been conducted at ISU but results are not analyzed yet. Major emphasis should be placed on minimizing feed intake depressions in late gestation and at lambing.

ELIMINATING EXISTING INFECTIONS

There are three ways existing infections are eliminated: **1) spontaneous cure; 2) culling; and 3) treatment.**

1) **Spontaneous cure:** Ewes eliminate many infections through their own immune system (white blood cells). This occurs with 50-70% of all mastitis infections.

2) **Culling:** This is usually a dirty word, but many times a necessary, profitable one. Decreased lamb performance, coupled with signs of mastitis (palpable lesions, elevated CMT scores) should be used for culling criteria. Ewes with palpable abscesses in both udder halves are a prime cull candidate.

3) **Treatment:** Treatment strategies for mastitis should be considered separately for: A) lactating infections; B) prophylactic dry treatment at weaning; and C) pre-lambing. Treatment does not necessarily mean antibiotics. **Supportive therapy such as oxytocin, frequent milkout, antiinflammatory agents like aspirin, fluids, electrolytes, good feed, and adequate water are important**, especially in acute clinical cases. Work closely with a veterinarian to establish sound control and treatment programs.

A) **Lactation treatment:** The key to successful treatment or therapy is **early diagnosis or detection**. Close observation, palpation, etc. are crucial. If clinical mastitis occurs:

- Keep ewes on good feed and water
- Keep lamb nursing if possible and supplement if needed
- Utilize supportive therapy
- Treat especially if systemic signs are present
- Most treatments are given intramuscular (IM)
- Intramammary treatments have been used in dairy cattle, but sheep data

is limited.

Use a safe, approved, efficacious drug (i.e. work with a veterinarian)

-Consider use of a long lasting antibiotic to avoid retreatment. **Be concerned about residues** especially with aminoglycosides (streptomycin).

B) **Dry treatment:** Recent research has centered on dry treatment of sheep. Most results show a reduction in infections (Table 4), and one study showed increased production in the subsequent lactation. Data is limited, however, and more is needed on efficacy as well as economics.

1) **Should I dry treat?**

Flocks with lactation mastitis problems or individual problem ewes are prime candidates for dry treatment. Purebred ewes of high monetary value should also be considered. Routine prophylactic dry treatment is not advocated unless economic justification is assured.

2) **Dry treatment advantages**

- Better cure rates than lactation treatment
- can use longer lasting antibiotics and higher doses
- high cure rate for lactation infections

3) **Dry treatment efficacy facts**

-designed to cure lactation infections
-Most dry treatments have little or no effect against sanitation is vital!
-During late gestation/lambing, there is little or no antibiotic present in the udder and essentially no protection. Sole controls for mastitis are minimized animal stress and organism exposure.

4) **What should I use?**

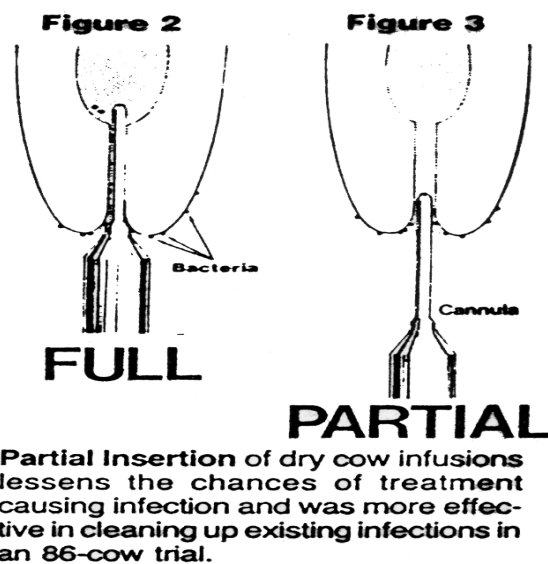
Most veterinarians are recommending one tube of dairy intramammary dry treatment per ewe (.5 tube/half). ISU research on IM injections using 5 ml benzathine penicillin showed similar cure rates to intramammary treatments.

5) **DRY TREATMENT - MANAGEMENT BEYOND ANTIBIOTICS**

There is no question that proper antibiotic choice is a key to successful dry therapy. However, there are more important management practices which influence dry treatment success or failure.

-SANITATION: There is no substitute for sanitation. **Clean teats prior to treatment** with alcohol swabs or apply teat dip. Make sure to not contaminate the treatment cannula or tip. Dip teats with a good germicide after treatment. Keep hands clean. If a ewe has an infected half, treat the uninfected half first. Cleanliness between half insertions is imperative.

-MINIMAL CANNULA INSERTION: Avoid full insertion of treatment cannula. Insert as little as possible (Figure 2). Research in dairy cattle showed that partial insertion at drying off improved cure rates 37% and showed a 50% increase in prevention of new mastitis infections. This results from 1) less teat end damage (reaming of keratin); 2) less chance of bacterial inoculation; and 3) some deposition of antibiotics at the teat opening. This should be especially beneficial in sheep due to their small teat orifice.



-COMBINE WITH OTHER MANAGEMENT PRACTICES: Avoid dry treating sheep in a standing position. It will be hard, if not impossible, to constrain the ewe, thus making sanitary, partial insertion difficult. At weaning, flip the ewe on her butt. This can allow for udder palpation, foot trimming, and labor efficient, sanitary, proper dry treatment.

- 6) **Dry treatment economics:** Dry treatment will cost about \$1.00-\$1.50/ewe. This investment should be weighted against possible returns.

Keys to dry treatment success are good sanitation, reducing ewe milk production prior to weaning, proper treatment procedures, and proper antibiotic choice (in order of importance).

Dry treatment with antibiotics is no substitute for poor management.

C) **Pre-lambing treatment:** Since many infections occur 3-5 days prior to lambing, interest has surfaced regarding potential treatment at this time. Research in dairy cattle has shown variable results depending on organisms. Current studies at ISU are being conducted to evaluate this option.

SUMMARY

Sheep mastitis can cause large economic losses, with much of these due to subclinical mastitis. Knowledge of causative agents and attention to proper management, especially at times of high susceptibility, are crucial. Diligent observation, palpation, and early detection are essential. The key to successful mastitis control is **PREVENTION!** Proper attention to minimizing organism exposure (**sanitation**) and animal stress (**proper nutrition, weaning procedures, etc.**) particularly at **weaning/postweaning and late gestation/lambing** are imperative. The ability to block exposure with a barrier teat dip or kill organisms with treatment prior to lambing may provide further solutions to controlling sheep mastitis and economic losses in the future.

Table 1. Effects of status of infection and of other sources on ADG of lambs (LSMEANS).

Source		1988	1989	1990
Infection status	(uninfected)	0.71 ^a	0.69 ^a	0.68 ^a
	(infected)	0.67 ^a	0.62 ^b	0.65 ^a
Sex of lamb	(male)	0.73 ^a	0.71 ^a	0.70 ^a
	(female)	0.65 ^b	0.61 ^b	0.63 ^b
No. of lambs reared	(one)	0.77 ^a	0.76 ^a	0.72 ^a
	(two)	0.68 ^b	0.66 ^b	0.65 ^a
	(three)	0.63 ^b	0.57 ^c	0.62 ^{a,b}

Figures shown are ADG (lbs).

^{a,b,c} Means with different superscripts within year within source are significantly different (P < 0.05).

Table 2. Effects of different infection statuses on ADG of lambs in 1989 trial.

Infection status	1989
Uninfected	0.71 ^a
Infected at weaning only	0.66 ^{a,b}
Infected at lambing only	0.58 ^{b,c}
Infected at lambing and weaning	0.54 ^c

Figures shown are ADG (lbs.)

^{a,b,c} Means with different superscripts within year source are significantly different (P < 0.05).

Table 3. Prevalence of subclinical intramammary infections in sheep, across lactations.

	1988		1989		1990	
	Lambing	Weaning	Lambing	Weaning	Lambing	Weaning
Ewes, total	196	196	126	126	190	190
Ewes infected	48 (25%)	43 (22%)	32 (25%)	19 (15%)	24 (13%)	31 (16%)
Halves, total	392	392	252	252	380	380
Halves infected	48 (17%)	54 (14%)	42 (17%)	20 (8%)	33 (9%)	34 (9%)
Halves infected with: ^a						
Coagulase-ve staphylococci	63 (95%)	51 (94%)	38 (92%)	19 (95%)	30 (91%)	30 (88%)
E. coli	1 (2%)	3 (6%)	3 (7%)	1 (5%)	2 (6%)	1 (3%)
Environmental streptocci	2 (3%)	--	1 (2%)	--	1 (3%)	3 (9%)

^aPercentages shown are relative to halves infected.

Table 4. Effects of dry treatment on ovine intramammary infections from 1988 to 1990.

	1988 ^a		1989 ^b		1990 ^b	
	Trt	No Trt	Trt	No Trt	Trt	No Trt
Halves:						
Infected at weaning	8 (7)	1 (5)	9 (8)	15 (13)	20 (9)	15 (12)
Cured	4 (50)	0	6 (67) ^c	5 (33) ^d	18 (90) ^e	7 (47) ^f
New infections	23 (21)	5 (26)	12 (11)	13 (13)	25 (12)	14 (13)
Infected at postweaning	27 (23)	6 (30)	15 (13)	23 (21)	27 (12)	22 (18)

^a Postweaned sample at subsequent lambing

^b Postwean sample 60 days postweaning

^{c,d,e,f} Mean cure rates within year significantly different ($P < .10$) and ($P < 0.01$)

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