A SURVEY OF CURRENT PRACTICES IN THE DIAGNOSIS AND TREATMENT OF BOVINE MASTITIS IN AUSTRALIA

Seguya A.G¹, Mansell, P.D²* and Brightling, P².

ABSTRACT.

A survey was sent to bovine practitioners in Australia to document the current methods used in the diagnosis and treatment of bovine mastitis. Questionnaires were posted to 45 Australian veterinary practices whose profile had a substantial component of dairy work. Responses were received from 33 practices from six of the seven states in Australia. Respondents routinely collected a milk sample before treatment of cases. Treatment comprised of either intramammary or systemic antibiotics or a combination of both. Injection of oxytocin was commonly done. Practitioners regularly dispensed antibiotics to farmers for cases of mastitis that they did not attend and also advised stripping of infected quarters. Farmers are also advised to collect and store a milk sample before treatment of these cases. Fluid therapy and anti-inflammatory drugs were commonly used for peracute cases but treatment of subclinically infected cows during lactation was generally not recommended. Cows with a long history of high individual cow cell counts (ICCC), recurrent episodes of clinical mastitis or infection with insidious pathogens were recommended for culling.

Herd problems due to Streptococcus agalactiae were not commonly seen by the survey respondents. Management of affected herds consisted mainly of segregation of cases, correcting milking machine function and milking practice. Whole or partial herd ‘blitz’ treatment was not popular, the respondents preferring the treatment of clinical cases. The results of this survey indicate that there is a wide variety of practices currently in use and recommended by dairy practitioners in Australia and the majority of the methods and strategies were appropriate. Within this variety, it is important that the dairy industry is presented with consistent advice so mastitis

¹ Department of Veterinary Medicine, Makerere University, P.O Box 7062, Kampala, Uganda.
² Faculty of Veterinary Science, University of Melbourne, 250 Princes Highway Werribee, 3030 VIC, Australia.
* For correspondence
control programs in use continue to be based on sound scientific reasoning and evidence.

**INTRODUCTION**

Diagnosis and treatment of mastitis is very important, the disease being responsible for most losses to the dairy industry (Beck *et al.* 1992; Owens *et al.* 1997). Proper diagnosis and treatment of cases is important in the control of mastitis to ensure the speedy identification of the causative bacteria and their resistance patterns. Prompt treatment of these infections increases the probability of achieving a satisfactory resolution. Antibiotics continue to be a major tool in the therapy of bovine mastitis, the ideal antibiotic having the appropriate spectrum of activity against the causative organism. Such an antibiotic needs to be administered at the appropriate concentration, taking note of the drug withholding period to avoid the risk of residues in the milk. The extent of the inflammatory reaction caused by the infection needs to be assessed in order to select the most appropriate route of drug administration. In highly inflamed udders, the milk duct system is blocked by inflammatory products, leading to uneven distribution of locally administered antibiotics (Malmo 1992). In this case, the systemic route is more desirable. Ancillary measures such as periodic stripping and massage of the quarters, the administration of oxytocin and anti-inflammatory drugs, and both oral and intravenous electrolytes have been found to be of benefit in the treatment of mastitis in addition to antibiotic therapy (DeGraves and Anderson 1990; DuPreez 1988; Ekman *et al.* 1994; Erskine *et al.* 1993; Soback 1990; Ziv 1995).

Farmers obtain information on methods of control and therapy of mastitis from a variety of sources such as field extension personnel, milk factory personnel and publications, various other industry publications and their local veterinarian. The latter is usually a major source of advice on mastitis and the main source of information concerning diagnosis, treatment and control of the disease. There is, however, no published work that documents the nature of advice and mastitis treatment practices recommended or used by veterinarians in Australia. This is important to assess the state of knowledge of mastitis, the quality of information given
to the farmers and the methods used by the practitioners in the management of the disease. A survey of Australian dairy cattle practitioners was therefore undertaken to document current practice and recommendations given to farmers for the diagnosis and treatment of bovine mastitis in Australia.

MATERIALS AND METHODS

A questionnaire was designed to collect information regarding the attitudes, practices and recommendations by private veterinary practitioners relating to the diagnosis and treatment of bovine mastitis. Information was sought on their recommendations to farmers for cases of clinical mastitis to which they do not attend; their treatment methods for clinical cases; their handling of recurrent mastitis cases; treatment methods they use for cows with elevated somatic cell counts and their recommendations for dry cow therapy and handling of herd problems due to *S. agalactiae*.

A draft copy of the questionnaire was tested by members of the Victoria Mastitis Research Group to identify potential problems in design and wording. Respondents were asked to rate their responses to different mastitis diagnostic, treatment and control techniques on a scale of 1 (usually) to 5 (never) and, where appropriate, to provide additional comments to specific questions (see Appendix A). The final questionnaire and covering letter were mailed to forty-five dairy practices in six states of Australia at the end of February 1997 for reply by the end of March 1997. The participating practices were selected from major dairying regions in Australia. Individual practices were specifically selected on the basis of having a sizeable dairy component in their practice. They were requested to send back one collective response or different responses from individual veterinarians where they differed in their methods. A follow-up letter (Appendix B) was mailed to non-respondents in mid-April and the survey was closed at the end of May 1997. The data was entered and analysed using Epi-info (Dean *et al.* 1996) and SPSS (Anonymous 1995) statistical packages.
RESULTS

Respondents

Forty-three veterinarians from thirty-three practices responded to the questionnaire. This represents a practice response rate of 73%. Of the veterinarians that responded, 32 (74%) were from Victoria; 3 each (7%) from New South Wales and South Australia; 2 each (4%) from Queensland and Western Australia; and 1 (2%) from Tasmania. Multiple responses were received from five practices, all in Victoria, representing 15 veterinarians. The total number of dairy herds serviced by the respondents was 7,420 of 13,753 dairy herds (54%) registered in Australia (ADC 1997).

Clinical cases of mastitis

Cases not attended to by the veterinarian

Most respondents did not feel that it was necessary to visit all cases of mastitis reported to them except those showing systemic signs, or cases involving the whole or a larger part of the herd. Most practitioners were content to recommending and supplying antibiotics to farmers for treatment of clinical mastitis cases to which they do not attend. The supply, however, is restricted to established clients of their practices or, for those farmers who are not clients, after discussing the mastitis problem with the farmer. Benzathine cloxacinil, neomycin combinations and erythromycin were the common drugs supplied to the farmers. It was, however, recommended that farmers collect and store a milk sample from clinical cases before treatment, specifically from cows exhibiting systemic signs, those that have not responded to previous treatment and recurrent cases. The practitioners, however, were not unanimous regarding the supply of printed advisory materials to supplement verbal advice and instructions given to farmers for use of the supplied drugs. About half of the respondents (22/42) said they supplied printed materials to their clients but in the majority of cases, this was periodical practice newsletters and only very few (4/22) provided instructions specific to the use of the drugs they supplied to the farmers. Ancillary measures such as the stripping of infected quarters, use of anti-inflammatory drugs and drying off of severely infected quarters were recommended in
addition to anti-microbial therapy. The practitioners were however equivocal about the administration of oxytocin and the massage and hot fomentation of affected udders was not commonly recommended. None of the practitioners recommended acupuncture techniques to farmers for the treatment of clinical mastitis.

Clinical cases attended to by the veterinarian

The majority of clinical cases of mastitis attended to by the veterinarians present as being peracute (median 40%, range 0-85%) or acute (median 30%, range 5-80%).
Table 1: Frequency with which ancillary treatments are recommended to farmers by veterinarians for the treatment of clinical mastitis.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Response to survey</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Always/Usually</td>
</tr>
<tr>
<td>Cases not attended by the veterinarian</td>
<td></td>
</tr>
<tr>
<td>Stripping of infected quarters</td>
<td>34</td>
</tr>
<tr>
<td>Injection of oxytocin</td>
<td>11</td>
</tr>
<tr>
<td>Massage of infected quarters</td>
<td>6</td>
</tr>
<tr>
<td>Acupuncture</td>
<td>0</td>
</tr>
<tr>
<td>Cases attended by the veterinarian</td>
<td></td>
</tr>
<tr>
<td>Stripping of infected quarters</td>
<td>39</td>
</tr>
<tr>
<td>Injection of oxytocin</td>
<td>19</td>
</tr>
<tr>
<td>Massage of infected quarters</td>
<td>10</td>
</tr>
<tr>
<td>Acupuncture</td>
<td>0</td>
</tr>
</tbody>
</table>
Recurrent cases, on the other hand, represent only a smaller portion of presented cases (median 10%, range 0-80%). The practitioners recommend the collection of milk samples before commencement of treatment if no treatment with antibiotics has been done within the last 7-10 days. Most submitted the samples to the laboratory immediately after collection and requested for the anti-microbial sensitivity testing among other tests. A significant number of practices, however, use in-house laboratories as opposed to commercial ones. The same antibiotics were preferred by the veterinarians as they supplied to the farmers for cases that they do not attend. For intramammary and systemic combination treatment, benzathine cloxacillin with erythromycin; lincomycin/neomycin (Lincocin Upjohn Pty Ltd) with erythromycin; and procaine penicillin/novobiocin with oxytetracycline were the preferred drugs.

**Peracute mastitis**

The practitioners recommended the administration of fluids and anti-inflammatory drugs to peracute mastitis cases. Electrolyte solutions (20/28), water (10/28) and a combination of either with sugars (e.g dextrose, glucose, glycerine) were the preferred fluids. For IV therapy, hypertonic saline is preferred (14/28) usually in combination with oral fluid therapy. Other IV fluids used include Electrolyte P54 (Parnell Laboratories Pty Ltd, Australia) (5/27), Hartman’s solution (3/27), isotonic saline (3/27) and unspecified home-mix solutions (3/27). The anti-inflammatory drugs preferred for the treatment of peracute mastitis included flunixin meglumine (32/36), phenylbutazone (9/36), ketoprofen (4/36) and dexamethazone (3/36). The combination of ramiferazone/phenylbutazone/dexamethazone/cincochaine (Dexatomanol®, Boehringer Ingelheim Pty Ltd) is preferred for cows of low economic value (2/36). Ancillary measures recommended for peracute cases included teat amputation (4/19) in gangrenous mastitis, antihistamines (2/19) in toxic mastitis and calcium salts (1/19) in recumbent cows.
Table 2: Frequency with which milk sampling procedures and diagnostic methods are used or recommended by veterinarians in cases of clinical mastitis.

<table>
<thead>
<tr>
<th>Method</th>
<th>Always/Usually</th>
<th>Sometimes</th>
<th>Rarely/Never</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sampling before treatment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinical cases treated by farmer</td>
<td>31</td>
<td>11</td>
<td>1</td>
<td>43</td>
</tr>
<tr>
<td>Clinical cases treated by veterinarian</td>
<td>19</td>
<td>15</td>
<td>9</td>
<td>43</td>
</tr>
<tr>
<td>Recurrent cases</td>
<td>23</td>
<td>15</td>
<td>4</td>
<td>42</td>
</tr>
<tr>
<td><strong>Sample submission to laboratory</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediately after collection</td>
<td>33</td>
<td>6</td>
<td>0</td>
<td>39</td>
</tr>
<tr>
<td>After treatment failure</td>
<td>5</td>
<td>12</td>
<td>16</td>
<td>33</td>
</tr>
<tr>
<td>After further cases occur</td>
<td>4</td>
<td>10</td>
<td>19</td>
<td>33</td>
</tr>
<tr>
<td><strong>Anti-microbial sensitivity test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinical cases</td>
<td>33</td>
<td>4</td>
<td>2</td>
<td>39</td>
</tr>
<tr>
<td>Recurrent cases</td>
<td>33</td>
<td>2</td>
<td>4</td>
<td>39</td>
</tr>
<tr>
<td><strong>Culture of samples</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-house laboratory</td>
<td>4</td>
<td>10</td>
<td>19</td>
<td>33</td>
</tr>
<tr>
<td>Commercial laboratory</td>
<td>4</td>
<td>10</td>
<td>19</td>
<td>33</td>
</tr>
</tbody>
</table>
**Recurrent mastitis**

Practitioners used the results of bacteriological culture and anti-microbial sensitivity tests, where available, to direct their treatment decisions (12/37). The recommended strategies for treatment of recurrent mastitis cases included: changing to other drugs or drug combinations after failure of initial treatment (17/37); changing to a combination of intramammary and systemic antibiotics (6/37); changing from intramammary to systemic antibiotics (4/37); and using the same antibiotic as in the previous treatment but at increased dosage and duration of treatment (4/37); drying off the affected quarters during lactation (1/37) and culling the cow depending on the infecting agent and the rate of recurrence of mastitis (3/37). Recurrent *S. aureus*, *Nocardia* spp., *C. pyogenes*, *Pseudomonas* spp., *Bacillus* spp. and fungal infections are generally recommended for culling as well as all cows that have had three or more cases of mastitis in a lactation; cows that have not responded to repeat treatments; old cows with repeat infections; low value cows that have had mastitis twice or more in a single lactation; cows with fibrosed and indurated udders; recurrent cases infected in multiple quarters; and cows with *S. aureus* that have had less than two weeks between episodes of mastitis.

**Subclinical mastitis**

Most practitioners (20/40) did not recommend treatment of high ICCC cows during lactation except in infection. They felt that all cows with elevated cell counts should be treated at the end of the lactation period and culling those that had a poor prognosis. For treatment of *S. agalactiae* cases erythromycin is preferred for systemic therapy and benzathine cloxacillin for the intramammary route (31/41). For milk sample collection, the practitioners recommended composite samples for herd investigation (24/38) and quarter samples for individual cow investigation (19/35).

**Dry cow therapy recommendations**

There was broad support amongst practitioners for DCT as a mastitis control strategy with both blanket and selective DCT used as the main strategies. The ICCC method was used for selection of cows for treatment in the selective DCT strategy. A threshold value of 250,000 cells/ml was used in the majority of cases though some practitioners specified a lower threshold for heifers. In addition to all cows that had
ICCC above the threshold, all cows that had had clinical mastitis in the current lactation were recommended for DCT irrespective of their cell count status.

**Recommendations for management of Streptococcus agalactiae herds**

*Streptococcus agalactiae* mastitis did not appear to be a major cause of subclinical mastitis in Australian herds. The majority of the practices had only handled up to 2 herds suspected of *S. agalactiae* infection in the current lactation. The most commonly used methods for detection of subclinically infected cows were ICCC data throughout lactation, ‘spot check’ ICCC and bacteriological culture. The majority of the respondents did treat clinical and subclinical cases of *S. agalactiae* during lactation but the decision was made on a case by case basis as opposed to treatment of the whole or part of the herd (total or partial ‘blitz’ therapy). Benzathine cloxacillin and procaine penicillin/novobiocin in combination were the drugs of choice for intramammary antibiotics whereas erythromycin and benzyl penicillin were preferred for systemic therapy. Segregation of infected cows from those that are not uninfected was widely recommended as a strategy to control the spread of infection within the herd. The testing of the functioning of the milking machine by a qualified technician was recommended to be part of the investigation of problem herds.

As a DCT strategy in herds suspected of *S. agalactiae* infection, the veterinarians recommended blanket therapy of non lactating cows. A few, however, were prepared to use the selective cow DCT, usually at a threshold of 250,000 cells/ml of milk to select cows for treatment. In this strategy, all cows that have had a clinical episode in the lactation were also recommended for treatment. selection of cows for DCT was not popular among the practitioners that were surveyed.
**Table 3:** Frequency of use of different treatments of peracute, recurrent and subclinical mastitis by veterinarians

<table>
<thead>
<tr>
<th>Method</th>
<th>Always/Usually</th>
<th>Sometimes</th>
<th>Rarely/Never</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peracute mastitis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral fluids</td>
<td>21</td>
<td>12</td>
<td>10</td>
<td>43</td>
</tr>
<tr>
<td>Intravenous fluids</td>
<td>14</td>
<td>13</td>
<td>15</td>
<td>42</td>
</tr>
<tr>
<td>Anti-inflammatory drugs</td>
<td>34</td>
<td>7</td>
<td>0</td>
<td>41</td>
</tr>
<tr>
<td>Massage of infected quarters</td>
<td>6</td>
<td>9</td>
<td>26</td>
<td>41</td>
</tr>
<tr>
<td>Acupuncture</td>
<td>0</td>
<td>0</td>
<td>41</td>
<td>41</td>
</tr>
<tr>
<td><strong>Recurrent mastitis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change treatment when no response</td>
<td>34</td>
<td>7</td>
<td>0</td>
<td>41</td>
</tr>
<tr>
<td>Repeat initial treatment</td>
<td>4</td>
<td>16</td>
<td>18</td>
<td>38</td>
</tr>
<tr>
<td>Do not re-treat</td>
<td>3</td>
<td>12</td>
<td>22</td>
<td>37</td>
</tr>
</tbody>
</table>
Table 4: Frequency of recommendation of dry cow therapy strategies by veterinarians

<table>
<thead>
<tr>
<th>Method</th>
<th>Always/Usually</th>
<th>Sometimes</th>
<th>Rarely/Never</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCT strategy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blanket therapy</td>
<td>30</td>
<td>8</td>
<td>4</td>
<td>42</td>
</tr>
<tr>
<td>Selective cow DCT</td>
<td>26</td>
<td>10</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>Selective quarter DCT</td>
<td>0</td>
<td>0</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>No DCT</td>
<td>2</td>
<td>1</td>
<td>37</td>
<td>40</td>
</tr>
<tr>
<td>Selective cow DCT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High ICCC*</td>
<td>39</td>
<td>0</td>
<td>0</td>
<td>39</td>
</tr>
<tr>
<td>All clinical cases*</td>
<td>36</td>
<td>0</td>
<td>3</td>
<td>39</td>
</tr>
<tr>
<td>Indirect tests</td>
<td>4</td>
<td>1</td>
<td>29</td>
<td>34</td>
</tr>
</tbody>
</table>

* based on records for the entire lactation
Table 5: Frequency of diagnostic methods recommended by veterinarians for herds infected with *Streptococcus agalactiae*.

<table>
<thead>
<tr>
<th>Method</th>
<th>Always/Usually</th>
<th>Sometimes</th>
<th>Rarely/Never</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis of subclinical infections</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of ICCC*</td>
<td>31</td>
<td>2</td>
<td>2</td>
<td>35</td>
</tr>
<tr>
<td>‘Spot check’ ICCC</td>
<td>18</td>
<td>10</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>Bacteriological Culture</td>
<td>17</td>
<td>5</td>
<td>13</td>
<td>35</td>
</tr>
<tr>
<td>Rapid Mastitis Test</td>
<td>5</td>
<td>11</td>
<td>19</td>
<td>35</td>
</tr>
<tr>
<td>Electrical Conductivity Test</td>
<td>2</td>
<td>2</td>
<td>31</td>
<td>35</td>
</tr>
<tr>
<td>NAGase</td>
<td>0</td>
<td>1</td>
<td>34</td>
<td>35</td>
</tr>
</tbody>
</table>

* based on records for the entire lactation
DISCUSSION

Documentation of the methods and advice given to farmers by veterinarians for management of mastitis cases is very important, they being the farmer’s first point of contact. This information is lacking in Australian literature, but is important in monitoring the quality of such services and allows for identification of potential areas for improvement and possible research.

Since there was no comprehensive list of veterinary practices in Australia which service dairy clients, it was not possible to select the participating practices at random. However, the number of veterinary practices that have a substantial dairy clientele is not large, and the selection methods used are likely to have identified the majority of the relevant practices. The number of herds serviced by the respondents that were selected was 54% of all registered herds in Australia, indicating that the results of the survey are likely to be representative of the situation in the broader industry. The practice response rate to the survey of 73% was satisfactory but it was not feasible to determine the total number of veterinarians in the practices that responded to the survey. Since each practitioner was regarded as a response, it is possible that the responses in this survey are underestimated since some respondents were answering on behalf of a number of their colleagues. The failure to require respondents to specify the number of veterinarians covered by each returned survey is recognised as a weakness in the questionnaire design. While the majority of the responses were received from Victorian veterinary practices, this reflects the concentration of the dairy industry (and hence the dairy based veterinary practices) in this state.

Practitioners are prepared to recommend and supply drugs to farmers for cases of mastitis that they have not examined, given that attendance to all reported cases of mastitis is hard to justify economically. Restriction of the supply to established clients may be an attempt to avoid the possible misuse of antibiotics. For their clients, the practitioners already have information about the likely pathogens on the farms and perhaps the antibiotic resistance patterns from previous experience. They are also
likely to know the ability of the farmer to competently use the supplied antibiotics without veterinary supervision. It has been suggested that the veterinarian should collect information about the prevalent pathogens on the farm and formulate guidelines for treatment of cases before delegating the responsibility for the treatment of mastitis to other dairy personnel (Guterbock 1994). There was, however, reported misuse of antibiotics by some farmers in their bid to quickly solve the mastitis problems on their farms. It was felt that many farmers place more emphasis on the treatment of individual cases than on institution of wider control measures involving the whole herd. This calls into question the practice of supply of antibiotics ‘over the counter’ especially where the farmers are not provided with printed instructions on the use of the drugs as was the practice by a number of practitioners. The misuse of antibiotics may lead to

The collection and storage of a milk sample before commencement of treatment is widely recommended as a diagnostic ‘backup’, in agreement with current recommendations for the rational treatment of mastitis (DuPreez 1988; Hady et al. 1993; Ziv 1992). Farmers are encouraged to seek veterinary attendance in cases showing clinical signs, or if there is suspicion of the existence of a more extensive problem involving the whole or a substantial part of the herd. However, the veterinarians expressed concern over failure of farmers to contact them in such cases, often leading to inadequate or inappropriate treatment of mastitis. The main intramammary antibiotics supplied to farmers for treatment of clinical mastitis are benzathine cloxacillin and neomycin based combinations. Benzathine cloxacillin is a penicillin drug that combines resistance to penicillinase and stability in an acid environment. It is indicated in infections of the mammary gland by penicillinase-producing cocci (Einstein et al. 1994). Of the neomycin combinations, those that contain dihydrostreptomycin and novobiocin are the most commonly recommended and supplied. They have a wide spectrum of activity and high efficacy against β-lactamase producing *S. aureus* which is responsible for most of the chronic mastitis infections on farms. The use of this combination with anti-inflammatory drugs has been reported to produce an earlier return of the udder to normal function for both acute and chronic cases (Einstein et al. 1994). Erythromycin is preferred for systemic therapy - this drug having wide application against staphylococcal mastitis, especially
when used in combination with intramammary antibiotics (Einstein et al. 1994). It is preferred for the treatment of persistent udder infections caused by Gram-positive pathogens, due to its high passage from blood to the udder (DuPreez 1988). Although the popularity of some therapeutic drugs amongst the practitioners could be due to their pharmacokinetic properties and previous success during use of the products, their selection could also be influenced by other factors such as their marketing, the profit margin related to their sale or pressure from the farmers for supply of products with which they are already familiar.

In addition to the antimicrobial therapies, the respondents recommended ancillary treatments to farmers for treatment of clinical mastitis, mainly the stripping of infected quarters and administration of oxytocin. These two measures are reported to be beneficial in clearing the mammary gland of bacteria and toxins, thereby improving the distribution of intracisternally and systemically administered antibiotics (Malmo 1992; Ziv 1992). In peracute and acute mastitis, the distribution of drugs may be impaired by the obstructive effects of inflammatory materials in the udder. It is interesting to note that the use of alternative methods for treatment of mastitis such as acupuncture and homoeopathy is not generally supported by dairy practitioners in Australia.

**Clinical Cases Attended to by the Veterinarian**

Treatment of mastitis cases is usually instituted on the basis of a presumptive clinical diagnosis. Early institution of treatment in mastitis has been reported to increase the probability of attaining a satisfactory resolution (Milner et al. 1997). Veterinarians collect a milk sample before commencing treatment for culture in case of failure of the initial treatment. The results of subsequent testing are used to direct re-treatment of those cases that have not responded to the initial treatment, or those that have recurred. This is in line with current recommendations for treatment of mastitis (DuPreez 1988; Ziv 1992). It is appropriate that samples are not collected from cows that have been treated in the last 7-10 days, to allow ample time for the elimination of antibiotic from the udder. The presence of antibiotic in samples collected for
bacteriological culture inhibits the subsequent growth of pathogens in vitro and increases likelihood of failing to isolate pathogens from infected cows.

The survey showed that there is a significant number of practices that have established in-house laboratories to process their bacteriological samples. The recent closure of government supported regional veterinary laboratories has left many practices with relatively poor access to diagnostic laboratory services. The practices that have set up their own laboratories reported an improvement in the time that the test results were available to them. Though a number of practices now have ready access to bacteriological methods of diagnosis of mastitis, many expressed the need for a simple, cheaper and preferably cow-side test for detection of mastitis. This, they felt, would reduce the cost and the time taken to get results and further reduce the time lag between examination of the cases and the establishment of an aetiological diagnosis.

The value of antibiotic sensitivity testing is recognised for all types of mastitis, with the respondents routinely requesting the test on samples they submit to the laboratory. The test is useful in the selection of the appropriate antibiotic and, when done over a period of time, gives an antibiotic resistance pattern for a particular herd which is useful in making treatment decisions (Ziv 1992). Sensitivity testing results are most useful in those pathogens that show variable susceptibility to antibacterial agents between locations [Radostits, 1994 #2]. They have been reported to give a good indication of the outcome of therapy of newly acquired *S. aureus*, *S. uberis*, *S. agalactiae* and *S. dysgalactiae* infections but not in chronic *S. aureus* cases [Owens, 1997 #90]. The latter view was also expressed by a number of the practitioners that reported poor response of cows to treatment after antimicrobial sensitivity testing. The possible reason given for this situation is that the interpretative guidelines for these tests are set using the pharmacokinetic properties of the drugs in man, using standard media and conditions. These are different from the ones found in animals and milk as a medium in which the antibiotics operate during treatment. To address this, efforts are underway to establish performance standards and interpretative guidelines for antimicrobial susceptibility testing of veterinary pathogens in a bid to improve the validity of the tests [Radostitis, 1994 #2; Owens, 1997 #90].
Interpretative criteria for antimicrobial susceptibility testing of a penicillin and novobiocin combination for the treatment of mastitis have been suggested (Thornsberry et al. 1997).

Drug selection for the treatment of clinical cases by respondents to the survey differs in range of products from that which they recommend to farmers. In addition to benzathine cloxacillin and neomycin-based products, oxytetracycline, ampicillin and lincomycin combinations are also frequently used. While most antibiotics are used within the dosage recommendations of the manufacturers, others are not. Notable among these are procaine penicillin/novobiocin (Mastop, Upjohn Pty Ltd) which is used consistently at three repeats instead of two and neomycin/dihydrostreptomycin/novobiocin (Special Formula 17900 Forte V, Upjohn Pty Ltd) which is also used at three repeats routinely whereas the manufacturers recommend this strategy only as an exception (Alexander 1997). Of the systemic antibiotics, erythromycin is consistently used at higher dosages than recommended - a doubling of the dose on the first day of treatment, use of a higher dose for the entire duration of the treatment and use of a longer than recommended duration of treatment being the main causes. The label dose and duration of treatment given by drug manufacturers in large animals are sometimes inadequate, and it is a common strategy for practitioners to increase them [Radostitis, 1994 #2]. However, where it is necessary to exceed the label dose and dose intervals, the problem of tissue and milk residues should be recognised and the drug withdrawal period adjusted accordingly [Radostitis, 1994 #2; Ziv, 1992 #158]. The responsibility of advising the new withdrawal period is on the practitioner and it is important to recognise that the new withdrawal period cannot simply be extrapolated from the label dose [Radostitis, 1994 #2]. From the findings of this survey, the majority of practitioners do not advise an adjustment of the withdrawal period to reflect the extra-label use of some antibiotics. The dangers of the use of an incorrect withdrawal period are mainly related to public health, economic and aesthetic concerns. The former involves possible health issues such as allergies to the antibiotic residues and development of antibiotic resistance due to ingestion of small quantities of the residue antibiotics by consumers [Radostitis, 1994 #2]. Economic losses are a result of downgrading of manufacturing milk due to the effect of the antibiotics on the starter cultures. Aesthetic concerns are
due to the increasing demand of the consumers for animal products that are free of antibiotic residues. The withdrawal and withholding periods differ with the dose of the drug given and the dose interval. Other factors that affect the length of these periods include the age of the animal and its state of health. These factors alter the physiology of individual animals in different ways and this will have an effect on the pharmacokinetic properties of the drugs. Some drugs such as aminoglycosides are also deposited in tissues after prolonged treatment and are released slowly for sometime after cessation of treatment. These factors make it difficult to estimate the appropriate withdrawal or withholding period for milk or meat after extra-label use of a drug. In the USA, the Food and Residue Avoidance Database offers assistance to veterinarians trying to determine the appropriate withholding or withdrawal periods after extra-label drug use (Sundlof et al. 1991). Such a service is helpful to assist veterinarians avoid estimations that may not be suitable. A number of cow-side tests for antibiotic residues are also available and these may be the short-term solution for veterinarians and farmers to avoid penalties and dangers associated with antibiotic residues in the milk (Jones and Seymour 1988; Sischo and Burns 1993). These, however, are not widely accessible in Australia.

Both intramammary and systemic routes are used for the treatment of clinical mastitis cases. Intramammary infusion is the most widely used route (DuPreez 1988; Hady et al. 1993; Malmo 1992) due to the ease of application of the tubes and the low cost of treatment. In cases of peracute mastitis, the treatment by this route is unsatisfactory due to the obstruction of the mammary ducts by inflammatory materials. The route is also not appropriate for treatment of tissue invasive and chronic staphylococcal infections (DuPreez 1988). Using a combination of intramammary and systemic therapy has been proposed as a solution to these shortcomings (Hady et al. 1993; Malmo 1992; Ziv 1980; Ziv 1992). The use of a combination of procaine penicillin/novobiocin and oxytetracycline by some practitioners in the present study, however, is a concern as it is contraindicated due to the potential for antagonism (Einstein et al. 1994).

The ancillary treatments used by the respondents for treatment of clinical mastitis are consistent with those they recommend to their clients. Stripping of the infected
quarters and administration of oxytocin are widely used. In peracute mastitis, the practitioners use fluid replacement therapy and anti-inflammatory drugs to complement antimicrobial therapy. These measures have also been recommended in reviews on the treatment of acute clinical mastitis (Erskine et al. 1991; Jones and Ward 1990). Oral fluid replacement therapy is used by a number of veterinarians, despite the view of some authors that it is not effective in the treatment of acute mastitis. These authors cite the impairment of absorption from the gut in cases of endotoxic shock as a drawback of using the oral route for fluid therapy (Erskine et al. 1993). However, where there is no cause to suspect impairment of alimentary function, the oral route offers a lot of advantages for fluid replacement therapy. There are no stringent requirements of sterility required of the parental routes and the selective absorption in the intestines means that there are fewer restrictions on the composition of the fluids. Large volumes of homemade solutions can be constituted at a fraction of the cost of the commercial preparations, and can be given cheaply and safely, in cases showing dehydration (Michell et al. 1989). In addition to the oral route, the intravenous route is also widely used in cases exhibiting shock. The route is reported to be the most suitable for these cases since the fluids are administered directly into the circulation (Michell et al. 1989). The preference of hypertonic saline for this route is likely to be related to economic and practical rather than clinical considerations. No advantage of using hypertonic over isotonic saline in clinical terms has been reported (Tyler et al. 1994). Its use, however, avoids the use of large volumes of isotonic solutions in what are often difficult farm settings. Caution needs to be taken during the use of the fluids as some cows, especially those with impaired renal function, run the risk of sodium ion toxicosis (Erskine et al. 1993).

In addition to fluid therapy, the administration of anti-inflammatory drugs is widely used by veterinarians during the treatment of peracute mastitis for the relief of clinical signs. Flunixin meglumine is the drug of choice, probably due to its high potency and the good results in peracute cases (Einstein et al. 1994). Dexa-tomanol (Boehringer Ingelheim, Pty Ltd) is used by a few practitioners in cows of low economic value, despite not being registered for use in food producing animals in Australia. The low doses required to attain therapeutic action makes it useful for this purpose. The use of anti-inflammatory drugs is reported to be useful in cases with endotoxic shock.
Some authors, however, have reported no significant difference in clinical and production aspects of the treated cows, after using the drugs (Dascanio et al. 1995; Green et al. 1997). Although the use of corticosteroids seems contraindicated due to their detrimental effect on the immune system, the positive effect of alleviation of clinical signs is equally, if not, more important. It is important to realise, however, that the corticosteroids would only be beneficial if given early before the clinical signs of endotoxic shock appear. Their effect is greatly reduced after the appearance of clinical signs and are unlikely to be of any clinical benefit at that stage (Ziv 1992). The use of unregistered drugs in food producing animals, in the absence of convincing evidence of a therapeutic benefit, is a cause of concern.

**Recurrent Mastitis Cases**

Practitioners do recommend institution of a second phase of treatment, different from the initial one, for cases of mastitis that have recurred. The selection of the treatment strategy is governed by the results of bacteriology and antimicrobial sensitivity testing, in line with current recommendations (DuPreez 1988; Hady et al. 1993; Malmo 1992; Ziv 1992). Recurrent cases of chronic *S. aureus, C. pyogenes, Nocardia spp.*, *Pseudomonas spp.*, *Bacillus spp.* and fungal mastitis are generally recommended for culling due to the difficulty of attaining a clinical or bacteriological cure in these cases. Their treatment, therefore, is not justifiable on clinical and economic grounds [Erskine, 1993 #336; Radostitis, 1994 #2]. The cows are a constant source of infection to their herd-mates and contribute to the high somatic cell counts in the milk. Hence, their removal from the herd is a logical management solution.

**Subclinical Cases with Elevated Individual Cow Cell Counts**

Most practitioners do not attempt to treat cows with elevated cell counts during lactation nor do they recommend that farmers treat these cows. The preferred strategy is to wait until the end of lactation and treat them with DCT. The treatment of cows with subclinical mastitis during the lactation is characterised by poor response especially in infections caused by *S. aureus* (Radostits et al. 1994a; Shephard 1997). The loss of earnings due to the discarding of milk that follows treatment outweighs
any clinical benefits (Kirk et al. 1994). Some veterinarians, however, do attempt
treatment of these cows, sometimes due to pressure from the farmers. Erythromycin is
the antibiotic routinely chosen for systemic therapy and benzathine cloxacillin for the
intramammary route under these circumstances. The systemic route is preferred to the
intramammary route in an attempt to reduce the risk of introducing new infections.
This is of special relevance when large numbers of animals are to be tested
simultaneously - a situation where the use of intramammary preparations may be
logistically difficult and may lead to failure to maintain adequately hygienic
administration. Treatment follows collection of a milk sample with both composite
and quarter samples collected for this purpose. Composite samples are preferred for
herd investigations and quarter samples for investigations of individual cows. Cows
with high ICCC which have had elevated cell counts in two consecutive lactations
despite DCT; old cows with *S. aureus* infection; and cows producing below capacity
or with fertility problems are recommended for culling. The chance of success in
treatment of these cows is low and culling is often the most rational approach
[Radostitis, 1994 #2].

**DRY COW THERAPY RECOMMENDATIONS**

Veterinarians recognise DCT as an important method of treatment for non-lactating
cows. Blanket and selective cow DCT strategies are recommended or used for this
purpose. Apart from knowing that the two strategies are widely used by veterinarians,
due to a weakness in the questionnaire design, it was not possible to ascertain from
the responses to the current survey, the circumstances under which the veterinarians
would chose one strategy over the other. However, it was mentioned by a number of
practitioners that they do not use the selective cow DCT strategy in herds suspected of
*S. agalactiae*. In these herds, the blanket DCT strategy is recommended due to the
highly contagious nature of the pathogen and the serious consequences of failing to
detect an infected cow. This pathogen has been associated with very high cell counts.
Milk with high cell counts is downgraded by the milk factories, leading to reduced
farm receipts. A selective quarter DCT strategy is not recommended for use in
infections by any of the practitioners, the strategy reported to increase the rate of new
infections in the dry period and the following lactation (Browning *et al*. 1994). For
selective cow DCT, veterinarians generally follow the current recommendations in Australia. A threshold value of 250,000 cells/ml of milk is used and has been found to be the optimum value in most Australian dairy farms (Victoria Mastitis Research Group 1992). However, the authors of that study have recommended changes to this threshold depending on the prevalence of infection and the relative cost of misdiagnosis. A decision surface for selection of the optimum threshold was also provided. Some practitioners preferred to use a lower threshold for heifers than for adults. This is because heifers have not been as exposed to the mastitis pathogens as the adult cows. A lower threshold is therefore used to pick as many of the infected heifers as possible in order to remove a possible reservoir of infection. Heifers are thought to be infected through sucking each other after ingestion of infected milk as calves [Radostitis, 1994 #2]. Other mechanical methods such as flies may also be responsible for spread of infection to the heifers (Nickerson et al. 1995).

The use of indirect tests as an alternative method of selection of animals for DCT is not recommended by practitioners, a finding likely to be related to economic considerations. The ICCC test is already available at a small cost as part of the cow production testing service provided by the herd improvement cooperatives. The veterinarians are happy to recommend this since it is backed up by a reliable recording service and information on the results of the test and other production information can be easily retrieved from the one source.

**HANDLING OF **Streptococcus agalactiae** **HERDS

The prevalence of *S. agalactiae* problem herds appears to be low, the majority of the practitioners having been involved with less than two herds in the current lactation. Cell counting is the popularly used method for detection of subclinical infections and the other indirect tests are not used to any great extent. The majority of the practitioners use a threshold of 250,000 cells/ml for selecting infected cows. None, however, volunteered whether they used the same or a different threshold for heifers. Bacteriological culture is widely used, the test being particularly useful in *S. agalactiae* infections due to the high shedding of bacteria by the infected cows [Radostitis, 1994 #2].
As part of their investigation of problem herds, practitioners recommend looking further than the infected cows to include the environment and the milking equipment. Observation of the milking process and recommendation of the testing of milking equipment by qualified personnel is an attempt to investigate all the likely factors that may be involved in a mastitis problem. *S. agalactiae* is an obligate inhabitant of the mammary gland and transmission is mainly by contact. Milking machines do play an important role in the epidemiology of *S. agalactiae* infections by physically transporting the bacteria between quarters and cows during milking. Faulty machines also cause teat end damage through an improper vacuum, faulty pulsation, wrong liner length, or over-milking and this compromises the udder against invasion by the pathogens. Milk impacts on the teat canal due to a faulty vacuum, causing infected milk to penetrate the teat canal, is another method thought to be important for the transmission of the pathogens (Joe 1992). For these reasons, the milking equipment should be well serviced and in proper working condition. The lack of proper milking machine maintenance by the farmers, and the lack of qualified milking machine technicians to repair problematic milking machines, are problems that were cited by the respondents.

Scrutiny of the milking process is intended to evaluate the standard of hygiene during and after milking: the state of the milking parlour; the cleanliness of the udders before the milking process; and the technique used by the milking staff during milking. This is the recommended procedure in the investigation of the role of the environment and the human factor in causation of mastitis [Radostitis, 1994 #2]. *S. agalactiae* is known to be transmitted in unhygienic conditions such as on the milker’s hands, udder cloths and bedding. Sucking between calves after exposure to the pathogen is thought to be the source of infection in heifers that have never been milked. A number of veterinarians felt that hygiene at milking and post milking was a major problem on many farms, especially where *S. agalactiae* was prevalent. It was also felt that there was a need to increase the education of the milking staff about proper milking management and urge farmers to make recommended changes in good time. However, the practitioners felt that the changes, when they are recommended, are usually not implemented quickly enough to arrest the situation. Most attributed this to
the high cost of instituting or changing existing milk management processes and sometimes the reluctance of the farmers to spend money on implementing these changes. Another limitation is that some of the farms are managed by ‘share farmers’ that are actually in a management contract with the owners of the farms. All infrastructure changes on the farm are the responsibility of the owner and sometimes they are not willing to finance the proposed changes.

The treatment of clinical and subclinical *S. agalactiae* mastitis during lactation is highly recommended. The practitioners, however, were not unanimous about the appropriate treatment strategies. While a significant number preferred ‘blitz’ therapy as a strategy for cases, the majority did not use the strategy. It was not possible to discern from the responses whether those veterinarians that used ‘blitz’ therapy did so in clinical, subclinical cases or in both cases and in what circumstances they used the strategy. ‘Blitz’ therapy has been reported to be beneficial in herds with a high prevalence of infection (Erskine and Eberhart 1990) but is unlikely to be of any economic benefit in herds with low prevalence of infection. In the latter situation, a strategy of treating only the cows identified as being infected is a more rational approach to the management of *S. agalactiae* infections [Keefe, 1997 #396; Radostitis, 1994 #2; Yamagata, 1987 #175].

There was no difference in the antibiotics preferred for treatment of subclinical cases of *S. agalactiae* from those used by the practitioners for other types of mastitis. Benzathine cloxacillin and penicillin/novobiocin combinations are the main drugs used for intramammary treatment and erythromycin or benzylpenicillin are preferred for systemic therapy. For DCT strategy, the majority of the respondents prefer blanket therapy ahead of the selective cow DCT strategy and selective quarter DCT. This is to ensure that all infected animals are treated considering the highly contagious nature of the pathogen and the massive increases in milk somatic cell counts that it causes.

CONCLUSION

In general the advice and recommendations that the veterinarians give to the farmers are consistent with current state of knowledge and recommendations for management
of mastitis cases. The major limitations to the control of mastitis mentioned by the veterinarians included the lack of farmer education on mastitis, poor response in treated cases and poor availability of laboratory testing services. Most farmers were said not to understand ICCC, proper use and limitations of antibiotics, proper hygiene at milking and the need for maintenance of milking machines. Treatment of individual cases is placed ahead of control by many farmers and some are unwilling to spend money towards the recommendations given by the veterinarians. The practitioners also mentioned the poor response of the pathogens to antibiotics even after antimicrobial sensitivity testing as a major limitation. They wanted more information about determination of a new withholding period following extra-label use of the antibiotics. Some were also concerned about the use of drugs that are not registered for treatment of food animals, especially the anti-inflammatory drugs. Poor availability of laboratory testing services and proper interpretation and use of antimicrobial sensitivity testing results were other limitations to the control of mastitis that were mentioned.

In light of the comments that there was a problem of farmers misusing antibiotics, guidelines need to be put in place to outline the circumstances and type of clients to whom antibiotics are to be supplied for use in the absence of veterinary supervision. It was noted that the majority of the practitioners do not routinely supply advisory materials to supplement the verbal advise they give farmers for cases of clinical mastitis to which they do not attend. This is likely to be a contributing factor to the problem of misuse of antibiotics by the farmers. Since farmers are not familiar with the pharmacokinetic aspects of the drugs and sometimes the person that is given verbal advice is not actually the one that treats the cows, it is imperative to provide not only printed advisory materials that can be consulted, but also to offer training to the farmers and other dairy personnel about the use of the drugs supplied.

Further research is also needed to investigate the benefits of some mastitis treatments that remain controversial. Principal among these is the use of anti-inflammatory drugs in the treatment of peracute mastitis. The benefit of using corticosteroids in mastitis treatment needs to be investigated since they are known to have detrimental effects on the humoral and cellular defence mechanisms. The benefits of using NSAIDs in the
treatment of mastitis also needs to be investigated as their effect of inhibiting the inflammatory process may not always be beneficial as it curtails the host defence mechanisms. The benefits of using combinations of drugs for treatment of mastitis also needs to be investigated to weigh such benefits against strategies that aim to reduce antibiotic use for the treatment of mastitis.

The formulation of guidelines or provision of a database or other support service that the veterinarians can consult to determine a new withdrawal or withholding period following extra-label antibiotic use also needs to be addressed. Although data is not available to show to what extent the use of an improper withholding period following extra-label is responsible for antibiotic violation in the milk in Australia, this area is recognised elsewhere as an important source of antibiotic violation in the milk. The responsibility for formulating a new withdrawal period is wholly on the veterinarians and apart from the legal and public health implications that it carries, it is an area that contributes substantially to the losses on the farm.


