

Decide dry cow strategy - drying off dates, antibiotic Dry Cow and Internal Teat Sealant treatments?

At the end of lactation, dairy cows require a dry period that is of sufficient length to allow the udder tissue to repair and rejuvenate.

Alveolar cells, the cells that synthesise milk, collapse and the number of active alveolar cells declines to a minimum during the early dry period (Blowey and Edmondson 1995). New secretory tissue is laid down when cows start to 'freshen' ready for calving, so that the total amount of secretory tissue increases from one lactation to the next.

A minimum of six weeks is recommended between drying-off and calving for regeneration of udder tissue. A significant reduction in production has been observed where the dry period is less than 20 days (Kok *et al* 2017, Sawa *et al* 2012).

Another physiological process that occurs at the start of the drying-off period and is critical for preventing new infections over the remainder of the dry period, is the closure of the teat canal with a keratin plug made from the cells lining the teat canal (Woolford *et al* 1998). Formation of the keratin plug takes days after the last milking of a lactation and a complete closure of the teat canal is not typically achieved until around 16 days (Comalli *et al* 1984).

In a field trial in New Zealand, observers found quarters receiving antibiotic Dry Cow Treatment (DCT) at drying-off had a significantly higher rate of closure of the teat canals in the first four weeks of the dry period than untreated quarters (Williamson *et al* 1995). It is not known if the mechanism behind this observation is due to the presence of antibiotic in the treated quarter or mechanical forces applied to the teat canal during insertion.

14.1 Use expected calving dates to list drying-off dates, ensuring that all cows get at least six weeks (preferably eight weeks) dry period

Accurate expected calving dates are obtained through the combination of artificial breeding and/or natural submission information and early pregnancy testing data (cows tested at 6–16 weeks pregnant). These then provide the best estimate of optimal drying-off dates.

The length of the dry period impacts on the daily milk yield achieved in the following lactation. Observational studies from North America (Kuhn *et al* 2006a, Kuhn *et al* 2006b) and Europe (Kok *et al* 2017, Sawa *et al* 2012) have found that milk production is maximised with dry period lengths of approximately 40 to 60 days.

More recent observational studies in New Zealand (Bryan *et al* 2011, McDougall 2010) have found a positive correlation between increasing dry period length and new intra-mammary infection, but internal teat sealants (ITS) were not used in any of the study cows.

14.2 Consider drying-off high cell count cows early to help lower Bulk Milk Cell Count

Technote 12 describes how to use ICCV for management decisions.

Confidence – High

World-wide experience supports this recommendation.

Research priority – Low

Confidence

New fact sheet C flow chart.

14.3 Collect data to assess herd mastitis level

The dry cow strategy is best determined with information that allows us to estimate herd mastitis prevalence and the incidence of new infections throughout the lactation.

The optimal suite of information would include:

- › Bulk Milk Cell Counts for the entire lactation
- › Individual Cow Cell Counts (ICCC) where at least four ICCCs, including one ICCC recorded in the last 80 days before dry off, are available for the majority of the herd. Using information from at least four or more ICCC records is preferable to just relying on one, end of season, ICCC;
- › Records of all clinical cases;
- › Any milk culture records from both clinical and subclinical mastitis cases
- › Any bulk milk vat and/or waste milk PCR test results to assess for the presence of *Strep agalactiae* or *Mycoplasma bovis*.

Where ICCC records are available, the Countdown Mastitis Focus Report can be used to assess spread of infection relative to industry best practice trigger levels. Analysis presented within the Mastitis Focus Report is enhanced where clinical case information is available and incorporated.

14.4 Plan to use antibiotic Dry Cow Treatment in all appropriate cows in the herd

14.5 Choose the antibiotic Dry Cow Treatment product to be used – consult your veterinarian

14.6 Decide if an internal teat sealant product should be used – consult your veterinarian

The Australian dairy industry is recognised for its responsible use of antibiotic treatments (JETACAR 1999). Increasingly, animal production industries need to display appropriate and responsible antimicrobial stewardship, to reduce the use of antimicrobials and the risk of increased antimicrobial resistance in both production animal and human medicine (Aarestrup and Aidara-Kane 2012). Antibiotic DCT is used to:

- › Treat existing infections that have not been cured during lactation. Sustained antibiotic activity and appropriate doses of active ingredient increase the chance of curing infections embedded deep in the udder tissue;
- › Reduce the number of new infections that may occur during the dry period. Antibiotic DCT protects udders from new infections in the dry period directly through the effect of the antibiotic.

Historically, new quarter infections during the dry period were thought to be lower in pasture based dairying systems compared to housed dairy systems typical of Europe and Nth America. In Victoria in the 1980s, new quarter infections during the dry period were 2% for cows given whole herd antibiotic DCT and 4% for uninfected untreated cows (Browning *et al* 1990). However, a more recent study from New Zealand (McDougall, 2010) found 18% of untreated quarters from cows with an ICCC <150,000 cells/ml at drying-off became infected during the dry period compared with 4% of quarters from cows under the same ICCC threshold that were treated with cephalonium containing DCTs. This higher rate is more consistent with infection rates currently observed on farms in Australia (see the discussion in *Strep uberis* to follow).

Issues to consider when determining a farm's dry cow strategy are the:

- › Estimated mastitis prevalence in the herd;
- › New mastitis infection risk during the dry, transition and calving periods;
- › Likely pathogens causing the mastitis in the herd;
- › The economics of missing infected cows or treating uninfected cows;
- › Management of antibiotic use to avoid residue violations in meat and milk.

When formulating a dry cow strategy there are three over-arching decisions to be made:

- › Will the antibiotic DCT be part-herd (previously described as “selective treatment”) or whole-herd (previously described as “blanket treatment”)?
- › Is use of an ITS recommended to reduce new infection risk?
- › Is dry period length consistent with the chosen antibiotic to avoid the risk of cows calving while still within the treatment minimum dry period?

The most appropriate strategy should be planned with a veterinarian. Part-herd treatment should only be considered when each cow in the herd has at least four individual cow cell counts (ICCCs), which includes one in the last 80 days before drying-off, for the current lactation. Fact Sheet C of the Countdown Farm Guidelines for Mastitis Control (new version web based only) gives a three-step flow chart that helps with this decision process.

The reasons behind each decision node when choosing a dry cow strategy are:

- › **Step 1:** assesses the prevalence of mastitis infection in the herd; determines if we can confidently classify our cows as infected or not infected; determines if we have highly infectious organisms that will influence our strategy
- › **Step 2:** assesses likely risk of new infection in cows over the dry, transition and calving period
- › **Step 3:** assesses the risk of new infection in first-calving heifers during the transition and calving period

Understanding the decision to use part-herd antibiotic Dry Cow Treatment

The consideration to use part-herd antibiotic DCT is aimed at reducing both antimicrobial use on farm and treatment costs, whilst maintaining equivalent calving period clinical and sub-clinical mastitis rates. Research work, primarily from overseas, has explored the effect of part-herd treatment on mastitis prevalence.

Some clinical trials that examined the use of part-herd antibiotic DCT without ITS, have found non-treated cows had a significant increase in incidence of new mastitis infections at calving compared to cows treated with antibiotic DCT (Berry and Hillerton 2002, Kiesner *et al* 2016, McDougall 2010). In a large clinical trial in 97 Dutch herds, multiparous animals with an ICCC of <250,000 cells/ml, were treated in two quarters with antibiotic Dry Cow Treatment while the remaining two quarters were left untreated (an ITS was not used). The untreated quarters had 3.7 times greater odds of clinical mastitis during the subsequent lactation compared to the treated quarters. This result suggests that untreated quarters from cows, selected with an ICCC below the 250,000 cells/ml threshold, had an adverse mastitis outcome. Conversely, a subsequent observational study in Dutch herds, found no increase in either BMCC, clinical mastitis, or subclinical mastitis as a result of Dutch industry mandatory uptake of part-herd antibiotic Dry Cow Treatment. Approximately 50% of herds in this study used an ITS.

A recent clinical trial used farm records to select cows to be treated with antibiotic DCT (Bradley *et al* 2010). In this trial, cows determined to be uninfected based on ICCC (<200,000 cells/ml in this study) and clinical mastitis records, were treated with either antibiotic DCT plus ITS (combination treatment) or ITS alone. No significant differences were found between the two treatment approaches in incidence of new intramammary infections at calving or clinical cases during lactation.

On balance, the literature indicates that farms using a part-herd antibiotic DCT strategy can lower the new mastitis infection risk by incorporating ITS into the approach.

Confidence box: Part herd treatment strategies are likely to have greater success if more information is available to identify infected from non-infected cows. Excellent clinical case detection and recording plus multiple ICCC records will increase the likelihood of a satisfactory outcome.

The role of an internal teat sealant

Internal teat sealant products contain no antibiotics and hence have no role in curing existing infections. Their purpose is only to prevent new infections, especially during the initial dry period and the transition period just prior to calving.

These products generally contain an inert, viscous bismuth material, designed to remain in the lower teat sinus after careful administration at drying off (refer to the Countdown Teatseal FAQ for recommended technique). It is positioned there, without hardening or setting, until removed by calf suckling or hand stripping immediately after calving.

A recent meta-analysis of 18 publications, conducted by Rabiee and Lean (2013) analysed the effect of an ITS on new intra-mammary infections, based on ICCC changes, and clinical mastitis after calving (up to 150 DIM).

It found that the use of ITS, either alone or in the presence of antibiotic DCT, reduced the risk of new intra-mammary infection after calving by 25% when compared to cows treated with antibiotic DCT only. This result suggests that the use of ITS augments the function of antibiotic DCT in preventing new infections over the dry period. When cows treated with ITS only were compared to those who received no treatment, the use of the ITS reduced new intra-mammary infection by 73%.

An ITS either used alone or in combination with antibiotic DCT reduced the risk of clinical mastitis after calving by 29% when compared to antibiotic DCT only.

Confidence

Part herd treatment strategies are likely to have greater success if more information is available to identify infected from non-infected cows. Excellent clinical case detection and recording plus multiple ICCC records will increase the likelihood of a satisfactory outcome.

Research priority

Using ICCC records and new diagnostic tests to identify infected cows prior to dry off.

Countdown FAQ:

Which herds benefit from using teat sealants?

Confidence – Moderate

When inserted according to label instructions, ITS material is designed to remain in the lower section of the teat sinus.

Research priority – Moderate

Research is required on post-insertion cattle handling procedures which will increase the risk of ITS product being distributed throughout the udder sinus thereby lowering its effectiveness

When cows treated with ITS only were compared to those who received no treatment, the use of the ITS reduced clinical mastitis by 48%.

Fact sheet C recommends that, where an ITS is incorporated into a dry cow strategy, it is administered to all teats of all cows in the herd that have completed a lactation.

Research conducted in New Zealand has shown that treatment of heifers, approximately one month prior to first calving, reduced both the incidence of clinical mastitis in early lactation by 70% and the rate of new intramammary infection due to *Strep uberis* by 70% (Parker *et al* 2007, Parker *et al* 2008). This aligns with a similar finding of a 56% reduction in clinical mastitis in the first 30 days after calving observed in Gippsland in 2009 and 2010 (Clyne L, 2013).

Important points to emphasise to farmers

When planning for antibiotic DCT, as a component of an overall dry cow strategy, farmers should be advised to:

- › Treat all quarters of all cows where antibiotic DCT is being administered (using either whole-herd or part-herd antibiotic DCT). In infected cows, restricting treatment only to infected quarters results in a higher new quarter infection rate than if dry cow antibiotic is given to all quarters (6.4% compared to 3.9%) (Browning *et al* 1994);
- › If using part-herd antibiotic DCT, treat all quarters of all cows with a peak ICCC above 250,000 cells/mL during the current lactation, and all cows that had clinical mastitis at any time during the current lactation (Victorian Mastitis Research Group 1982). Advisers who recommend a lower ICCC threshold will see an increase in test sensitivity but a small decrease in positive predictive value;
- › Antibiotic Dry Cow Treatment products do not protect against some environmental bacteria (such as *Pseudomonas*) that may be introduced into the udder if the intramammary infusions are given unhygienically (Radostits *et al* 1994);
- › Where antibiotic DCT is being used in conjunction with an ITS (combination treatment), emphasising specific techniques for administration of ITS such as kinking or pinching the top of the teat, slow administration of the product, and not massaging in the product is important.
- › Attention to thorough disinfection of the teat end, in addition to proper hygiene of gloved hands and treatment tubes during handling and insertion, is paramount. This procedure cannot be rushed – the farm team needs to be well prepared for this important task.

Dry Cow Mastitis Strategy Options based on Fact Sheet C

| Treatment strategy | Uninfected cows | Infected cows and/or clinical case |
|---|---|---|
| Part-herd Dry Cow Treatment | No treatment | Dry Cow Treatment |
| Part-herd Dry Cow Treatment Whole-herd ITS Treatment | ITS treatment | Dry Cow and ITS Treatment (combination treatment) |
| Whole-herd Dry Cow Treatment Whole-herd ITS Treatment | Dry Cow and ITS Treatment (combination treatment) | Dry Cow and ITS Treatment (combination treatment) |

Note: Veterinarian advice should be sought on any questions about classifying cows as infected or not-infected when a part-herd Dry Cow Treatment strategy is being used.

Technote 1 summarises characteristics of *Strep uberis*.

Confidence

Because no antibiotic DCT product is 100% effective, choices for a specific farm must be made on pathogens known to be present and on the herd's previous response to antibiotic DCT therapy.

Chronically infected cows. Use of ICCC to determine chronic infection risk; please add: A Countdown Mastitis Focus Report is a useful resource to determine the number of cows infected in multiple lactations in a herd.

Technote 3.1 lists Minimum Dry Periods and recommended withholding periods for various Dry Cow Treatments.

Technote 4.10 describes antibiotic residue violations associated with Dry Cow Treatments.

Blanket Dry Cow Treatment and *Strep uberis*

Strep uberis is ubiquitous in the environment. Infection most frequently occurs in the first two weeks of the dry period (secretions in the mammary glands of cows that have been dry for 7–28 days support the growth of *Strep uberis*) and during the transition period and early lactation.

In the 1980s, studies of Victorian herds with predominately *Staph aureus* infections showed that antibiotic DCT of uninfected cows was not warranted (Browning *et al* 1990). Consequently, the prime focus of dry cow strategies at this time was part-herd treatment of cows suspected to have mastitis with the aim of curing existing infections. In the 1990s, Williamson *et al* (1995) demonstrated that use of antibiotic DCT protected treated cows against new infections with *Strep uberis* during the dry period, significantly reducing the incidence of mastitis both in the dry period and post-calving.

Strep uberis infection is of increasing importance in Australia now accounting for around 53% of positive culture results from clinical mastitis cases (Charman *et al* 2012). The dry period is a key risk period for new *Strep uberis* intra-mammary infections. Veterinarians and dairy farmers should assess the risk of *Strep uberis* through milk cultures and clinical mastitis rates during the calving period (in the first 14 days in milk) and seek to optimise prevention of new infections through use of internal teat sealants (alone or in combination with antibiotic DCT).

There is no objective information on what constitutes “significant numbers” of *Strep uberis*, however, field experience suggests that isolation of this bacteria from more than 30% of milk cultures (identifying a bacterial isolate from sufficient numbers of cultures) from calving time mastitis cases indicates a significant problem with *Strep uberis* infection in the herd. The decision that the herd has a problem with *Strep uberis* during the dry period is supported by:

- › Milk cultures that are positive for *Strep uberis* from both clinical mastitis cases and subclinical cases where at least 20 culture results are available;
- › Assessing the management of fresh cows (e.g. how wet and muddy the calving paddocks are, the interval between calving and entering the shed, etc);
- › Assessing how wet and muddy the environment of the cows starting their transition cow period are; and
- › Demonstrating *Strep uberis* infection in a number of cases of clinical mastitis that occurred immediately prior to, or within the first two weeks following, calving.

Where *Strep uberis* is the predominant positive culture result on farm, the appropriate dry cow mastitis strategy can be determined through Fact Sheet C. Depending on mastitis prevalence overall, and in particular during the calving period, use of an ITS, in combination with part-herd or whole-herd antibiotic DCT may be indicated to reduce new infection risk.

Antibiotic Dry Cow Treatment product choice

The choice of antibiotic DCT depends on a number of factors, including the spectrum of activity, cure rates and periods of protection of the different products.

Cure rates following antibiotic DCT are greatly influenced by the bacteria causing the mastitis and how long the cow has been infected, and they vary a lot between herds. Other factors which will influence cure rates also include age of the cow, the number of infected quarters and the immune response.

Generally, cure rates will be high for *Strep agalactiae* and lower and more variable for *Staph aureus*. For example, cure rates of 92% to 100% were reported following treatment of *Strep agalactiae* infections with cloxacillin or cephalonium (Sol and Sampimon 1995) while cure rates for *Staph aureus* ranged from 53% to 100% depending on the trial (Shephard *et al* 2004, Bradley *et al* 2010, Bryan *et al* 2011). The study reported by Shephard *et al*

(2004) found no significant differences in cure rate for *Staph aureus* when comparing a cephalonium antibiotic DCT to a cloxacillin based product.

Cure rates for *Strep uberis* ranged from 83% to 100%, again depending on the trial (Shephard *et al* 2004, Bradley *et al* 2010, Bryan *et al* 2011). In general, cure rates for *Strep uberis* tend to be higher than for *Staph aureus*, however caution needs to be exercised in extrapolating trial results to multiple herds as study power (small numbers of positive isolates for select bacteria, eg: *Staph aureus*) can limit interpretation of cure rates.

A recent meta-analysis of 22 studies from 1967 to 2003, examining antibiotic DCT efficacy, was reported by Halasa *et al* (2009). The overall cure rate for *Staph aureus* infection with treatment was 77% while spontaneous cure (no antibiotic DCT administered) was 44%. For *Strep uberis*, the overall cure rate to treatment was 89% while spontaneous cure was 47%. For all pathogens reported in this meta-analysis, the overall cure rate to treatment was 78% while the spontaneous cure rate was 46%.

Active ingredient and spectrum of activity for Antibiotic Dry Cow Treatments and Internal Teat Sealant products (2017)

| Product name | Company | Active ingredient | Spectrum of activity |
|-------------------------|----------|---------------------------------------|----------------------|
| Ampiclox DC | Jurox | Ampicillin 250 mg, Cloxacillin 500 mg | Gram +, Gram - |
| Bovaclox DC | Norbrook | Ampicillin 300 mg, Cloxacillin 600 mg | Gram +, Gram - |
| Cepravin DC | Intervet | Cephalonium 250 mg | Gram +, Gram - |
| Elaclox DCX DC | Norbrook | Cloxacillin 600 mg | Gram + |
| Juraclox LA 600 Dry Cow | Jurox | Cloxacillin 600 mg | Gram + |
| Maxalac DC | Jurox | Cephalonium 250 mg | Gram +, Gram - |
| Noroclox 500 | Norbrook | Cloxacillin 500 mg | Gram + |
| Orbenin Enduro DC | Zoetis | Cloxacillin 600 mg | Gram + |
| Teatseal | Zoetis | Bismuth subnitrate 650 mg | No activity |
| Sureseal | Norbrook | Bismuth subnitrate 650 mg | No activity |

In the laboratory, bacteria present in milk cultures are Gram stained and examined microscopically as part of the identification process. Gram positive (+) bacteria appear blue or purple and include Staph and Strep species. Gram negative (-) bacteria appear pinkish red and include coliform species.

14.7 Purchase and store the products you will need at drying-off

Farmers planning to administer antibiotic DCT and/or ITS are advised to obtain their supplies well ahead of the drying-off date. Advisers should emphasise the importance of correctly storing products, as specified on the label, for efficacy and safety reasons (Food Quality Program 1999). For example, many veterinary antibiotics should be stored at refrigeration temperatures to retain their effectiveness.

From a practical point of view, it is important to discourage storage of antibiotic DCT near Lactating Cow Treatments. This reduces the risk of accidentally administering antibiotic DCT to lactating cows – which can be a very expensive mistake in terms of antibiotic violations and costs associated with withholding milk from the vat. For many milk processor Quality Assurance schemes, antibiotic product compliance requires antibiotic DCT to be stored in a completely separate location to Lactating Cow Treatments.

Teat wipes used for sanitizing teats prior to antibiotic DCT and ITS administration should be kept unopened in their container prior to use. This will limit the risk of alcohol contained in the wipes evaporating thereby reducing their efficacy. It also lessens the risk of bacterial contamination (through organic material) prior to use. If alcohol wipes are used to clean organic material off teats prior to tube insertion a second wipe should be used to sterilise the teat end after the organic material has been removed.

Where antibiotic DCT or ITS tubes are exposed to cold temperatures, product viscosity immediately prior to administration can be improved through gentle heating. This can be achieved by sitting the container on top of a hot water service vessel for a brief period, or by placing the product storage bucket in a warm water bath or warm room at the same time, the temperature should remain within manufacturer's requirements. Under no circumstances should antibiotic DCT or ITS tubes be immersed directly in warm water as this increases the chances of bacterial contamination, especially with *Pseudomonas* species.

References

- Aarestrup F, Aidara-Kane A (2012) Reducing Antimicrobial use in Animal Husbandry. The Evolving Threat of Antimicrobial Resistance—Options for Action. In World Health Organization, Geneva, Chapter 4, pp 50-61.
- Berry, E. A. and J. E. Hillerton. 2002. The effect of selective dry cow treatment on new intramammary infections. *J Dairy Sci* 85(1):112-121.
- Blowey R, Edmondson P. Structure of teats and udder and mechanisms of milk synthesis. In: Mastitis control in dairy herds, Chapter 2, Farming Press Books, Ipswich, United Kingdom, 1995:5-16.
- Bradley A, Breen J, Payne B, Williams P, Green M (2010) The use of a cephalonium containing dry cow therapy and an internal teat sealant, both alone and in combination. *J Dairy Sci* 93(4): 1566-1577
- Browning JW, Mein GA, Barton M, Nicholls TJ, Brightling P. Effects of antibiotic therapy at drying off on mastitis in the dry period and early lactation. *Aust Vet J* 1990;67:440-442.
- Browning JW, Mein GA, Brightling P, Nicholls TJ, Barton M. Strategies for mastitis control: dry cow therapy and culling. *Aust Vet J* 1994;71:179-181.
- Bryan MA, Heuer C, Emslie FR (2011) The comparative efficacy of two long-acting dry-cow cephalonium products in curing and preventing intramammary infections. *N Z Vet J* 59(4): 166-73
- Charman N *et al.* (2012) A survey of mastitis pathogens in the south-eastern Australian dairy industry. In: Proceedings of the Countdown Symposium, Melbourne, July 2012, 18-22.
- Clyne J (2013) A study investigating the prevalence and associated risk factors for heifer mastitis in the MID. In: Proceedings of the Countdown Symposium, Melbourne, May 2013, 16-19.
- Comalli, M. P., R. J. Eberhart, L. C. Griel, and H. Rothenbacher. 1984. Changes in the microscopic anatomy of the bovine teat canal during mammary involution. *Am J Vet Res* 45(11):2236-2242.
- Food Quality Program. Storage of farm chemicals and veterinary drugs Dairy First Fact Sheet 4-7. Guidelines for a dairy farm HACCP system: reference manual. Department of Industry, Science and Tourism and Dairy Research and Development Corporation, February 1999.
- Halasa T, Nielsen M, Whist AC, Osteras O (2009) Meta-analysis of dry cow management for dairy cattle. Part 2. Cure of existing intramammary infections. *J Dairy Sci* 92(7): 3150-7
- JETACAR. The use of antibiotics in food-producing animals: antibiotic-resistant bacteria in animals and humans. Report of the Joint Expert Technical Advisory Committee on Antibiotic Resistance, Commonwealth of Australia, Canberra, 1999.
- Kiesner, K., N. Wente, O. Volling, and V. Kromker. 2016. Selection of cows for treatment at dry-off on organic dairy farms. *J Dairy Res* 83(4):468-475.
- Kok A, van Knegsel A, van Middelaar C, Engel B, Hogeveen H, Kemp B, de Boer I (2017) Effect of dry period length on milk yield over multiple lactations. *J Dairy Sci* 100(1): 739-749
- Kuhn M, Hutchison J, Norman H (2006a) Dry period length to maximize production across adjacent lactations and lifetime production. *J Dairy Sci* 89(5): 1713-1722
- Kuhn MT, J LH, Norman HD (2006b) Effects of length of dry period on yields of milk fat and protein, fertility and milk somatic cell score in the subsequent lactation of dairy cows. *J Dairy Res* 73(2): 154-62
- McDougall S (2010) A randomised, non-inferiority trial of a new cephalonium dry-cow therapy. *NZ Vet J* 58(1): 45-58

Parker K, Compton C, Anniss F, Weir A, Heuer C, McDougall S (2007) Subclinical and clinical mastitis in heifers following the use of a teat sealant precalving. *J Dairy Sci* 90(1): 207-218

Parker KI, Compton CWR, Anniss FM, Heuer C, McDougall S (2008) Quarter-Level Analysis of Subclinical and Clinical Mastitis in Primiparous Heifers Following the Use of a Teat Sealant or an Injectable Antibiotic, or Both, Precalving. *J Dairy Sci* 91(1): 169-181

Rabiee, A. R. and I. J. Lean. 2013. The effect of internal teat sealant products (Teatseal and Orbesal) on intramammary infection, clinical mastitis, and somatic cell counts in lactating dairy cows: A meta-analysis. *J Dairy Sci* 96(11):6915-6931.

Radostits OM, Blood DC, Gay CC. Major mastitides. In: *Veterinary Medicine*, Chapter 15, 8th edition. Bailliere Tindall, London, 1994:598.

Sawa A, Bogucki M, Neja W (2012) Dry period length and performance of cows in the subsequent production cycle. *Archiv Tierzucht* 55(2): 140-147

Shephard R, Burman S, Marcun P (2004) A comparative field trial of cephalonium and cloxacillin for dry cow therapy for mastitis in Australian dairy cows. *Aust Vet J* 82(10): 624-629

Sol J, Sampimon OC. Dry cow treatment with 600mg dynamilled cloxacillin or 250mg cephalonium: comparison of cure rate, new intramammary infection rate and somatic cell count. In: *Proceedings of the 34th National Mastitis Council Annual Meeting, Texas 1995*:146-148.

Victorian Mastitis Research Group. Individual cow cell counts. In: *Milk, Production and Mastitis*, Government of Victoria, Technote 18, October 1982.

Williamson JH, Woolford MW, Day AM. The prophylactic effect of a dry-cow antibiotic against *Streptococcus uberis*. *NZ Vet J* 1995;43:228-234.

Woolford MW, Williamson JH, Day AM, Copeman PJA. The prophylactic effect of a teat sealer on bovine mastitis during the dry period and the following lactation. *NZ Vet J* 1998;46:12-19.