# Prudent use of dry cow antibiotics on New Zealand farms

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## Introduction

There is growing pressure to reduce the use of antimicrobials in agriculture, due to the emergence of antimicrobial resistance among human and animal pathogens (CDC 2014). Improved stewardship of animals, and clear guidelines that reduce the reliance on use of antimicrobials, are key steps in addressing these concerns (IDF 2013).

In dairy, up to 85% of the antimicrobials used on farm are associated with treatment and prevention of mastitis (Compton *et al.* 2014). From DairyNZ farmer surveys (Lacy-Hulbert 2015, unpublished data), we estimate that at least 85% of dairy cows in New Zealand are protected at dry off, with approximately 50–60% of farmers choosing to treat all cows with antibiotic dry cow treatment (DCT) and 20% using DCT plus internal teat sealant (ITS).

Internal teat sealants have been available as an effective non-antimicrobial for protecting low somatic cell count (SCC) cows since the late 1990s but survey data suggest that less than 15% of farmers choose to protect cows with ITS as a single treatment. In contrast, 30–40% of farmers reported that they used ITS to protect first lactation heifers in winter 2015 (Lacy-Hulbert 2015, unpublished data).

Veterinarians and farmers comment that they prefer to use antimicrobial approaches in systems with a perceived higher risk of mastitis. The absence of efficacy data relating to ITS alone in wintering systems that use forage crops or house cows indoors may contribute to this reluctance, since most New Zealand studies involve cows wintered on pasture (Woolford *et al.* 1998, Compton *et al.* 2014). One New Zealand study used herds that wintered cows on forage crops or wintering barns (Bryan *et al.* 2011) but compared effectiveness of two antibiotic dry cow treatments, thereby providing little information on the underlying risk of mastitis in such systems or the protective effect of non-antibiotic treatments.

With the recent decline in milk price, farmers are more circumspect with animal health costs at dry off, and many are revisiting the value of protecting low SCC cows. System-specific data on the true risks of leaving cows unprotected in different wintering systems would help veterinarians and farmers make more cost-effective choices. During the winter of 2015, nil treatment and three interventions at dry off were tested for their ability to prevent mastitis at calving on two well-recorded farms, operating in Southland.

## Materials and methods

The trial was conducted between May and November 2015 on two farms in Southland. Herd 1, near Winton, housed cows in a free-stall wintering barn with water-cushioned, rubber mats as bedding and fed predominantly grass silage and straw, and Herd 2, near Invercargill, wintered cows on the farm, on fodder beet supplemented with baled grass silage and hay.

All cows confirmed to be pregnant and free of clinical mastitis in the last two weeks prior to dry off were enrolled. Cows with a low somatic cell count (SCC; <250,000cells/ml) at the first three herd tests of the 2014/15 season, and no record of clinical mastitis in the lactation were assigned to the Prophylactic study whilst cows with a higher SCC (1 or more of the three tests >250,000cells/ml and/or record of clinical mastitis) were assigned to the Therapeutic study.

Cows eligible for the prophylactic study were assigned to one of four treatments whilst cows eligible for the therapeutic study were assigned to the two treatments that involved dry cow antibiotics. Treatments were:

- No treatment (NT; 10% of eligible cows assigned)
- ITS (65% bismuth subnitrate in a mineral oil base, Teatseal, Zoetis, Auckland, NZ);
- DCT (250mg cephalonium, Cepravin MSD Animal Health, Upper Hutt, Wellington, NZ); and
- DCT+ITS, whereby DCT was administered, followed immediately by ITS.

Cows on each farm were dried off in three mobs between May and July 2015, allocated on the basis of predicted calving date (Herd 1) or body condition score (Herd 2). Following the last milking, duplicate milk samples were collected by trained veterinary technicians from all quarters, using aseptic technique. Dry cow treatments were then administered, all cows teat sprayed with teat spray and managed according to normal farm practice.

At approximately seven and 21 days after dry-off all cows were checked for signs of clinical mastitis by a veterinarian, by manual palpation of the udder. Quarters identified as clinical (i.e. swelling, heat, pain, hardness or lumpy secretion in the gland sinus) were sampled in duplicate for bacteriology and treated with lactating cow antibiotics according to normal farm practice.

Duplicate milk samples were collected from freshly calved cows using aseptic technique by trained veterinary technicians before the first milking, and on a second occasion, two to four days after calving. Any quarters diagnosed with clinical mastitis in the dry period or in the first 30 days in milk were also sampled in duplicate for bacteriology by farm staff, or by veterinary technicians. All samples were frozen (-20°C) for up to 30 days prior to transport to the DairyNZ Mastitis Research Laboratory, Lye farm, Hamilton for bacteriological analysis. Identification of bacteria in milk was performed using internationally recognised procedures (Hogan *et al.* 1999).

A quarter was defined as infected if ≥200cfu/ml of a single bacterial species was isolated (≥100cfu/ml from a clinical mastitis sample). Samples were defined as contaminated when three or more different colony types were identified. Major pathogens were defined as *Staphylococcus aureus*, *Streptococcus uberis*, *Streptococcus dysgalactiae*, *Escherichia coli*, other streptococci and other pathogens. while minor pathogens were defined as coagulase negative staphylococci (CNS) spp. and *Corynebacterium* spp.

## Statistical analysis

Milk production and cow SCC data were derived from herd testing, carried out on four occasions in the lactation preceding dry off, and the first two herd tests of the subsequent lactation. All SCC data was $\log_{10}$ transformed prior to analysis. Bacteriological data was summarised to determine prevalence of infection at each of the three samplings: dry off (DO), before the first milking (M1) and on a second occasion within four days of calving (M2), on a quarter basis. New intramammary infections (defined as presence of a new pathogen in a single quarter that was not present at a previous sampling) and bacteriological cures (absence of a pathogen that was previously present) were determined on a quarter basis, and aggregated by cow and by pathogen for statistical analysis.

Effect of treatment applied at dry off was determined by the proportion of cows that developed a clinical mastitis between dry off and 30 days after calving, a new subclinical infection by M1 or M2, and proportion of cows that developed a cure by M1, using a binary logistic regression model (Proc GLIMMIX, SAS/STAT 12.1, Cary, North Carolina 27513, USA). The model included farm, treatment and farm-by-treatment interaction as fixed effects, mob within farm as blocking factor, and geometric mean of SCC at herd tests one to three and length of the dry period as covariates.

# Results

A total of 929 cows were enrolled to the study and received treatments at dry off (Table 1). Of these, 864 cows calved and 861 were sampled at both M1 and M2. A review of feed budgets in mid-winter led to discretionary culling from both herds, contributing to removal of 8.6% of cows from the Herd 1 and 6.0% cows from Herd 2 before calving, spread evenly (P>0.05) across the different treatments (Table 1).

| Study | Treatment | N cows enrolled | N cows (M1) | N cows (M2) | % lost to analysis[1] |
|---|---|---|---|---|---|
| Prophylactic | NT | 67 | 60 | 60 | 10.4 |
| | ITS | 212 | 205 | 205 | 3.3 |
| | DCT | 211 | 199 | 198 | 6.2 |
| | DCT+ITS | 214 | 198 | 196 | 8.4 |
| Therapeutic | DCT | 111 | 99 | 99 | 10.8 |
| | DCT+ITS | 114 | 103 | 103 | 9.6 |
| Total cows | | 929 | 864 | 861 | 7.3 |

[1]N lost by M2 as percentage of enrolled cows.

**Table 1.** Number of cows enrolled at dry off, sampled at the first milking after calving (M1) and sampled again two to four days later (M2) and percentage of enrolled cows lost to analysis, where cows received no treatment (NT) at dry off or administration of internal teat sealant (ITS), dry cow antibiotics (DCT), or DCT followed immediately by ITS (DCT+ITS).

At dry off, *Strep. uberis* was the most prevalent major pathogen isolated in Herd 1 (Table 2) whilst *Staph. aureus* was the most prevalent major pathogen isolated in Herd 2, from cows enrolled to both studies.

| | Herd 1 | | | | Herd 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Prophylactic | | Therapeutic | | Prophylactic | | Therapeutic | |
| Item | n | % | n | % | n | % | n | % |
| Total quarters | 1084 | | 360 | | 1732 | | 540 | |
| Total with valid result | 1084 | | 359 | | 1730 | | 539 | |
| Total with no bacterial growth | 1039 | 95.8 | 302 | 84.1 | 1660 | 96.0 | 432 | 80.1 |
| Total with bacterial growth | 45 | 4.2 | 57 | 15.9 | 70 | 4.0 | 107 | 19.9 |
| With major pathogens[1] | 10 | 22.2 | 28 | 49.1 | 19 | 27.1 | 73 | 68.2 |
| Staph. aureus | 2 | 4.4 | 13 | 22.8 | 13 | 18.6 | 55 | 51.4 |
| Strep. dysgalactiae | 1 | 2.2 | 0 | 0.0 | 0 | 0.0 | 7 | 6.5 |
| Strep. agalactiae | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.9 |
| Strep. uberis | 7 | 15.6 | 16 | 28.1 | 7 | 10.0 | 16 | 15.0 |
| Other organism[2] | 0 | 0.0 | 1 | 1.8 | 0 | 0.0 | 0 | 0.0 |
| With minor pathogens | 35 | 77.8 | 33 | 57.9 | 52 | 74.3 | 38 | 35.5 |
| CNS | 19 | 42.2 | 20 | 35.1 | 52 | 74.3 | 38 | 35.5 |
| Corynebacterium spp. | 16 | 35.6 | 15 | 26.3 | 0 | 0.0 | 0 | 0.0 |

[1]Due to mixed infections in some quarters, the number of quarters positive for an individual pathogen adds up to more than the total number of quarters with a major pathogen infection, [2]Other organism was: Listeria monocytogenes

**Table 2.** Bacterial species isolated from quarters (n) and as a percent of quarters that yielded growth (%) at dry off for Herd 1 and Herd 2.

Between dry off and calving, 10 quarters across six cows were treated for clinical mastitis (Table 3A). In the prophylactic study, three cows were on NT (4.4%) and two were on ITS (1.0%). One cow in the therapeutic study, on the DCT+ITS treatment, was also treated for clinical mastitis. *Streptococcus uberis* was isolated from all 6 cases detected in Herd 2 whilst in Herd 1, *Trueperella* spp. was isolated from one case, and no bacterial growth or no sample collected for the other cases. Three cows that developed clinical mastitis in the dry period were culled before calving, but only one due to mastitis (*Trueperella* spp.).

During the first 30 days after calving, 61 quarters across 46 cows were detected and treated for clinical mastitis (Table 3B). In the prophylactic study, the proportion of cows on NT that developed clinical mastitis (11.7%) was almost three-fold higher than for ITS (4.4%), DCT (3.6%) and DCT+ITS (3.4%), with the difference between NT and DCT+ITS being significant (P=0.045). In the therapeutic study, there was a two-fold difference in proportion of cows that were treated for clinical mastitis on DCT compared with DCT+ITS, but this difference was not significant due to the low numbers of cows involved.

**A.** Dry period

| Study and treatment | Herd 1 | | | Herd 2 | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | n | N | % | n | N | % | n | N | % |
| Prophylactic | | | | | | | | | |
| NT | 2 | 1 | 4.2 | 3 | 2 | 4.5 | 5 | 3 | 4.4 |
| ITS | 2 | 1 | 1.2 | 1 | 1 | 0.8 | 3 | 2 | 1.0 |
| DCT | 0 | 0 | | 0 | 0 | | | 0 | |
| DCT+ITS | 0 | 0 | | 0 | 0 | | | 0 | |
| Therapeutic | | | | | | | | | |
| DCT | 0 | 0 | | 0 | 0 | | | 0 | |
| DCT+ITS | 0 | 0 | | 2 | 1 | 1.5 | 2 | 1 | 0.9 |
| Total | 4 | 2 | | 6 | 4 | | 10 | 6 | |

**B.** After calving

| Study and treatment | Herd 1 | | | Herd 2 | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | n | N | % | n | N | % | n | N | %[1] |
| Prophylactic | | | | | | | | | |
| NT | 2 | 2 | 10.0 | 7 | 5 | 12.5 | 9 | 7 | 11.7[a] |
| ITS | 4 | 4 | 5.1 | 6 | 5 | 6.3 | 11 | 9 | 4.4 |
| DCT | 3 | 2 | 2.2 | 6 | 6 | 5.0 | 9 | 8 | 3.6 |
| DCT+ITS | 1 | 1 | 1.3 | 9 | 6 | 4.8 | 10 | 7 | 3.4[b] |
| Therapeutic | | | | | | | | | |
| DCT | 2 | 2 | 6.8 | 9 | 8 | 12.7 | 11 | 10 | 10.9 |
| DCT+ITS | 2 | 2 | 5.4 | 9 | 3 | 5.1 | 11 | 5 | 5.2 |
| Total | 14 | 13 | | 46 | 33 | | 61 | 46 | |

[1]Where superscripts differ in this column, proportion of cows treated for clinical mastitis differed (P<0.05) in pairwise comparison.

**Table 3.** Number of quarters (n), cows (N) and as a percentage of cows enrolled to the study (%) that were treated for clinical mastitis between dry off and calving (A) or that were treated for clinical mastitis in first 30 days of lactation (B), as a percentage of cows that calved (%), for Herd 1 and Herd 2, where cows received no treatment (NT) at dry off or administration of internal teat sealant (ITS), dry cow antibiotics (DCT), or DCT followed immediately by ITS (DCT+ITS).

Across both herds, the most frequently isolated pathogen from clinical samples was *Strep. uberis* (33% of cases), followed by *Staph. aureus* (17%) and *E. coli* (16%). No pathogen was isolated from 20% of cases. In Herd 1 *Strep. uberis* and *E. coli* were the predominant pathogens isolated from clinical samples (both 35.7%), whereas *Strep. uberis* and *Staph. aureus* were the predominant pathogens in Herd 2 (32.6% and 19.6% respectively). The proportion of cows that developed clinical mastitis due to *Strep. uberis* was higher for cows on NT compared with DCT+ITS for Herd 2 only (4/44 vs. 1/132 cows; P=0.034), with the distribution of clinical cases by other pathogens too low for analysis.

In the prophylactic study, there was a significantly higher proportion (P<0.001) of cows that developed new intramammary infections at the first milking after calving (Table 4) for cows that received NT at dry off, compared with cows that received an intervention.

Due to significant interactions between farm and treatment for CNS infections (P<0.05), data from each herd are shown separately in Table 4. When aggregated across both herds, the new infection rate for all pathogens by the first milking after calving, was significantly higher for cows on NT compared with DCT (50.6% vs. 15.1%, P<0.001), and between cows on DCT compared with ITS alone or DCT+ITS (15.1% vs 6.4% or 5.1% respectively; P<0.001) in pairwise comparisons.

New infections by *Strep. uberis* followed a similar pattern to all pathogens. In contrast, an interaction was observed between farm and treatment (P=0.026) for new CNS infections, such that Herd 2, with a much lower incidence of new CNS infections, showing no benefits of an intervention at dry off.

When the new infection rate over the dry period was determined using the second sampling after calving, the proportion of NT cows identified with a new infection by all pathogens remained higher than for cows that received an intervention. However there was a significant interaction between farm and treatment (P<0.01) for all pathogens and for new CNS infections, with a strong effect of treatment at dry off only observed in Herd 1. For new infections by *Strep. uberis*, there was a more consistent and significant effect of treatment at dry off, when averaged across both herds (P=0.003). The proportion of cows with new infections due to *Strep. uberis* had dropped considerably between M1 and M2 across all treatment groups (Table 4).

**A.** Herd 1

| | NT | ITS | DCT | DCT+ITS |
|---|---|---|---|---|
| Isolate | Between dry off and M11 | | | |
| *Strep. uberis* | 12.9 ±8.6[a] | 0.8 ±0.9[b] | 1.4 ±1.2[b] | 0.8 ±0.9[b] |
| CNS | 48.8 ±14.7[a] | 6.2 ±3.08[b,c] | 11.1 ±4.5[b] | 3.2 ±2.05[c] |
| Any pathogen | 63.1 ±13.1[a] | 7.2 ±3.0b | 12.5 ±4.2[b] | 5.0 ±2.4[b] |
| | Between dry off and M2 | | | |
| *Strep. uberis* | 2.8 ±3.0 | 0.9 ±0.9 | 0.3 ±0.3 | 0.4 ±0.5 |
| CNS | 58.6 ±13.7[a] | 9.1 ±4.3[b] | 9.2 ±4.2[b] | 1.6 ±1.6[b] |
| Any pathogen | 72.7 ±11.1[a] | 12.1 ±4.5[b] | 11.2 ±4.2[b] | 2.7 ±2.0[b] |

[1]Where superscripts differ in a row, number of cows with a new infection differed (P<0.05) in pairwise comparisons.

**B.** Herd 2

| | NT | ITS | DCT | DCT+ITS |
|---|---|---|---|---|
| Isolate | Between dry off and M11 | | | |
| *Strep. uberis* | 29.3 ±10.1[a] | 1.7 ±1.2[b] | 7.8 ±3.5c | 0.5 ±0.6[b] |
| CNS | 5.7 ±3.4[a] | 2.4 ±1.3[a,b] | 8.7 ±3.4[a,c] | 2.5 ±1.4[a,b] |
| Any pathogen | 38.0 ±9.1[a] | 5.8 ±2.2[b] | 18.2 ±4.7[c] | 5.3 ±2.1[b] |
| | Between dry off and M2 | | | |
| *Strep. uberis* | 6.1 ±4.4[a] | 0.4 ±0.4[b] | 1.8 ±1.3[b] | 0.2 ±0.3[b] |
| CNS | 8.2 ±5.0 | 5.3 ±2.4 | 10.3 ±3.8 | 6.3 ±2.7 |
| Any pathogen | 21.6 ±7.4[a] | 7.9 ±2.8[b] | 13.5 ±4.0[a,b] | 9.7 ±3.2[a,b] |

[1]Where superscripts differ in a row, number of cows with a new infection differed (P<0.05) in pairwise comparisons.

**Table 4.** Number of cows with a new intramammary infection, expressed as covariate adjusted % of cows (%±SEM), where cows received no treatment (NT) at dry off or administration of internal teat sealant (ITS), dry cow antibiotics (DCT), or DCT followed immediately by ITS (DCT+ITS), when examined at first milking after calving (M1) or two to four days later (M2) for cows on Prophylactic study, in Herd 1 (A) or Herd 2 (B).

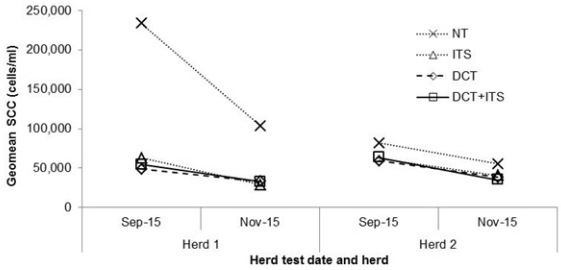
In the therapeutic study, most infections present at dry off had cured by the first milking after calving (Table 5). For Herd 1, only six cows were detected with Staph. aureus infections at dry off and all had cured by calving. In Herd 2, 35 cows had Staph. aureus infections at dry off, with 18.8% of DCT cows and 57.8% of DCT+ITS cows cured by calving. However there was insufficient power for this difference to be statistically significant.

| | DCT | | | | | | DCT+ITS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Herd 1 | | | Herd 2 | | | Herd 1 | | | Herd 2 | | |
| | | Cure | | | Cure | | | Cure | | | Cure | |
| Isolate | N | n | % | N | n | % | N | n | % | N | n | % |
| *Staph. aureus* | 2 | 2 | 100 | 16 | 3 | 18.8 | 4 | 4 | 100 | 19 | 11 | 57.8 |
| *Strep. uberis* | 4 | 4 | 100 | 7 | 6 | 85.7 | 4 | 4 | 100 | 4 | 4 | 100 |
| CNS | 7 | 7 | 100 | 15 | 15 | 100 | 4 | 5 | 80 | 13 | 12 | 92.3 |
| All pathogens | 11 | 11 | 100 | 33 | 24 | 72.7 | 13 | 13 | 100 | 27 | 21 | 77.8 |

**Table 5.** Number of cows (N) with bacterial isolates present at dry off, and number that cured (n cure, %) by the first milking after calving for cows treated at dry off with administration of dry cow antibiotics (DCT) or DCT followed immediately by internal teat sealant (DCT+ITS), on Therapeutic study only.

There was no difference in milk yield or milksolids production at the first two herd tests in the subsequent lactation for cows on different treatments in either study. However there was an interaction between herd and treatment in the prophylactic study for cow SCC, such that untreated cows in Herd 1 had a significantly higher SCC (P<0.001) at the first two herd tests compared with cows that received an intervention (Figure 1A). In the therapeutic study, cows on DCT had a slightly higher SCC but there was no significant effect (P>0.05), and no herd by treatment interaction.

Prophylactic study




Therapeutic study

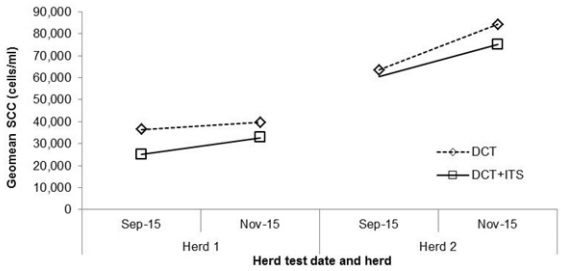



**Figure 1.** Geometric mean (back-transformed) SCC at first two herd tests following calving for Herd 1 and 2, for cows that received no treatment (NT) at dry off or administration of internal teat sealant (ITS), dry cow antibiotics (DCT), or DCT followed immediately by ITS (DCT+ITS).

# Discussion

The study was established to (1) identify the consequences of leaving some low SCC cows unprotected in wintering systems considered to have a high risk for environmental mastitis, and (2) evaluate the protection provided by teat sealant alone, compared to dry cow antibiotics or a combination of the two. Both objectives were achieved, with no serious consequences. It is acknowledged however that the risks associated with poor hygiene at infusion of ITS were mitigated by administration of all treatments by trained veterinary technicians. In both herds, cows that were left untreated at dry off had more clinical mastitis in the dry period and after calving, a higher rate of cows with new intramammary infections at calving, and a higher SCC in the subsequent lactation.

The level of clinical mastitis in the dry period among untreated cows was lower than expected by the farm managers, but only 10% of eligible cows in each herd were exposed. Both farm managers commented that having a greater proportion of the herd unprotected would have created a more noticeable and unfavourable result. Compared to cows that received no treatment, the interventions achieved a protective effect ranging from 70 to 100% in the dry period, with a decline after calving (50 to 90% in Herd 1 and 50 to 62% for Herd 2). These effects were similar to previous studies. McDougall (2010) reported a 95% reduction in proportion of cows that developed clinical mastitis in the dry period, and 45% reduction in cows that developed clinical mastitis after calving, through use of DCT at dry off in a Waikato-based study. Laven and Lawrence (2008) reported a 37% reduction in clinical mastitis after calving for cows protected with ITS, compared to unprotected cows for a farm in the Manawatu.

Protection against new intramammary infections after calving was also significant for all three interventions compared with no treatment, ranging from 80–95% for new *Strep. uberis* infections, 50–90% for new CNS infections and 70–90% for any pathogen. These effects were similar to previous studies where cows were wintered on pasture and protected with DCT (McDougall 2010), or ITS (Compton *et al.* 2014) or with a combination of DCT and/or ITS (Woolford *et al.* 1998).

Protection against new *Strep. uberis* infections remained evident for infections detected at the second sampling, two to four days after calving, compared to dry off. This was despite a considerable decline in level of new *Strep. uberis* infections observed in unprotected cows between the first and second sampling after calving. McDougall (2010) reported a halving of the new *Strep. uberis* infection rate for cows sampled within one day after calving compared to cows sampled three or more days after calving. Further analysis of this dataset is required to determine the outcomes of *Strep. uberis* infections detected at the first milking after calving, and identify the relative proportion that progress to a clinical case of mastitis, or to a self-cure within the first few days after calving. For CNS infections, there was a wide variation in incidence of new infections between farms, compared to between sampling days, suggesting that herd-specific factors are linked to the likelihood of new infection by these pathogens.

The study design was not powered sufficiently to test non-inferiority of the interventions at drying off. Nevertheless, in the prophylactic study, Herd 1 showed a step-wise decline in clinical case rate between ITS, DCT and DCT+ITS treatments whereas in Herd 2, the degree of protection was similar between the three interventions. For prevention of new intramammary infections, the pattern was a little different, with ITS alone generally performing better than DCT alone, and similar to DCT+ITS.

These mixed findings support published literature, whereby smaller studies tend to report no difference in protection between the different interventions (Woolford *et al.* 1998), whereas larger studies (Bradley *et al.* 2010) or metaanalyses (Halasa *et al.* 2009, Rabiee and Lean 2013) usually report superior protection for cows receiving a combination of dry cow antibiotics and teat sealant. Predicting the most appropriate interventions for different herds will require multi-herd studies to validate ITS alone across a range of infection scenarios at dry off, as well as different types of environmental exposure during the dry period.

In the prophylactic study, the higher SCC observed for untreated cows in Herd 1 was in agreement with studies that assigned cows to a negative control. McDougall (2010) reported a nearly two-fold higher SCC for cows that received no treatment compared with cows that received DCT at dry off. In Herd 2, which had a much lower incidence of new infections among untreated cows after calving, there was no significant effect of leaving cows unprotected at dry off. A lack of treatment effect between different interventions is a common finding in smaller single herd studies (Laven and Lawrence 2008) whereas larger studies (e.g. Runciman *et al.* 2010) tend to report a benefit of DCT+ITS compared with DCT.

In the therapeutic study, the slightly higher SCC observed in the subsequent lactation for cows receiving DCT compared with DCT+ITS supports previous reports (Runciman *et al* 2010, Bates *et al* 2016), but the small size of this study limited detection of a significant effect. Further analysis is required to identify the most appropriate interventions for cows presenting with different SCC at dry off.

# Conclusion

Among cows that received no protection at dry off, there were almost three times as many cases of clinical mastitis, more infections present at calving, and a higher SCC at the first two herd tests in the subsequent lactation. For cows receiving teat sealant alone, the level of protection was almost the same as a combination of dry cow and teat sealant, and for some measures, was better than dry cow treatment alone. However it is acknowledged that the size of the study did not have sufficient power to consistently distinguish between the different interventions.

Multi-herd studies are required to determine if these factors can be modelled to provide better predictors of the effectiveness of different strategies. Some herds may gain no additional benefit from the combined approach whilst others may benefit more from teat sealant alone.

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For formatting purposes, all original long URLs have been condensed using the bit.ly format.

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