Pain and Stress in Cattle: A Personal Perspective

Bomzon, A.

Consulvet, Haifa, Israel

Correspondence: Dr. Arieh Bomzon, Apartment 5, 48 Hantke Street, Haifa, Israel 34608, Tel: 972 4 8110904, Fax: 972 4 8344464, E-mail: bomzon@consulvet.com

ABSTRACT

Recognition of pain and/or stress and their severity are difficult to determine in most animal species. The recognition of pain and/or stress and their severity are more challenging in cattle because cattle have evolved as a prey animal, and may mask behavioral signs of pain and/or stress so as not to display weakness to a potential predator. Despite the tremendous advances of pain control in companion animals over the past 20 years, bovine veterinarians and food-producing farmers have been slow in responding to the demands of animal welfare groups and consumers to provide pain relief and stress management to the cattle that are under their care. Costs, efficiency, food safety, and training are some of the issues that have been proposed to underlie the slow response of bovine veterinarians to provide pain relief and stress management to the cattle that are under their care. This article describes (a) the current concepts of pain relief and/or stress management, and (b) a personal perspective for the slow adoption of these concepts by bovine veterinarians. This article concludes by suggesting possible strategies in order to improve the welfare of cattle by adopting, amending, and expanding the existing strategies for managing pain and/or stress that are used in companion animals.

Keywords: pain, stress, distress, analgesia, cattle

INTRODUCTION

Pain control in companion animals has evolved enormously in the past 20 years in companion animals with the development of new modalities of pain control and introduction of new analgesic drugs. Over the same 20-year period, awareness on the welfare of cattle and other food producing animals and the need to prevent or treat pain and stress due to routine husbandry procedures, such as castration and dehorning, have increased as a result of consumer interest and animal activism. Despite this increased awareness and need, bovine veterinarians and farmers have been slow in responding to the demands of animal welfare groups and consumers to provide pain relief and stress management to the cattle that are under their care.

Animal welfare issues in food production are now being driven by animal activists, food companies, and consumers. Consequently, animal welfare assurance programs have been developed, and are encoded in non-mandatory codes or guidelines, government regulations, inter-governmental agreements, and corporate programs (1). For example, McDonalds has developed a set of 'Animal Welfare Guiding Principles' which includes a statement that animals should be free from cruelty, abuse, and neglect while embracing the proper treatment of animals and addressing animal welfare issues.

In the light of this background, this article describes the current concepts of pain relief and stress management, and presents some reasons that possibly underlie the slow adoption of these concepts by bovine veterinarians. Using these reasons as a platform, this article concludes by proposing possible strategies to improve the welfare of cattle by adopting, amending, and expanding the existing strategies for managing pain and/or stress that are used in companion animals.

Definitions of Pain, Stress, Distress, and Suffering

Many veterinarians use the word "pain", "stress", "distress", and "suffering" interchangeably, although each word describes a different physiological state. Pain is a sensory process that results from tissue damage, and is intended to prevent further tissue damage following injury. The pain experience has two components: a sensory component and a motor component. Both components are reflected in the two widely accepted

definitions of pain which defines it as an unpleasant aversive sensory and emotional experience. This experience is associated with actual or potential tissue damage and elicits protective motor actions, results in learned avoidance, and may modify behavior (2,3). Pain can be categorized as being either normal and protective (adaptive) or abnormal and non-protective (maladaptive) (3) (Figure 1). Protective or adaptive pain increases the potential for survival by protecting the animal from injury and promoting healing, whereas non-protective or maladaptive pain is a disease in which pain persists long after its initiating causes have been removed (3).

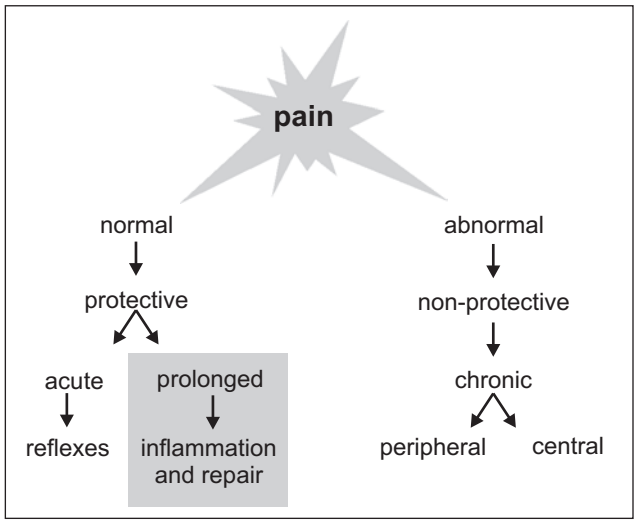

Figure 1: Pain that is considered "normal" has a protective function, whereas pain that is considered "abnormal" provides no protective function might. Reprinted with permission from "Definition of Pain and Distress and Reporting Requirements for Laboratory Animals, 2000 by the National Academy of Sciences, Courtesy of National Academies Press, Washington, DC, USA.

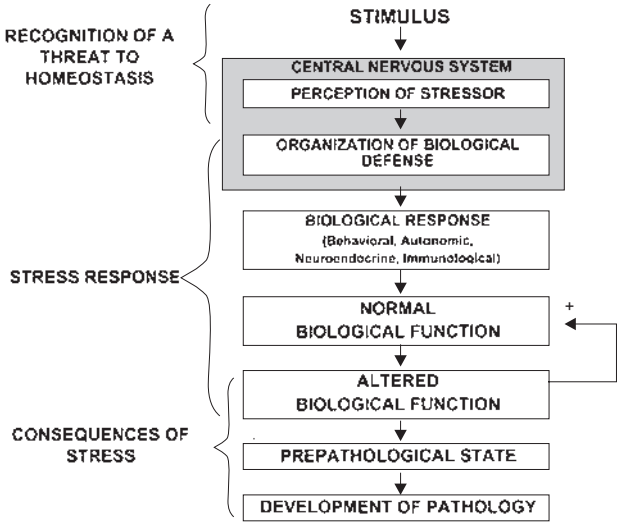

Figure 2: Model of the biologic response of animal to stress. Reprinted by permission from Macmillan Publishers Ltd: Lab Animal Moberg, GP. When Does Stress Become Distress? Lab Animal 28: 22-26, copyright © 1999.

Stress is an induced alteration in the biologic equilibrium due to external (environmental) or internal factors (2,4). Stress can be a real or perceived perturbation to an organism's homeostasis or psychological well-being. In the stress response, the animal uses behavioral and physiological mechanisms to counter the perturbation (Figure 2).

Events that precipitate stress (stressors) can elicit any of a number of coping mechanisms or adaptive changes that include behavioral reactions, activation of the sympathetic nervous and adrenal medulla, secretion of stress hormones, such as glucocorticoids and prolactin, and mobilization of the immune system (4) (Figure 3).

A good example of stress and the response to stress is surgery which has four post-operative or recovery phases. Phase 1 or the immediate response to the surgical injury is a phase of negative nitrogen balance where the animal loses weight, eats less food, and the sympathetic-adrenomedullary and hypothalamic-pituitary-adrenocortical systems are activated. Phase 2 is a "turning point" where the animal stops losing weight, the hyperactivity of the sympathetic adrenom-

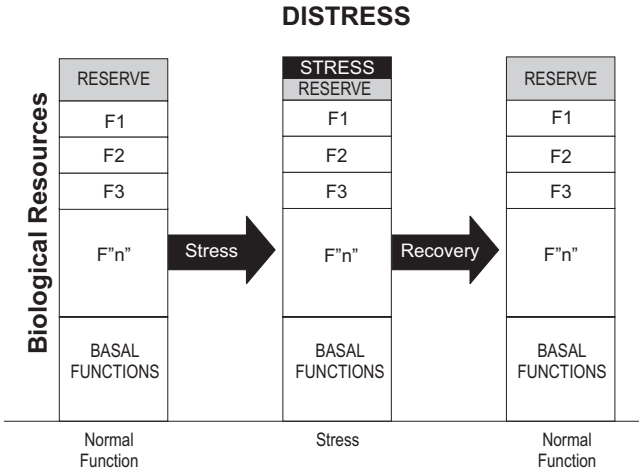

Figure 3: Hypothetical scheme of how stress diverts biologic resources during mild stress. In this scheme, biologic resources are arbitrarily assigned to various biologic functions (F1-F"n"). During mild stress, only reserve resources are used to cope with the stressor. The total stress response extends from the time biologic resources are diverted until the reserves have been replenished. Reprinted by permission from Macmillan Publishers Ltd: Lab Animal Moberg, GP. When Does Stress Become Distress? Lab Animal 28: 22-26, copyright © 1999.

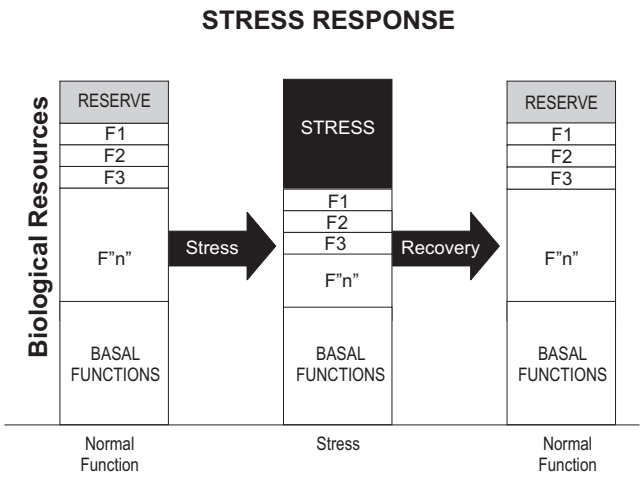

Figure 4: Hypothetical scheme of how biologic resources are diverted in a severely stressed or distressed animal. Many biological functions are significantly impaired in severe distress or distress, and when compared to mild stress (Figure 3), the biological cost of severe stress or distress requires a much longer recovery period. Reprinted by permission from Macmillan Publishers Ltd: Lab Animal *Moberg*, GP. When *Does Stress Become Distress?* Lab Animal 28: 22-26, copyright © 1999.

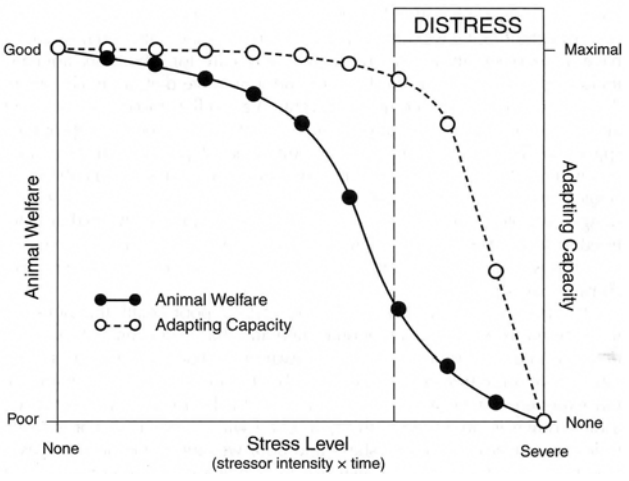

Figure 5: Hypothetical depiction of the relationship of stress, distress, adaptive capacity, and animal welfare. Reprinted with permission from "Recognition and Alleviation of Distress in Laboratory Animals, 2008 by the National Academy of Sciences, Courtesy of National Academies Press, Washington, DC, USA.

edullary system ceases, and the activity of the hypothalamic-pituitary-adrenocortical system begins to wane. Phase 3 is the phase where weight gain begins to occur and body weight returns to what it was prior to the surgery due to the animal moving into positive nitrogen balance. Phase 4 is the phase in which weight gain occurs due to the accumulation of protein and/or fat. In cattle and probably other food production species, the common causes of stress are husbandry practices: inappropriate cage/enclosure size, infrequent changes in bedding and waste removal, stale food and dirty water, social intimidation, abuse and unprofessional behavior by handlers who have poor and inappropriate handling techniques (bad stockmanship), frequent changes in procedures and staff, and social and maternal deprivation.

Distress has many definitions (2). It has been defined as an aversive, negative state in which coping and adaptation processes in response to stressors fail to return an organism to physiological and/or psychological homeostasis. Distress has also been defined as an aversive state in which an animal is unable to adapt completely to stressors, and can result in maladaptive behaviors or an aversive state that results from maladaption or inability to adapt to stressors. Another definition is that distress is a state in which an animal cannot escape from or adapt to the internal or external stressors or conditions that it is experiencing and results in negative effects on its well-being (Figure 4).

The transition from stress to distress depends on several factors: the type of stressor, the duration and intensity of the stress, and the capacity of an animal to respond to stress. Inherent in the transition from stress to distress is the impact on animal welfare, and this relationship is hypothetically described in Figure 5. An animal's quality of life may progressively deteriorate while it is successfully coping with a stressor. At some unknown moment, the animal switches from being able to cope to a distress or maladaptive state, and then rapidly deteriorates into a sick or debilitated animal (5).

Finally, suffering is a term that is frequently used with pain, stress, and distress. Suffering is the conscious endurance of pain and/or distress, or a negative emotional state that is produced by persistent pain and/or distress. Although evidence exists that some animal species can experience a negative emotional state, no such evidence and the measures of suffering have been presented for cattle.

The Recognition of Pain and Stress

There are two categories of pain in cattle: surgical pain and disease pain. As already noted, pain is a stressor, and elicits a stress response, and both pain and the response can potentially exert many negative effects on the animal. For cattle and other production animals, pain and stress evoke eco-

nomic concerns because they can decrease productivity. As mentioned in the Introduction, pain and stress in production animals are now important for consumers because of their growing interest in animal welfare. Therefore, the exact determination of the impact of pain and/or stress on production parameters is critical if pain and stress control and animal well-being are to have any relevance to livestock producers.

Confirming pain and/or stress in animals is difficult because of differences between and within species in the behavioral response to noxious stimuli. The presence of pain and stress in an animal is further complicated by the fact that normal behavior is not always indicative of a pain-free and/or stress-free state because the animal may show "normal" behavior as an inherent response to avoid predation. Recognizing pain and/or stress in cattle is a challenge because cattle have evolved as prey animals, and may mask behavioral signs of pain and/or stress in order not to display weakness to a potential predator (6). Consequently, pain and/or stress in cattle or any animal is often inferred from the absence of normal behaviors. The diagnosis or recognition of pain and/or stress is seldom made on the basis of a single observation or a laboratory value. Instead, the diagnosis is dependent on a combination of good examination skills, familiarity with the species, breed, and individual behavior. The diagnosis also depends upon knowledge of the degree of pain and/or stress that accompanies particular procedures and illnesses, and recognition of the signs of discomfort, pain, and stress.

Table 1: Primary signs of pain in cattle

Mobility	Avoidance or escape behavior Turning toward site of stimulus Restlessness, pacing Reluctance to move Kicking, stamping Rolling Limping
Behavior	Licking/biting at site of damage Vocalization Grunting Bruxism
Appearance	Dull and depressed Inappetance Weight loss Decreased milk yield
Clinical findings	Colic Tachycardia Tachypnea Elevated plasma cortisol levels

Causes of Pain and Strategies of Pain Management

The principal signs of pain in cattle are summarized in Table 1. These signs are general in that they are displayed by most animals and are not species-specific. As already mentioned, pain in cattle is difficult to recognize because cattle are the natural prey of several predators, and it is in their nature to disguise signs of pain. It is equally difficult to assess the severity of pain in cattle because the behavioral changes of an individual animal in response to pain are very subjective and can be influenced by differences in individual perception and interpretation. For example, escape behaviors that are seen during castration, but not seen afterwards, may reflect a specific acute pain or may be a behavioral response that is indicative of a desire to escape confinement.

Although pain management in cattle is the responsibility of the attending veterinarian, in practical terms, it is a partnership between the farmer/stockperson and the veterinarian. For all species, pain management is a combination of prompt effective treatment, provision of an environment in which the animal can recover, and the repeated administration of analgesic drugs until the cause of pain is no longer present. Current management of pain can be either pre-emptive (anticipated and prevented) or post-inductive (recognized and alleviated). Pre-emptive analgesia presumes that the pain will result from the procedure, and can be prevented by instituting non-pharmacological and pharmacological protocols prior to the induction of the pain-inducing procedure. Post-inductive analgesia is the administration of pain relief after pain has already been induced. Regardless of the strategy that is used to relieve pain, animals must be evaluated post-procedurally to ensure that any pain that was induced by the procedure has indeed been alleviated.

The treatment of pain in any animal should be tailored to the individual animal because biological and non-biological factors can influence the response to analgesics. For this purpose, one needs to consider the species, the breed and/or strain, the animal's age and sex, the health status of the animal, the type of procedure and its potential to cause tissue trauma and pain, and the availability of drugs and pain-relieving strategies. The selection of the most appropriate analgesic

drug or pain-relieving requires veterinary judgment so that the clinical and humane requirements of the individual animal are met. Therefore, the overall therapeutic approach to pain management is usually a combination of pharmacologic and non-pharmacologic approaches, where the selected analgesics and the pain-relieving strategy are designed to match the anticipated pain and its severity and duration. Using a pharmacological strategy as an example, this strategy should ideally include (a) the provision of analgesia as early as possible and preferably preemptively, (b) the use of more than one class of analgesic agent acting at different sites of action within the pain pathways (multimodal analgesia), and (c) be practical in terms of frequency and route of administration.

Given the difficulties in recognizing pain in cattle, why treat pain? According to Anil and colleagues (7), the legal requirements to use analgesics are few, and when legally required, the analgesics are approved only for some procedures, such as dehorning. This legislative vacuum appears to have been exploited by cattle veterinarians, who, like all veterinarians, have a moral obligation to treat pain in animals. This obligation is universal, and consistent with the principles of best veterinary practice. In the USA, new veterinary graduates are asked to state: "Being admitted to the profession of veterinary medicine, I solemnly swear to use my scientific knowledge and skills for the benefit of society through the protection of animal health, the relief of animal suffering, the conservation of animal resources, the promotion of public health, and the advancement of medical knowledge." This declaration is not much different from (a) the first of the ten guiding principles of the Royal College of Veterinary Surgeons, United Kingdom which states that veterinarians will make animal welfare their first consideration in seeking to provide the most appropriate attention for animals committed to their care, and (b) the European Code of Veterinary Ethics and Principles of Conduct where it is written that veterinarians shall endeavor to ensure the welfare and health of the animals under their care in whichever section of the veterinary profession they work.

Pain in cattle can be mild, and is frequently caused by common routine procedures, such as vaccinations, ear tagging, and hoof trimming. The causes of moderate to severe pain in cattle also include routine procedures (branding, castration, and dehorning), as well as lameness, obstetrical procedures, and abdominal complaints, such as bloat, intestinal obstructions, and volvulus. With the exception of chronic lameness, chronic pain can be difficult to recognize in cattle. When chronic pain is present, the stockman may notice decreased feed intake, and the animal may avoid the herd, appear dull and poorly groomed, and have a "hunched up" appearance with abdominal pain.

Unfortunately, the management of pain in cattle is still too rarely considered in bovine veterinary practice. The well-understood concepts of pre-emptive and multimodal analgesia that are now used in human medicine and companion animal practice are significantly underused in cattle practice. While no food producer or veterinarian would deliberately or consciously inflict pain on an animal, food producers and bovine veterinarians plan and organize routine tasks and treatments based on their convenience and need for efficiency. As a result, concerns about preventing or mitigating pain and stress in cattle are rarely discussed or made a priority. When analgesics are used, the duration of the analgesia is frequently shorter than would be ideal for reasons that will be outlined later in this article.

Several studies have surveyed the attitudes and perceptions of cattle practitioners and producers in New Zealand, Great Britain, Canada, and the USA to pain and the use of analgesic drugs in routine procedures in cattle (6;8-13). The results from these surveys are remarkably consistent: the response rates from bovine veterinarians were consistently low, and the induction of analgesia, be it from the administration of a local anesthetic prior to the procedure or a systemic analgesic after the procedure, is not widely practiced. While it is possible that only veterinarians who use analgesics were more willing to complete the questionnaires than those that don't use analgesics, these results highlight that pain management is not a priority for bovine practitioner. Accordingly, there is a need for bovine veterinarians and food producers to manage pain in cattle better than they do at present.

Several reasons could account for the low use of analgesics in cattle. According to Coetzee *et al.* (13), the lack of approved analgesic drugs for livestock in the USA is because no validated methods for pain assessment in cattle and other food-producing animals exist. In other words, approval for use of an analgesic drug in cattle requires evidence that the drug does indeed relieve pain. A second reason is cost. Huxley and Whay (11) reported that the cost of analgesic treatment is an issue for many cattle farmers. Accordingly, they proposed that bovine practitioners must be able to offer a variety of costed analgesic treatment protocols in or-

der to ensure that these farmers are able to make informed decisions about the treatment of the animals that are under their care. These issues were also showcased by Hewson *et al*.. (12) who noted that (a) more cost-effective analgesics, with shorter withdrawal periods, should be developed or made available for use in food animals in order to improve the feasibility of multimodal analgesia for veterinarians and producers, and (b) licenses should be granted more readily for the use of longer-acting analgesic drugs in young animals that are not going to be part of the human food supply until they are much older. A third reason is the effect of treatment on production, and it is not known whether the use of analgesics in these procedures improve production or prevent the potential loss in production. Using lameness in dairy cows as an example, it is a cause of lost production because it results in loss of body weight and condition, and reduced milk yield and fertility (14). As O'Callaghan notes in her article, it is not uncommon for a cow with chronic lameness to produce 30 liters of milk per day. This begs the question to which there seems to be no answer: "What could the same cow produce if she was not lame or treated for her lameness?" Another aspect of production is withdrawal times because of the need to consider the hazards of drug residues in human food. In dairy cattle, the withdrawal times after the administration of ketoprofen is 24 hours and for xylazine is 72 hours after the last treatment (15). Therefore, it is understandable why dairy farmers would be reluctant to remove a high milk-producing cow that was being treated with an analgesic from the production line.

Can one measure the effects of pain and pain management on production? At present, the answer to this difficult question is challenging because production parameters are often too imprecise to reflect the pain that is experienced by animals following a routine surgical procedure, such as dehorning or castration, which causes pain (16). In their review, Stafford and Mellor (16) give several examples on the use of weight gain to evaluate the effect of pain by dehorning or castration. They concluded that there is little firm and repeated evidence to show that the effect of these husbandry procedures on weight gain are due to pain *per se*, and that analgesic administration will influence the changes in body weight that occur after the procedures.

Treatment of Pain in Cattle

Pain can be treated pharmacologically and non-pharmacologically, and bovine veterinarians should consider combining pharmacological and non-pharmacological methods in order to achieve efficacious analgesia. Pharmacological treatment of pain relies on three classes of drugs: local anesthetic agents,

Table 2: Systemic analgesics used to alleviate pain in cattle according to Anderson and Muir (2005), Stafford *et al.* (2006), and Wren (2008). The frequencies of administration for each drug are not given and readers are asked to consult the cited article for this information.

		Anderson & Muir (2005)	Stafford, Chambers, and Mellor (2006)	Wren (2008)
Local Anesthetic Agents	lidocaine			
	mepivicaine			
	bupivicaine			
NSAIDS	ketoprofen	2 mg/kg IV	3 mg/kg IM or IV	3.3 mg/kg IV
	flunixin	1 mg/kg IV	2.2 mg/kg IV	1.2-2.2 mg/kg IV
	meloxicam		0.5 mg/kg IV or SC	
	phenylbutazone	5-10 mg/kg PO		
	aspirin	100 mg/kg PO	not recommended	100 mg/kg PO
Opioids	morphine	0.05-1 mg/kg	not recommended	0.05-0.1 mg/kg IV
	butorphanol	0.05 mg/kg SC		0.02-0.25 mg/kg IV
	buprenorphine	0.005 mg/kg*		
	meperidine	3.3-4.4 mg/kg		

Abbreviations: NSAIDS - non-inflammatory steroidal drugs; IV – intravenous; IM – intramuscular; SC – subcutaneous; PO – per os
*dose used in sheep and goats

non-steroidal anti-inflammatory drugs (NSAIDS), and opioids (Table 2).

Although there seems to be consistency in the recommended dosage of some of these drugs, one cannot help wondering whether the analgesia is efficacious because doses are related to body weight, and it may not be practical or possible to weigh an animal before initiating analgesic drug therapy. Local anesthesia is used to prevent pain by blocking specific nerves or infiltrating the surgical site. Of the local anesthetic agents, lidocaine is most commonly used agent for dehorning and castration, and often, a sympathomimetic drug, such as epinephrine, is added to the local anesthetic preparation in order to cause local vasoconstriction and prolong the duration of drug action. NSAIDS, such as ketoprofen, flunixin, and meloxicam have a long duration of action, and hence are useful for treating post-operative and chronic pain and any other situation where analgesia is required. Interestingly, no consensus exists on the use of aspirin and opiates, such as morphine and butorphanol in cattle (15, 17, 18). Stafford *et al*.. (18) do not recommend their use, whereas Anderson and Muir (17) and Wren (15) provide doses and the duration of the analgesic action in their reports. In addition to these recognized analgesics, the α2-adrenoceptor agonists, such as xylazine, detomidine, and medetomidine, are also advocated as analgesics. This class of drugs generally lack analgesic properties, and should not be relied on as sole sources of analgesia (19). Interestingly, they have been reported as providing good analgesia in sheep and goats (19). In the absence of evidence of analgesic efficacy in cattle, it is probably because of their known efficacy in these two other ruminant species that they are recommended for use as an analgesic in cattle (15,17,18). Nevertheless, they can be administered to decrease stress and anxiety, and enhance the efficacy of concurrently administered analgesics, even though they may not be efficacious analgesics in cattle.

The non-pharmacological methods for pain alleviation in cattle include (a) best veterinary practices, such as using small-bore needles and being proficient in the procedures in order to reduce or minimize the severity of procedural pain, (b) good husbandry practices, such as keeping injured and treated animals in clean, well-ventilated areas with causes of stress kept to the minimum, (c) nutritional support, (d) acupuncture, and (e) cautery. The latter method is interesting because third degree burns are less painful than first and second degree burns due to reduced pain input.

The Recognition and Treatment of Stress

Stress in cattle has not been studied to the same extent as pain. However, stress is also important to treat because it decreases the animal's resistance to infection and wound healing ability, and stress has unwanted effects on production in that they decrease weight gain and reproduction through an adverse effect on the reproductive hormones. Stress can be diagnosed by the presence of maladaptive behaviors and clinical laboratory measures, such as serum glucocorticoid, prolactin, and α-melanocyte stimulating hormone levels and various immunological parameters. The treatment of stress can be both pharmacological and non-pharmacological, and applying the five freedoms of animal welfare (20) should be the standard non-pharmacological methods for identifying, modifying, avoiding, and minimizing most causes of stress. Other non-pharmacological methods for minimizing stress would include choosing an age to conduct the procedure when stress responses are least, and a procedure which causes the least stress. Additional strategies to avoid, minimize, and alleviating distress include good stockmanship and animal husbandry, and suitable housing with environmental enrichment and socialization, if appropriate.

The pharmacological treatments include the α2-adrenoceptor agonists, anxiolytics (benzodiazepines), antidepressants (the monoamine oxidase inhibitors, the tricyclic and tetracyclic antidepressants, and the selective serotonin reuptake inhibitors), tranquilizers (chlorpromazine and acepromazine), and antipsychotics (dopamine receptor antagonists, such as haloperidol). Some of these drugs can be administered in conjunction with analgesics to enhance their efficacy, and even induce surgical anesthesia (19). Similar to the management of pain, the management of stress can also pre-emptive or post-inductive, and the most common pre-emptive management of stress is the administration of α2-adrenoceptor agonists and tranquilizers. While pharmacological information on the efficacious doses of the α2-adrenoceptor agonists and most tranquilizers are known for companion animals (15,17,18), information on dosage, efficacy, and the pharmacokinetics of the anxiolytics, the various types of antidepressants, and antipsychotics are not known or reported in cattle and other species. Hence, obtaining this information in order to establish efficacious doses of these drugs would be required before their routine clinical use.

Future Perspectives on Pain and Stress Management in Cattle

Anil and colleagues (7) identified several goals for improving the existing farm-level strategies for pain alleviation: pain identification by veterinarians and the producer, increased availability and use of analgesics in food-producing animals, and a costed analysis of the benefits of using analgesics in the course of food production. They also added that scientific knowledge, ethics, regulations, and technology must be amalgamated to find a satisfactory solution for pain and stress in cattle. Unfortunately, Anil and colleagues did not consider stress and its treatment, and the impact and cost of stress on the animals in their analysis. Since knowledge on pain and stress in cattle and other production animals has been and is still a constraint, any future solution must rely on the results of research on pain and pain-related issues, as well as stress and stress-related issues. Bovine veterinarians need to recognize that consumer and trading pressures are powerful societal drivers that are encouraging the use of pharmacological and non-pharmacological methods for managing pain and stress in cattle and other food-producing animals. Accordingly, bovine veterinarians should be advocating the use of analgesics, sedatives, tranquilizers, anxiolytics, and antidepressants, as well as encouraging the use of non-pharmacological methods in pain and stress management because they are ethically obliged to prevent unnecessary and unreasonable pain and stress. To advocate the increased use of these drugs, bovine veterinarians and veterinary scientists need to establish reliable methods for evaluating and treating pain and stress in cattle. At the same time, bovine veterinarians need to recognize the existence of the dilemma between consumer protection from food residues, the cost of these drugs on production, and the legal limitations on who may use such drugs.

Achieving a balance between the pressures that encourage the use of veterinary and husbandry practices that will improve the welfare of cattle and the forces that slow the adoption of these practices requires investment in at least four areas. The first area involves determining the pain and stress experiences of cattle in the course of food production, and should encompass the establishment of validated criteria for assessing pain and stress and their severity or intensity. The second area is practical, and relates to (a) improving bovine veterinarian's existing knowledge on the pharmacology of analgesic agents that are in current use, (b) exploring the use in cattle and other animal species of currently available drugs to treat stress in human medicine and companion animals, and (c) developing new analgesic and anti-stress drugs that are suitable for use in cattle and other production animals so that the public concerns on animal welfare and food safety are fulfilled. The first of these three areas can be met by providing continuing education to active bovine veterinarians. All three areas can be met, for example, by studying the effects of dehorning and castration on pain and/or stress, and then using the findings to evaluate the efficacy of existing and new analgesic and anti-stress drugs.

The fourth area is education and training. The results of research on pain, stress, and welfare in cattle and other food-producing animals must be integrated into veterinary curriculum. This integration must also be accompanied by improved knowledge on the pharmacology of analgesic and anti-stress drugs so that newly-graduated veterinarians can appreciate that pain and stress relief are distinct from each other, and should be treated differently. This seems to have been done to some extent in the curricula of veterinary faculties in the United Kingdom and Norway. Huxley and Whay (6) reported that more recent graduates in the United Kingdom tended to give a higher pain scores for most conditions in cattle than older graduates. In their survey of 300 veterinary students in Norway on their attitudes to pain in cattle, Kielland *et al.* (21) reported that their year of enrollment determined the pain score for a range of conditions: students who enrolled in 2002 tended to have lower scores than students who enrolled in 2005. Interestingly, the results from both studies also revealed a sex-bias because women gave higher pain scores in cattle than men. The finding that young female veterinarians were more in favor of the use of analgesics and more concerned about the possible negative effects upon cattle of experiencing pain than old male veterinarians was recently confirmed by Thomsen *et al.* in their very survey of Scandinavian bovine veterinarians' attitudes to the use of analgesics in cattle (22). In view of this finding, one could then argue that the management of pain and/or stress in cattle would improve dramatically if more women became bovine veterinarians because bovine veterinary practice is a male-dominated sector of the veterinary profession.

CONCLUSIONS

Although cattle are stoic creatures, bovine veterinarians should be concerned about the level of pain and/or stress that cattle experience and endure from "routine" treatments, and especially the pain and stress that they experience from "non-routine" treatments, such as surgery. While the evidence is still not compelling or even convincing, paying close attention to animal comfort does improve animal performance and increases profitability. Therefore, recognizing the benefits of pain and stress management is the next step forward, and should become a part of the culture of bovine veterinary practice. For this to happen, there is an urgent need to disseminate up-to-date knowledge to ensure that pain and stress treatment in cattle is efficacious. Another big step toward achieving this sea change in culture is to consider the animal, and this will involve taking conscious steps to reduce pain and stress in cattle by organizing routine tasks for their benefit.

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