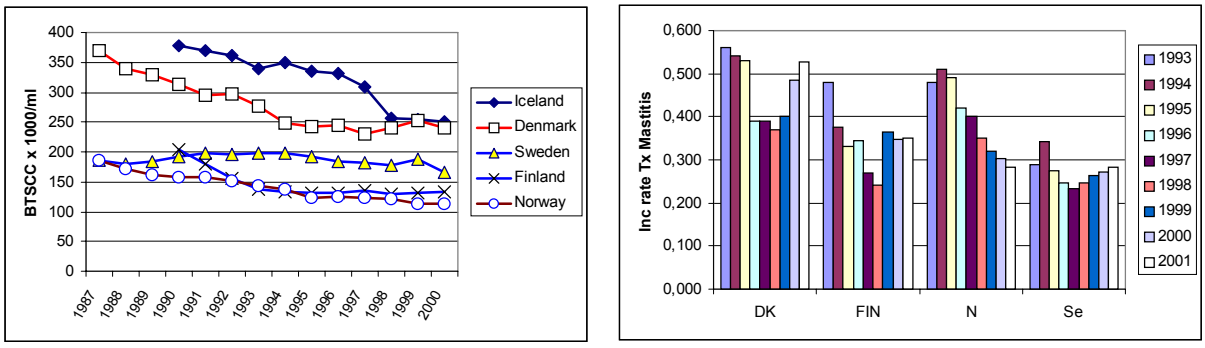
MASTITIS CONTROL AND DRY COW THERAPY IN THE NORDIC COUNTRIES

Torkel Ekman[1] and Olav Østerås[2]
[1] Swedish Dairy Association, Uppsala, Sweden
[2] TINE BA, ÅS, Norway

Introduction

In Norway and Sweden, as in other Nordic countries, big efforts have been made to reduce the use of antibiotics in milk production as well as in other animal production. An example of the latter is that Sweden and most other Nordic countries have, by law, banned the use of antibiotics in feed as growth promoters. The Swedish law was passed in 1986. In Sweden and Norway the estimated treatment rates for mastitis in dairy cows is 0.28 in both countries. In Norway treatments for mastitis have decreased with 43 percent since 1994. This progress is partly possible because complete disease treatment recording systems have existed in the Nordic countries, with the exception of Iceland, since the early eighties and since 1975 in Norway. The most important reason, however, is that comprehensive programs promoting cattle health, where emphasis is placed on good management of animals and good quality housing, alternate actions to treatment with antibiotics and selective - rather than total - dry cow therapy are presented to the farmers. Sales of antibiotics are also restricted in the Nordic countries and law does not allow veterinarians to earn money by selling antibiotics. The therapeutic regimens and quality payment systems are, however, different between the Nordic countries. The data of BTSCC and incidence rate of recorded mastitis treatments is presented in figures 1 a and b.



Figures 1 a and b, Bulk tank somatic cell count and incidence rate of treatment of mastitis in the Nordic countries (Østerås et al, 2001).

Disease Treatment Recording Systems In Sweden

The foundation for any action or control program to reduce or control a disease is to have accurate and reliable records. The Swedish disease treatment recording system was introduced in 1982. The Swedish Association for Livestock Breeding and Production (SHS), which in 2000 merged with the Swedish Dairy Association, was given the responsibility to run the recording

system. In the year 1999 the Swedish Board of Agriculture, which employs the district veterinarians responsible for most visits to farm animals, changed to a computerised system and resumed the responsibility for the national disease treatment database. A diagnose of the disease, as well as treatment method and amount of antibiotics and/or other pharmaceuticals per animal and farm, is recorded. The disease treatment records are stored and processed at the Swedish Board of Agriculture and are also sent weekly to the main frame at the Swedish Dairy Association in Eskilstuna were they are incorporated with production and fertility data in the milk recording system. Associated dairy farmers, about 75% owning about 85% of the dairy cows in Sweden, then receive a monthly report plus one annual report. Currently (October 2002) a new version of the monthly report is being marketed. The new report contains data on udder health, fertility, claw disorders etc and is updated with 3 and 12 month rolling averages monthly. The data are stored for a minimum of three and five years, health and AI-data, respectively. Data used for research purposes can be stored for longer periods of time in other systems (Olsson, et al., 1999).

Preventive Veterinary Medicine and Herd Health Programmes

Cattle health programmes have been used in the Nordic countries, and in Sweden and Norway in particular, as part of preventive veterinary services offered to the farmers already from the early 70-ties (Olsen, 1971; Olsen, 1975; Funke, 1988). During the first ten to fifteen years the efforts were concentrated on mastitis and reproductive problems. The farmers were offered regular visits with clinical examinations, CMT of cows, milk sampling for bacteriological diagnosis, mastitis therapy and advice intended to avoid further problems. In both countries, veterinarians were responsible for the service, even though animal technicians also were involved, mainly to check the milking technique and to test the milking equipment. Over the last ten to fifteen years, the service principles have been further developed, now including also other diseases and general herd health investigations.

In Sweden a new preventive program called FRISKKO (HealthyCow) has been developed in the last 5 years and is now (2002) being launched nation-wide (Hallén Sandgren, 1999; Hallén Sandgren & Carlsson, 2000). The program aims at improving health in dairy cattle by helping the farmer to focus on what he/she can do to improve management and feeding with as little use as possible of antibiotics or hormones. The program also comprises computerized tools for working with udder health, fertility, claw disorders and various other herd health problem areas. It also features a computer program for comparing the economic result on a particular farm, based on its production records, with other farms in Sweden. Specific advice concerning prevention of mastitis include:

1. Good housing with clean and dry stalls and sufficient clean and dry bedding.
2. Keeping animals clean and well fed and managed.
3. Keeping good records of the udder health of dairy cows by being part of the cow control system.
4. Using those records to establish a milking order with healthy cows being milked first and infected cows last.
5. Milking the cows with a good and clean technique and with the same friendly routine by all milkers.

6. Keeping the milking equipment in good condition.
7. Using post milking teat dipping if the herd has an elevated cell count.
8. Treating acute clinical mastitis in young or previously untreated cows promptly.
9. Using dry cow therapy selectively.
10. Culling chronically infected cows or cows with recurrent mastitis – clinical or sub clinical.

Use Of Antibiotics In Nordic Disease Treatment And Prevention

Drugs are only used after prescription from a veterinarian. Neither technicians nor farmers are allowed to buy or use any antibiotic drugs or hormones by themselves without a veterinary diagnosis. In Finland and Sweden systemic treatment with procaine penicillin for 4-6 days is used when treating cases of clinical mastitis (Ekman et al. 1994) whereas in Denmark, Iceland and Norway generally systemic treatment is used only the first day of a 4-5 day treatment with intra-mammary preparations. Treatment of sub-clinical mastitis is discouraged in Finland, Norway and Sweden.

In Sweden as well as in other Nordic countries the discussion about relevant mastitis therapy has been very active within the veterinary society. Test trials for different antibiotic drugs and strategies have been made (Funke, 1961; Franklin et al., 1986; Funke, 1982; Funke, 1983; Jarp et al., 1989, Pyörälä & Pyörälä, 1998). The early work by Funke (1961; 1982), showing that intra-muscular administration results in better distribution of antibiotics in the udder parenchyma and leads to better bacteriological cure rates is the reason why systemic use of antibiotics is preferred in Sweden and Finland.

The most common udder pathogens are Gram-positive micro-organisms such as *Staphylococcus aureus* (*S aureus*), *Streptococcus dysgalactaie* (*Sr d*) and *Sr uberis* (*Sr u*). *Streptococcus agalactiae (Sr a)* is found in less than 1% of clinical and subclinical mastitis cases. In Finland the main contagious bacteria are the coagulase negative staphylococci (CNS) (Myllys 1995). The incidence of clinical mastitis induced by *Escherichia coli (E coli)* is about 20% in Sweden and only 12% in Norway. The incidence of ß-lactamase resistent *S aureus* strains associated with clinical mastitis is about 6% in both Sweden and Norway (Nilsson et al 1997; Tine, 1999). In Sweden, as in most other Nordic countries, the veterinarian initiates the treatment with an injection of penicillin-procaine, commonly 20 mg/kg SID, but in Sweden the farmer is then allowed to continue with intra-muscular injections another four to five days. Intra-mammary tubes are used to support the systemic therapy in about 50% of cases of acute clinical mastitis (Ekman et al. 1994). The consumption of injectable antibiotics in Sweden with the indication bovine mastitis is shown in figure 2. The use of penicillin is increasing at the expense of broad-spectrum antibiotics.

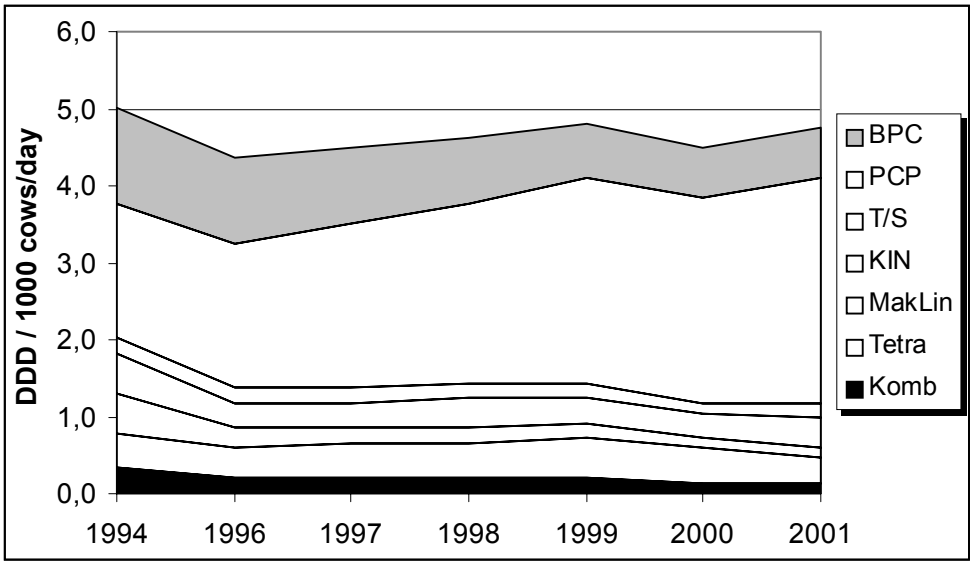


Figure 2. Estimated consumption in defined daily doses (DDD) / 1 000 cows / day, by dairy cattle in Sweden, of injectable antibiotic with mastitis as one indication (Odensvik, 2002). BPC: benzyl penicillin, PCP: penicillin procain, T/S: trimethoprim/sulfa, KIN: fluoroquinolones, MakLin: makrolides & lincosamides, Tetra: tetracyclines, Komb: PCP & dihydrostreptomycin sulphate.

Lactational therapy of subclinical mastitis

In a recent study of treatment of sub-clinical mastitis during lactation, including a cost-benefit analysis/10 months, and performed by the Swedish Dairy Association, intra-muscular injections of potassium penicillin 9.5 mg/kg BID for 5 days was statistically significantly better than intra-mammary infusions with penicillin/DHS in oil for 5 days but not better than no treatment, table 1 (Hallén Sandgren, 2000).

Table 1. Estimated costs/10 months when treating lactational sub-clinical mastitis with systemic injections of potassium penicillin 9.5 mg/kg BID x 5 days, intra-mammary infusions with PC/DHS in oil x 5 days and no treatment. Costs associated with treatments in US dollars (USD)

	Discarded Milk	Extra labor	Culling	Recurrent mastitis	Anti-biotics	Total costs
Inj with PC, 5 d	20	50	165	7	35	277 USD
I-mammaries, 5 d	38	50	347	38	27	500 USD
No treatment	0	0	159	16	0	175 USD

Selective dry cow therapy in the Nordic countries

Selective, rather than "blanket" dry cow therapy with long acting intra-mammaries is recommended in the Nordic countries (Olsen, 1971 & 1975; Funke, 1988). In Norway selective dry cow therapy is recommended but practised on only 1-2% of dairy cows, in Finland the rate is about 20% percent, in Sweden about 25% (Odensvik, 2002) and in Denmark 6-7%. To evaluate the effect of dry cow therapy at national level it is of interest to compare these figures with the

level of BTSCC and incidence rate of clinical mastitis in figure 1. In Norway where dry cow therapy is hardly practiced the lowest BTSCC is found and there has been a decrease of >40% of treatments of clinical mastitis during the last 5 years. This indicates that, in the Nordic countries, mastitis is handled by other means than dry cow therapy.

In a recent Nordic study of when in lactation cows were treated for mastitis only 1.1% of Norwegian cows were recorded treated for mastitis in the period from the last cow milk somatic cell count (CSCC) in the prior lactation to 30 days before calving. From day 30 before calving till the day of calving 8.4% of the cows were treated for mastitis. A total of 86.2% of all Norwegian cows had no treatment from the last CSCC before drying off till the first CSCC after calving. Dry cow preparations with long acting effects may be used after application to the proper Norwegian authorities, and in Denmark farmers are allowed to use dry cow treatment only if they subscribe to a preventive herd health program.

In an other recent study of the cumulative risk of treatment for mastitis and other diseases in Nordic dairy herds, and performed on data from 1997, it was shown that the overall highest risk of being treated for mastitis was from 2 days prior to 14 days post calving and that around 31, 47, 44 and 34% of all mastitis treatments were done during this period in Sweden, Finland, Norway and Denmark respectively (Østerås, et al. 2002). It was also shown that the risk curves for first parity calvers were higher than the risk curves for second parity calvers up to 28-30 days post partum. In Sweden and Finland the risk curves for first parity calvers also exceeded the risk curves for third lactation cows.

The new infection rate during the dry period is very much in focus in the arguments for dry cow therapy. The Norwegian data, however, show that there is great dynamics in the shift of infections during the dry period. Of the cows with <100,000 CSCC in geometric mean in the last three samples before drying off 26% had >100,000 in CSCC in geometric means in the first three samples after calving. On the other hand 36% had CSCC >100,000 before drying off and 38% of those had changed to less than 100,000 after calving. The shifts in CSCC is presented in Table 1. There is a slight increase in the prevalence of cows with higher CSCC during the dry period. The postulated high new infection rate could be questioned, however. There is also a fairly high self cure rate.

Table 1. The shift of CSCC during the dry period (Norwegian data, Østerås, 2002).

Before\after dry period	<100,000	>100,000	Total
<100,000	474	166	640
>100,000	137	223	360
Total	611	389	1,000

The question of total or selective dry cow therapy is the question of the necessity of treatment of the 61,1% that are healthy at the next lactation or an attempt to select some of those 38,9% that are not “healthy” at the next lactation. Some of the “unhealthy” cows have chronic subclinical mastitis and will not cure anyway and thus do not need therapy. The question of “blanket” or selective dry cow therapy is also the question of if you view distribution of antibiotics as an

insurance against infection or whether you emphasize other means of preventing cows from being infected during the dry period. The Nordic philosophy has always been to stress the importance of truly preventive measures instead of trying to control the new infections with antibiotics (Olsen, 1971 & 1975; Funke, 1988). Therapy at drying off does not have to be at random, and prognosis for treatment can be predicted according to Østerås et al, 1999 and Sol et al. 1994. Selection or blanket dry cow therapy thus is a question of being able to and having the benefit of this selection process. This will depend on information available, herd situation and health situation. It could be hypothesized that the worse the health situation is the more effective – at least in the short run (?) - is the concept of blanket dry cow therapy, the better the health situation the better is the concept of selective dry cow therapy.

Policy for the Use of Antibiotics When Treating Bovine Mastitis

When Sweden started implementing the EU milk directive January 1st 1994, the dairy farmers and the dairy co-operatives had to enforce the rule of not exceeding the 3-month, rolling geometric mean of 400 000 cells/ml in the milk tank. Some farmers had difficulties with this and asked their veterinarians to treat cows with high somatic cell counts *i.e.* sub-clinical mastitis. This lead to an increase in the rate of treatment of dairy cows for mastitis with more than 25%, from 18 to 23,5%. At the same time no improvement of the objective udder health measurements could be detected (Svensk Mjölk, 2001). At this time persons within the Swedish Dairy Association responsible for udder health in dairy cows summoned Swedish scientists and experts on udder health and the use of antibiotics to draft a policy on the use of antibiotics. The policy was presented in the Swedish Veterinary Journal in 1995 (Ekman et al., 1995). Briefly the policy states that:

- Prevention of disease should be emphasized at all levels. Efforts should be made to find the true cause of the disease and to eliminate that through improved management, feeding and environment. An improved management will also have a positive effect on cure rate (both self cure rate and therapy cure rate).
- Before using antibiotics the prognosis and potential effect of treatment should always be considered. The listed examples are cases when treatment with antibiotics is probably not effective:
    - mastitis induced by *E. coli*
    - chronic clinic or recurrent mastitis
    - sub-clinical mastitis during lactation
- A milk sample for bacteriological diagnosis should be taken when starting a treatment of bovine mastitis and, when indicated, the sensitivity of the bacterium should be checked.
- A narrow spectrum antibiotic such as penicillin, correctly dosed and the treatment extended for a sufficient period of time, should be the drug of choice, unless repeated bacteriological diagnoses in the herd in question indicate otherwise.
- All treatments with antibiotics should be followed up.
- On farms with problems with resistant bacteria (*i.e.* β-lactamase production) treatment with antibiotics should be discouraged and a plan to eradicate those bacteria should be established.

- Alternate methods of treatment, such as separate milking or drying off of chronically infected quarters, isolation of infected cows and milking last and culling when production diminishes should be tried.

In a joint action by the Swedish and Norwegian Medical Products Agencies a common policy for the use of antibiotics when treating production animals was established in 1998 (Swedish Medical Products Agency, 1998; Grave et al, 1999). The document stresses the importance of preventive measures and good housing conditions, support of antibiotic treatment with bacteriological diagnosis whenever possible and environmental concerns about the use of antibiotics. In the absence of serious problems with resistant bacteria penicillin is generally recommended as the drug of choice when treating disease of cattle, sheep, horses and to some extent swine.

Dry Cow Treatment in Epidemiological Studies

The practice of dry cow treatment (DCT) has been included in many epidemiological studies. The effect on BTSCC by DCT and ”blanket” dry cow therapy (BDCT) is variable, with some studies showing lowering effects on BTSCC by DCT or BDCT (Bodoh et al., 1976; Hoare et al., 1979; Goodhope & Meek, 1980; Erskine et al., 1987; Hueston et al., 1987; Sischo et al., 1993) while others show no or even a positive association, that is udder health measured as BTSCC deteriorate with increased use of DCT or BDCT (Pearson et al., 1972; Dohoo et al., 1984; Hutton et al., 1990 & 1991; Howard et al., 1991; Miller & Bartlett, 1991; Bartlett et al., 1992; Bartlett & Miller, 1993; Wilson, 1997). In a study using multivariate statistical analysis on 82 farms in Sweden it was shown that DCT disappeared from the regression model in the presence of two other management factors – post milking teat dipping and keeping a strict milking order, i.e. milking the low cell count cows first (Ekman, 1998).

The studies of Hueston et al. (1987), Dargent-Molina et al. (1988), Hutton et al. (1990 and 1991) and Wilson et al. (1997), who examined effects of control practices on different pathogens, clearly indicate that the epidemiologies of *Sr a* and *S a* are different and that the control practices of post milking teat dipping (TD) and BDCT affect these two pathogens differently. It appears that TD and BDCT are more effective in controlling *Sr a* than *S aureus*. It is reasonable to hypothesize that this is because *Sr a* is more sensitive to treatment (penicillin) and more restricted to the parenchyma of the udder than *S aureus.*

The bacterial species of main interest at the time of the design of the Five Point Plan (5PP) and the introduction of the concept of BDCT were *S aureus, Sr a, Sr d and Sr u* (Dodd et al., 1969; Dodd & Neave, 1970). Since the flora of bacteria has shifted in most western countries and the importance of udder born, contagious gram-positive bacteria such as *S aureus* and *Sr a* have diminished (Marr, 1978; Wilson & Richards, 1980; Anonymous – Unit of Epid., 1981; Robinson et al., 1985; Myllys 1995), it is reasonable to argue that the indications for BDCT have been reduced concomitantly. The 5PP, although still with some relevance, appears to simplistic with the multi-factorial etiology of mastitis in modern milk production elucidated by analyses of risk factors from more recent epidemiological studies.

General Discussion

The recommendations in the Nordic countries, to stress the importance of measures to keep dairy cows clean and dry, well fed and well housed and to prevent healthy cows from being infected by cows with high cell counts, have clearly been effective as is shown by the national records for BTSCC and treatments of mastitis.

Especially the Norwegian program that has reduced the number of treatments of mastitis with antibiotics by >40% and concomitantly lowering the national cell count is impressive. So far the Norwegian trend continues. This result is partly due to 1) change in attitude by farmers, veterinarians and advisors of the general role of antibiotics in mastitis control; 2) an effective breeding program for mastitis resistance and 3) good information from health reports combined with advisory services in co-operation between veterinarians and advisors from farmers associations. That this improvement in udder health has been done in the absence of blanket dry cow therapy makes it even more instructive.

In Denmark the veterinary profession had a lively discussion in the middle of the 90-ties on the use of antibiotics when treating mastitis, which reduced the treatment incidence/year to less than 40% of the dairy cows. That discussion has since fallen silent and treatment levels have returned to around 50%. These fluctuations have had no impact on national BTSCC or herd levels of udder health.

On the subject of DCT research performed in the respective Nordic countries support the policy of selective DCT as the question of cure is not a question of random effect and can be predicted (Østerås et al, 1999 and Sol et al., 1994). The preventive effects often argued by anglo-sachsian workers have not been seen, neither the postulated high new infection rate during drying off. Clinical mastitis is relatively rare in the early dry period. One reason might be that the long standing advice on good housing and clean cows has made the Nordic farmers aware of the importance of such measures. Another reason could be that the majority of cows in Sweden, Finland and Norway are housed in tie stall barns and are managed as individuals on farms with, on average, 43, 20 and 15 dairy cows respectively. It may even be reasonable to hypothesise that the absence of BDCT has itself had a positive effect on the farmers' willingness to manage their dry cows well. One pharmaceutical reason for the lack of effect on udder health from DCT might be that a substantial part of the infections occur at the end of the dry period or at calving when the therapeutic effect is wearing off. The reasons for the high risk of mastitis in this period are still not sufficiently elucidated.

The results cited above that the risk curves for first parity calvers were higher than the risk curves for second and third parity calvers in the first month post partum indicates that the event of parturition is itself a great inducer of mastitis, especially in primipara. It also indicates that the risk does not increase with parity (*i.e.* dry period) which one should expect if infection during the dry period was the main force behind cases of mastitis in the early postpartum period.
One other potential contributing factor that deserves mentioning is the long standing breeding programs for healthier cows with good reproductive capacity. Although the programs differ in detail between countries they all work to make the Nordic dairy cow better suited to resist

infection and fight bacteria. The median cell count of Swedish dairy cows is estimated to be 73 000 cells/ ml with the indigenous Swedish Red being the better the two major breeds, the Swedish Holstein being the other one. There are no indications of immune incompetence in Swedish low cell count cows (Ekman & Emanuelson, 2000).

National Regulations of the Use of Antibiotics

The use of antibiotic drugs in veterinary medicine is strictly regulated in the Nordic countries. Antimicrobials for use in Swedish animals, as well as withdrawal times, are authorised by the Medical Products Agency. All antibiotics, hormones and other formulations for use in animals, are available on veterinary prescription only. The rules of veterinary practise of the Swedish Board of Agriculture (LSFS 1979:8) state that "the usage of medical products shall be motivated. When choosing type and dosage of a medical product the risk of residues in food of animal origin shall be taken into account". It is also stated that prescribing and handing out medical products shall be done with great restrictivety and "only when the need is apparent". According to the same regulations, medical products may, in each occasion, be prescribed or handed out only after careful examination by a veterinarian of the diseased animal or herd. This has resulted in a general awareness about the importance of prudent use of antibiotics in dairy production as well as in the pig and poultry industry. It also supports the general attitude of preventing disease and trying to reduce the use of antibiotics as far as possible in all kinds of food production. This attitude is not new in the Nordic countries, quoted by a Danish veterinarian already in 1795:

> *"It is important to cure diseased animals*
> *but even more important is,*
> *through skilled management and correct use,*
> *to prevent disease."*
> Erik Viborg, 1795
> Danish veterinarian

Acknowledgements

The authors want to thank Nordic colleagues Øyvind Runge Jepsen, Denmark and Laura Kulkas, Finland, for constructive contributions to this manuscript.

References

Anonymous, Unit. Of Epidemiology, 1981: Mastitis surveillance scheme: July to December 1980. Vet. Rec. **107**, 27.

Bartlett, P.C., G.Y. Miller, S.E. Lance & L.E. Heider, 1992: Environmental and managerial determinants of somatic cell counts and clinical mastitis incidence in Ohio dairy herds. Prev. Vet. Med. **14**, 195-207.

Bartlett, P.C. & G.Y. Miller, 1993: Managerial risk factors for intramammary coagulase-positive staphylococci in Ohio dairy herds. Prev. Vet. Med. **17**, 33-40.

Bodoh, G.W., W.J. Battista, XX Schultz & R.P. Johnston, 1976: Variation in somatic cell counts in dairy herd improvement milk samples. J. D. Sci. **59**, 1119-1123.

Dargent-Molina, P., J. Scarlett, R.V.H Pollock, H.N. Erb & P. Sears, 1988. Herd-level risk factors for *Staphylococcus aureus* and *Streptococcus agalactiae* intramammary infections. Prev. Vet. Med. **6**, 127-142.

Dodd, F.H., D.R. Westgarth, F.K. Neave & R.G. Kingwill, 1969: Mastitis – The strategy of control, J. D. Sci. **52**, 689-695.

Dodd, F.H. & F.K. Neave. 1970: Mastitis Control. Biennial reviews, Natl. Inst. For Res. In Dairying. 21-78.

Dohoo, I.R., S.W. Martin & A.H. Meek, 1984: Disease, production and culling in Holstein-Friesian cows. VI. Effects of management on disease rates. Prev. Vet. Med. **3**, 15-28.

Ekman, T., Åström, G. & Funke, H. 1994. Measures taken by Veterinarians in Sweden in Cases of Bovine Mastitis. Acta vet. scand., *35*, 329-335.

Ekman T, Franklin A, Hallén Sandgren C & P Jonsson. 1995. Antibiotikapolicy vid behandling av mastit hos ko – ”revisited”. SVT, 47, 15, 665-669. A policy on the use of antibiotics when treating dairy cows with mastitis, Swedish vet J. 1995. In Swedish.)

Ekman, T., 1998. A Study of Dairy Herds with Constantly Low or Constantly High Bulk Milk Somatic Cell Count – with Special Emphasis on Management. Doctoral Thesis: Veterinaria 32. Swedish Univ. Of Agric. Sci.

Erskine, R.J., R.J. Eberhart, L.J. Hutchinson & S.B. Spencer, 1987: Herd management and prevalence of mastitis in dairy herds with high and low somatic cell counts. JAVMA, **190**, 1411-1416.

Franklin A, Horn af Rantzien M, Obel N, Östensson K & Åström G. 1986. Concentrations of penicillin, streptomycin and spiramycin in bovine udder tissue liquids, Am J Vet Res, 47, 4, 804-807.

Funke H. 1961. Thesis, Acta Vet Scand, 2, suppl 1, 1961.

Funke H. 1982. Practical experiences in the treatment of acute mastitis. Symposium on Mastitis, April, Copenhagen, NOVO Ind A/S, 1982.

Funke H. 1983. Kliniska mastiter. Svensk Vet.tidning, 35, 707-711. (Treatment of Clinical mastitis. Swed Vet Journal. In Swedish.)

Funke, H., 1988: Mastitis prevention in Sweden. Proc: 6th Int. Congr. On Anim. Hyg., **1**, 209-214, June 14-17, Skara, Sweden.

Goodhope, R.G. & A.H. Meek, 1980: Factors associated with mastitis in Ontario dairy herds: a case control study. Can. J. Comp. Med. **44**, 351-357.

Hallén Sandgren C.,1999. The Dairy Cattle Health Programme in Sweden – FRISKKO 2000 – and the pc-tools and data used in the advisory service. NMSM Seminar - Prevention of production diseases, March 18-19, Honne, Biri, Norway.

Hallén Sandgren, C. 2000. Treatment of sub-clinical mastitis during lactation. Internal report Swedish Dairy Association, project no: 942525.

Hallén Sandgren, C. & Carlsson, J. 2000. FRISKKO – Friskvård med helhetsperspektiv. Svensk Veterinärtidning, 52-1, 19-22.

Hoare, R.J.T., D.J. Critchley, E.B. Dettman, R.F. Sheldrake & L.R. Fell, 1979: Mastitis control: a survey of farm practices and their relationship to bulk milk cell counts. Austr. J. Dairy Tech. **34**, 91-96.

Howard, W.H., R. Gill, K.E. Leslie & K. Lissemore, 1991: Monitoring and controlling mastitis on Ontario dairy farms. Can. J. Agric. Econ. **39**, 299-318.

Hueston, W.D., L.E. Heider, W.R. Harvey & K.L. Smith, 1987: The use of high somatic cell count prevalence in epidemiologic investigations of mastitis control practices. Prev. Vet. Med. **4**, 447-461.

Hutton, C.T., L.K. Fox & D.D. Hancock, 1990: Masitis control practices: Differences between herds with high and low somatic cell counts. J. D. Sci. **73**, 1135-1143.

Hutton, C.T., L.K. Fox & D.D. Hancock, 1991: Risk factors associated with herd-group milk somatic cell count and prevalence of coagulase-positive staphylococcal intramammary infections. Prev. Vet. Med. **11**, 25-35.

Grave, K., C. Greco, L. Nilsson, K. Odensvik, T. Mørk & M. Rønning. 1999. The usage of veterinary antibacterial drugs for mastitis in cattle in Norway and Sweden. Prev. Vet. Med. 42, 45-55.

Jarp, J., Bugge, H.P. & Larsen, S., 1989. Clinical trial of three therapeutic regimens for bovine mastitis. Vet.Rec., 124, 630-634.

Marr, A., 1978: Bovine mastitis control: A need for appraisal? Vet. Rec. **90**, 132-134.

Miller, G.Y. & P.C. Bartlett, 1991: Economic effects of mastitis prevention strategies for dairy producers. JAVMA. **198**, 227-231.

Myllys, V., 1995: Staphylococcal mastitis in heifers and dairy cows. Thesis, College of Vet. Med., Helsinki, Finland.

Nilsson, L., Franklin, A. & Funke, H. Antimicrobial drug susceptibility of bovine udder pathogens in Sweden. Proceedings, Society for Veterinary Epidemiology and Preventive Medicine. Chester, England, 1997.

Odensvik, K. 2002. Försäljning av antibakteriella och antiparasitära läkemedel för djur 2001. SVT, 54, 251-254. (Sales of anti-bacterial and anthelmintic drugs for animals 2001. Swedish Vet J, in Swedish)

Olsen, S.J., 1971: Status over mastitisbekaempelsen i Danmark (The present state of mastitis control in Denmark). Nord. Vet. Med. **23**, 295-308. (In Danish with English summary.)

Olsen, S.J., 1975: A mastitis control system based on intensive use of mastitis laboratories. Proc: Sem. On mastitis control, p 371. Int. Dairy Fed., Brussels.

Olsson, et al., 1999. Disease Recording Systems and herd Health Schemes for Production Diseases. NKVET meeting, oktober 1999.

Østerås, O., Ekman T., Rattenborg E., Andersen H.J., Kulkas L., & Anthorsdottir A., 2001. Unpublished, Nordic Dairies Association (NMSM): Dairy cattle health statistics.

Østerås, O., Valde, J.P., Lindberg, A., Lawson, L., Saloniemi, H. & Agger, J.F., 2002. Disease incidence in dairy cows in Nordic countries – comparison of national disease reporting systems. Final scientific report of project NKJ: 1 276.

Østerås, O., Determinants of success and failure in the elimination of major mastitis pathogens in selective dry cow therapy. J dairy Sci 82: 1221-1231.

Pearson, J.K.L., D.O. Greer, B.K. Spence, P.J. McParland, D.L. McKinley, W.L. Dunlop & A.W. Acheson, 1972: Factors involved in mastitis control: A comparative study between high and low incidence herds. Vet. Rec. **91,** 615-623.

Robinson, T.C., E.R. Jackson & A. Marr, 1985: Factors involved in the epidemiology and control of *Streptococcus uberis* and coliform mastitis. Brit. Vet. J., **141**, 635-642.

Pyörälä S & Pyörälä E. 1998. Efficacy of systemic therapy in bovine clinical mastitis during lactation. XVIII World Buiatrics Congress, Bologna, Italy, Proc I, 571-574.

Sischo, W.M., L.E. Heider, G.Y. Miller & D.A. Moore, 1993: Prevalence of contagious pathogens of bovine mastitis and use of mastitis control practices. JAVMA. **202**, 595-600.

Sol, J., O.C. Sampimon, J.J. Snoep & Y.H. Schukken. Factors associated with bacteriological cure after dry cow treatment of subclinical Staphylococcus mastitis. J Dairy Sci, 77: 75-79.

Svensk Mjölk, 2001. Djurhälsovård 2000/01 – Redogörelse För Husdjursorganisationens Djurhälsovård. Annual report of the LAI of the SDA. December 2001.

Swedish Medical Products Agency: Joint workshop on the use of anti-microbials in production animals in Sweden and Norway. Läkemedelsinformation, Supplement 1, May, 1998

Wilson, C.D. & M.S. Richards, 1980: A survey of mastitis in the British dairy herd. Vet. Rec. **106**, 431-435.

Wilson, D.J., H.H. Das, R.N. Gonzales & P.M. Sears, 1997: Association between management practices, dairy herd characteristics, and somatic cell count of bulk tank milk. JAVMA. **210,** 1499-1502.

Tine Norske Meierier, 1999. Årsrapport.