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Pain Detection and Amelioration in Animals on the Farm: Issues and Options

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Pain in nonhuman animals is a difficult concept to identify and measure. This article briefly describes the consequences of pain in animals on the farm and explains the reasons for the minimal use of analgesics in farmed animals. Pain can have implications for both animal welfare and economics. The reasons for a low use of analgesics in farmed animals include the lack of recognition of animal pain owing to the apparent lack of anthropomorphically identifiable behavioral changes, concern over human food safety, and lack of research efforts to develop safe analgesics for farm use. Treatment cost relative to the benefits expected is another hindering factor. Interventions to minimize pain must begin with developing objective and practical measures for pain identification and measurement at the farm level. A suggested use of a combination of different behavioral and physiological indicators would help to identify pain in animals. To facilitate continued usage of the methodologies on the farm it also is necessary to evaluate the economic implication of the pain alleviation intervention.

Pain detection and amelioration are important components in animal care. Animal pain has been controversial in its definition, as evidenced by the discussion as to whether some species experience pain (Rose, 2002). The simplest definition appears to be that if analgesics improve a situation, it was pain that the animal experienced (Gibson, 1985). The International Association for the Study of Pain (IASP; 1979) defined *pain* as an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage.

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There are many similarities between animals and humans regarding pain perception (Morton & Griffiths, 1985); indeed, many of the pain management strategies in humans were developed on the basis of animal models. It has been argued that animals should receive the benefit of the doubt. If a stimulus is capable of creating a painful sensation in humans, it should be assumed to cause the same sensation in animals. According to the Animal Welfare Act, a painful procedure is defined as any procedure that reasonably would be expected to cause more than slight and momentary pain or distress in a human being (AWIC Bulletin, 2000). The IASP (1979) suggested that the inability to communicate does not mean that the individual is not experiencing pain. Although the IASP definition pertains to humans—including human infants—this definition also may be applied to animals, given their inability, like human infants, to communicate. As presented by Flecknell (2000), most clinicians would agree that the issue is whether the animals can suffer and not whether they can communicate.

Pain is argued to have sensory and emotional components. Whether animals have emotions, an attribute defined as the ability to relate the present with the past and future, also is a controversial subject. A recent finding announced in a conference organized by Compassion in World Farming indicated that many species of animals on the farm, such as cattle and sheep, have the ability to be concerned about expected future events (Leake, 2005). Almost all definitions of animal pain focus on physical pain, yet discussions of pain almost invariably include an emotional component. This, however, does not mean that physical pain is more important than emotional pain. Studies historically have argued that emotional factors weigh more strongly in animals' behavioral choices than does physical pain (Scott, 1967; Weisner & Sheard, 1933).

Conversely, the lesser development of a neocortex has been cited as evidence that animals (except primates) cannot experience emotional pain (Bermond, 1997). Certainly, there is limited ability in assessing the mental states of animals; hence, treating emotional pain in animals is problematic. However, it can be argued that there is a link between emotional pain and productivity. Physical pain and emotional pain have the same function of alerting animals to a threat to their well-being, thus providing motivation to avoid it (McMillan, 2003). The sensory component needs further attention, given that animals are limited in their ability to communicate the degree and location of pain.

WELFARE IMPLICATIONS OF PAIN

Regulations concerning the use of anesthetics and analgesics vary with the country. Sweden requires local anesthesia and sedation for procedures such as dehorning (Bengtsson, Menzel, Holtenius, & Jacobsson, 1996). There are few requirements for anesthetic use in North America (Faulkener & Weary, 2000).

Denmark (Grondahl-Nielsen, Simonson, Lund, & Hesselholt, 1999) and the United Kingdom (Kent, 1999) have permitted routine surgical procedures without anesthetics only in young (0 to 4 weeks old) animals. This is based on the assumption that animals feel little or no pain when they are young, as evidenced by the absence of overt behavioral signs of pain. It also has been claimed that human infants are incapable of experiencing pain because of their immature nervous system; pain is transmitted through mature, myelinated nerves rather than the immature nerves that newborns have (Lee, 2002). However, it is unclear whether the absence of behavioral signs is due to the absence of pain or to the inability to express the behavior.

Studies have demonstrated that surgery with minimal anesthesia and analgesia, compared with the use of high-dose fentanyl and sufentanil anesthesia, results in increased stress hormones in human neonates (Anand, 1986; Anand, Carr, & Hickey, 1987; Anand & Hickey, 1987b). Moreover, in terms of behavioral and physiological responses following putatively painful procedures, there is experimental evidence of pain in ovine, bovine, and porcine newborns (Mellor, Molony, & Robertson, 1991; Mellor & Murray, 1989; Prunier, Mounier, & Hay, 2005; I. S. Robertson, Kent, & Molony, 1994; Stafford & Mellor, 2005; Taylor, Weary, Lassard, & Braithwaite, 2001; Weary & Fraser, 1999).

It has been suggested that newborn and young animals may experience pain more intensely than do older animals (Mellor & Gregory, 2003). There are reports that in neonates (human as well as rats) the spinal cord sensory nerve cells are more excitable than in adults, with intense and prolonged response (Fitzgerald, 1991, 1995; Fitzgerald, Millard, & MacIntosh, 1988, 1989). These reports also indicated that pain transmission occurs primarily along unmyelinated fibers (C-fibers) in neonates rather than myelinated (A-delta) fibers. Even before birth, human infants are reported to possess structures needed for pain perception (Anand & Hickey, 1987a).

In addition to routine surgical procedures, farmed animals experience a wide range of tissue injuries, which perhaps are more important. Systemic illnesses such as mastitis, metritis, enteritis, pneumonia, and meningitis also are probably painful. Fighting, mishandling, crowding, and rough transport can cause pain in farmed animals. In all these circumstances, pain alleviation must be accepted as part of responsible animal caretaking (ownership).

PRODUCTIVITY EFFECTS OF PAIN IN FARMED ANIMALS

Beside the need for treatment of unrelieved pain in farmed animals on ethical and moral grounds, the issue of pain management can result in economic ramifications. As Fisher (2002) observed, "Pain is not an end point in itself but may act as a pathogen in its own" (p. 1). Pain can cause discomfort, impaired physio-

logical functions, suppression of immune responses, negative energy balance, and self-mutilation (Hellebrekers, 2000).

Pain can alter the outcome of an event when it is associated with an injury involving blood loss compared with an event that involves blood loss alone. A change in cardiac function has been reported when pain occurs along with blood loss (Rady, Kirkman, Cranley, & Little, 1993; Rady, Little, Edwards, Kirkman, & Faithful, 1991); this has been suggested to increase mortality risk (Wiese, Muir, & Wittum, 2005).

In the short term, pain may have a beneficial effect, aiding in the healing process by allowing the animal to rest. Short-term pain temporarily enhances immune function (Bessler, Sztein, & Serrate, 1990; Griesen et al., 1999) and is beneficial. However, ongoing pain can have negative consequences for animal productivity. In farmed animals, pain—especially chronic pain—may adversely affect growth and immune functions. Inflammatory responses associated with injuries and pain have direct impact on feed intake. Anorexia and lethargy can be induced by cytokines (interleukin–1, interleukin–6, and tumor necrosis factor-alpha) released by the inflammatory process by stimulating tissue catabolism and their effect on the central nervous system (Johnson, 1997). Reduction in feed intake and body weight has been observed in farmed animals following painful procedures (Faulkner & Weary, 2000; Fisher, Crowe, Vagra, & Enright, 1996; Knight, Cosgrove, Death, Anderson, & Fisher, 2000; McMeekan et al., 1999). Even when treated, conditions such as lameness may cause changes in pain perception in cattle—increased sensitivity to noxious stimuli, termed *hyperalgesia* (Whay, Waterman-Pearson, & Webster, 1998a)—adversely affecting milk yield and fertility in the long term. In addition, lameness in horses (Chambers, Waterman, & Livingston, 1994), cattle (Whay, Waterman, Webster, & O'Brien, 1998), and sheep (Ley, Livingston, & Waterman, 1989), and mastitis in cattle (Fitzpatrick et al., 1998), may lead to hyperalgesia with long-term consequences in production and well-being.

Chronic pain is immunosuppressive (Logan, Lutgendorf, Kirchner, Rivera, & Lubaroff, 2001; Page, Ben-Eliyahu, Yirmiya, & Liebeskind, 1993). Pain increases secretion of cortisol (Kent, Molony, & Robertson, 1993; Lester, Mellor, Ward, & Holmes, 1991; Thornton & Waterman-Pearson, 1999), affecting the cells of the immune system that cause reduction in function and number (Roth, 1985; IASP, 2005). Experiments have shown that cortisol can reduce immune cell activity in cattle (Blecha & Baker, 1986; Kehrli & Burton, 1995) and in pigs (Salak-Johnson, McGlone, & Norman, 1996).

The need for analgesia in painful conditions is obvious in that it provides immediate pain relief and prevents development of a hyperalgesic state. Furthermore, nonsteroidal anti-inflammatory drugs (NSAIDs) have anti-inflammatory and antipyretic actions in addition to their analgesic activity. Although the adverse effects of pain are identified, farmed animals often are not treated—even in known painful conditions.

FACTORS AFFECTING PAIN ALLEVIATION IN FARMED ANIMALS

Despite a wide acknowledgment of pain in farmed animals, efforts to alleviate pain in farmed animals have been limited. Different factors have led to this situation.

Public Perception and Expectation

Rowan, O'Brien, Thayer, and Patronek (1991) described the focus of animal protection in the United States in the 21st century. The first U.S. law on farm animals came into effect in 1873 to ensure food, water, and rest to farm animals in transit. The Humane Slaughter (Humane Methods of Slaughter Act of 1958) bill was introduced 80 years later. These laws addressed the prevailing, important welfare concerns of transport and slaughter. However, recent intensive confinement of animals has resulted in new welfare concerns that focus on housing. Despite the known painful procedures and conditions to which farmed animals are exposed, the issue of pain prevention and treatment in farmed animals has not garnered attention in the realm of welfare discussions. One reason why pain in farmed animals has not received attention is that many farmed species seldom show overt signs of pain. Cows may show no major obvious signs when in chronic pain other than reduction in milk yield (Short, 1998). Sick or injured animals are more prone to predation, and hiding signs of pain has become a survival strategy in many species (Underwood, 2002). The unresponsive nature of animals, despite being in pain, has led to a public perception that farmed animals are not sensitive to pain. In a Finnish survey, more than 75% of veterinarians disapproved the perception (Raekallio, Heinonen, Kuussaari, & Vainio, 2003).

It is true that public concern over the use and treatment of food animals in the United States has increased over the years, especially following depiction of animal abuse in mass media. Although there are laws for humane transportation and slaughter of livestock, in general, the Animal Welfare Act (1966) does not apply to farm animals (Nolen, 2001). Often in debates on farm animal welfare, topics such as space allowance and restriction of movement overshadow the issue of pain. The priorities in these discussions are determined in agreement with the prevailing public perception and are not necessarily based on science alone.

One of the most pertinent challenges faced by food animal production today is that of effectively meeting emerging consumer concerns. The key points to be addressed in meeting consumer concerns have been identified as product safety and animal welfare (Verbeke & Viaene, 2000). Pain is the most evident welfare concern and will arguably require being placed at the top of research priorities regardless of whether it is emphasized in discussions. Public concern over animal welfare, accompanied by a willingness to pay higher prices for welfare-assured

products, may facilitate translation of public concerns into welfare research. Surveys conducted among citizens in European countries (European Commission, 2005) have provided encouraging results in this direction. However, the difference in issue importance and perception with respect to welfare among consumer groups—based on sociodemographic and behavioral characteristics (Verbeke & Viaene, 2000)—may make it difficult to suggest that a specific welfare concern such as pain be emphasized in research efforts.

Concomitant to public concerns, efforts by governments and retailers may provide additional support to research addressing pain and other farm animal welfare issues. Switzerland has adopted measures in terms of legal restrictions and financial incentives to promote farm animal welfare (Phan-Huy & Fawaz, 2003). In Britain, retailers such as TESCO and CO–OP have made available welfare-assured animal products in the market at extra price, which will encourage both producers and researchers.

Limited Ability for Identification and Assessment of Pain in Farmed Animals

To be alleviated, pain first must be identified and assessed. Identification and quantification of pain are crucial in pain alleviation at the farm level; they determine the start and end points of any intervention. Even under laboratory conditions, pain assessment is a difficult task. As described previously (Anil, Anil, & Deen, 2002), there are intraspecies and interspecies variations in responses to painful stimuli. Even the responses of the same animal may not be the same in all cases. This variation may be attributable to stage of development, sex, environment/context, and prior pain experience. In addition, indicators of pain can be different in different types of pain, for example, acute or chronic and internal or external. This makes identification and assessment of pain in animals difficult. Pain assessment is problematic because of difficulty in quantifying objectively the variables involved. In addition, other, not necessarily painful, conditions, such as depression or excitement, can cause similar changes in the variables involved (Anil et al., 2002). Similarly, conditions such as phantom limb pain that occur in humans may go unidentified if they occur in animals (S. A. Robertson, 2002).

Anthropomorphic approaches to animal pain assessment, although widely used, are reported to be limited in that human responses to pain are influenced by the ability to communicate, dependence on social groups, and learned social behavior (Livingston, 2002). Moreover, unless one is very careful, one may tend to consider this subjective tool as an objective one (Bath, 1998). To add to this complexity, pain is a "real-time perception" (Livingston, 2002). Although humans may remember the circumstances and unpleasantness of a previous painful stimu-

lus, pain cannot be re-experienced by remembering it. Given this, how successfully humans can anthropomorphize pain in animals is debatable. Even in humans, sensory and emotional components of pain are difficult to distinguish. The effect of an existing pain may vary with expectation on future aggravation or reduction of pain. Whether animals also experience the same is still arguable. Similarly, the role of motivation on intensity of pain in animals is unclear. Experiments on animals in the laboratory and dogs have shown that these animals—under strong motivation—expose themselves to repeated noxious stimuli such as electric shock (Scott, 1967; Weisner & Sheard, 1933).

At the farm level, an animal's overt behavior may suggest whether the animal is in pain. However, even with careful observation of an animal's behavior and posture, it may not be possible to assess pain in animals accurately without knowing what behavior to expect when the animal is in pain. Sows, when exposed to a laser beam (known to cause pain) responded by flicking the tail, moving a leg, or twitching a muscle (Jarvis et al., 1997). On commercial farms, it is difficult to consider that a pig showing the above signs may be in pain. Similarly, behavior may not be correlated with intensity or noxiousness of the stimuli (Lester, Mellor, Holmes, Ward, & Stafford, 1996; Stafford & Mellor, 1993). All these factors are critical and limit the usefulness of subjective measures such as anthropomorphism as a tool to identify and assess animal pain.

Biochemical indicators and many physiological indicators, although used for pain assessment under laboratory conditions, require specialized equipments and skills and are unavailable at the farm level. Furthermore, factors other than pain—physical activity or sexual excitement, for example—influence many of these variables.

Obviously, as in any other welfare issue, formulation of approaches to minimize and alleviate pain in farmed animals is complex. Ethics, technology, economics, regulations, and scientific knowledge all need to be amalgamated (Fraser & Leonard, 1993) to find a satisfactory solution. Inadequacy of research-based knowledge on pain in farmed animals has been a constraint in on-farm pain management.

Deficiencies of Research on Pain and Analgesia in Farmed Animals

Extensive research focusing specifically on farmed animals is needed to identify and quantify pain and to develop inexpensive, simple-to-use, and safe pain medication before widespread use of on-farm analgesia can be expected. As Stookey (2004) pointed out, "using pain-control methods on farm animals is not easy and has never been user-friendly, so it is often viewed as unrealistic in terms of cost and labor."

An effective pain management strategy requires adequate analgesia and treatment methods. The pharmacokinetics of analgesia in different species of animals

must be identified. Identification of pain and evaluation of the usefulness of analgesic therapy need to be based on objective pain assessment tools and should be supported by proof on the bioavailability of the analgesic (Short, 2003). Lack of pharmacokinetic data on different analgesics for various species has resulted in the use of past experience, based on close observation of animal responses, as the main basis for continuing or discontinuing analgesic therapy (Benson & Thurmon, 1987; Underwood, 2002). All these point to the need for research in the area of pain and analgesia, specifically focusing on farmed species.

Almost all animals used in experimental pain research are animals in the laboratory or humans. The use of farmed animals in pain research is limited. This may be due to an inability to detect the animal's response to pain and the difficulty associated with housing and managing large farmed animals for research purposes (Livingstone, Waterman, Nolan, Morris, et al., 1992). In addition, it is undeniable that pharmaceutical research is expensive and may not get funded without a possibility for future economic gain. Thus, a perceived lack of market demand for analgesics in farmed animals may be hindering analgesic studies for farmed species. Almost all the analgesic studies on farmed animals have been done with experimental models of pain rather than with clinical cases (Chambers, Stafford, & Mellor, 2002). Where farmed animals are involved, almost all pain research has been confined to species such as horses, in which the individual animal is the focal point of the industry. In other cases, adaptability or docility of the species, such as sheep, may be the inclusion criteria. In most cases, results of studies on analgesia are extrapolated from one species to another (Livingstone, Waterman, Nolan, & Amin, 1992). Given the wide variation among species and among members of the same species regarding responses to painful stimuli (Anil et al., 2002), such extrapolation also presents problems of validity.

The issue of research on chronic pain in animals confronts additional problems, such as the lack of a suitable model and ethical considerations associated with inflicting chronic pain (Nolen, 2001). At the farm level, inability to evaluate the effectiveness of an analgesic and the difficulty in selecting an appropriate, painful condition where external manifestations of pain are consistent and objectively gradable are the constraints faced by the veterinarians. Visceral pain or pain associated with external body surface may not be accompanied by a specific behavioral pattern.

In addition, the cognitive processes by which animals attach meaning to environmental information they gain are still largely unknown. Without understanding emotions and cognition, the knowledge on animal pain remains partial.

Inadequate Analgesic Interventions

Despite the acknowledgment of pain in farmed animals, the management of the same has not progressed to parallel that in companion animals. A proposal to in-

clude pain management requirements in the standards for accreditation, similar to the one put forward for hospitals by the American Animal Hospital Association (2002), is not found in food animal production units. The general attitude of the public, as well as the individuals closely associated with farmed animals, also may play a pivotal role in management of pain in farmed species.

Sensitivity to animal welfare issues among veterinarians, who are the key personnel in providing pain relief to animals, has been reported to vary with gender, nationality, and religious beliefs (Livingston, 2002). There is not a strong educational effort in the veterinary curricula on pain management for food animals compared with that for companion animals (Guard, 2004) to overcome this individual variation in the attitude toward pain alleviation. This limitation in the curricula leaves veterinarians, despite acknowledging the possibility of pain associated with a condition or procedure, with no dependable option based on the training they received. In such a situation, it is probable that public perception and attitude of what is ideal prevails. It also may lead the veterinarian to extrapolate his or her knowledge of pain and its management from one species to another, which may not always be the appropriate strategy.

The issue of pain management is somewhat simpler in companion animals, because the emotional utility associated with a pet is defined more easily. However, the case is different with farmed animals. There is a need to have a balance between acceptable production and profit while ensuring that measures to protect the animals are in place. Despite considerable efforts to improve the ability of veterinarians in pain management, farmed animals receive a lower priority than companion animal species or species in which the individual animal is of high economic value. Even most textbooks on animal pain management provide only limited information on food animals. This is in compliance with the selectively low usage of analgesics and anesthetics in farm animal practice.

At the field level, cost and choice are the two major factors limiting pain alleviation in farmed animals (Nolen, 2001). Concern over the misuse of drugs is another factor limiting the use of analgesics at the farm level. There are different types of analgesics that can be administered to food animals: opioids, alfa2–adrenergic agonists, NSAIDs, and local anesthetics. Local anesthetics are cheap, and food residues are less of a problem. However, it has been reported that some metabolites are carcinogenic (Chambers et al., 2002), which may reduce the use of such anesthetics in food animals. Morphine-type drugs, although inexpensive, are less effective in ruminants (Chambers et al., 2002). They cause food residues and are controlled strictly by law. They also may cause hyperactivity in ruminants. The short duration of effect (pethidine, fentanyl) is another factor limiting their usage. Ruminants may develop tolerance to opioids after repeated usage and may require high doses to achieve a required level of analgesia (George, 2003). Adrenergic alfa2 agonists are effective in most species, and only a short withholding time is needed. However, they produce dose-dependent sedation that may cause cardio-

vascular depression (Khan, Ferguson, & Jones, 1999). The NSAIDs are effective; however, some have long withholding times for meat and are expensive. Some of the NSAIDs, such as flunixin meglumine, may cause myonecrosis if administered intramuscularly (Chambers et al., 2002). They also may interfere with prostaglandin production during parturition and may affect the reproduction of the animal, restricting the window of their usage. New-generation NSAIDs such as carprofen are reported to be more effective and less ulcerogenic (George, 2003). However, their use in food animals may be limited by the long withholding time.

The availability of approved analgesic for use in food animal is a key factor in the context. The use of analgesia has been very much restricted in food animals in the United States. Only a few analgesics have been approved by the Food and Drug Administration for use in species such as pigs, and extralabel use is uncommon on swine farms. Aspirin, one of the analgesics used in food animals in the United States, is not registered as an analgesic. Flunixine meglumine is approved by the Food and Drug Administration for cattle and pigs. Isoflupredone acetate (PREDEF 2×) is a corticosteroid approved for intramuscular use in pigs who are in pain (Pharmacia and Upjohn Company, 2004).

One reason why the need for analgesics in species such as pigs has not received the attention it deserves is the absence of apparent disturbances in behavior of pigs that directly and immediately affect productivity and apparent financial costs. The lack of effective, affordable, and available anesthetics and analgesics thus has become a constraint in managing pain in farmed species; veterinarians, however, feel a need to manage pain in farmed species (Short, 2003). This limitation is exacerbated further by the inability to use even the available analgesics for fear of harming the animal—as in obstetrical cases—or the animal's offspring.

There are other factors that limit the use of analgesics in farmed animals. In some cases, the drug of choice may require a route of administration requiring individual confinement and housing for administration that may be prohibitively expensive to implement at the farm level. Drugs that require administration three or four times a day to maintain blood levels that achieve the desired level of analgesia may not be a practical option at the farm level. Similarly, shortage of personnel, equipment, or financial support may hinder the monitoring needed to ensure proper pain alleviation in many postoperative situations (Short, 2003).

Economic considerations may limit local anesthetics used either alone or in conjunction with technique modifications commonly used to reduce pain considerably in many farm procedures. The extent of analgesic usage at the farm level depends on cost of the medicine and the mandatory withholding time (Guard, 2004). Bovine practitioners frequently quoted the cost of analgesic drugs as a limiting factor in their use (Watts & Clarke, 2000). Guard calculated the cost of treating lameness in cattle using flunixin meglumine, including 3-day milk discard, to be $61. Depending on the price of milk in the United States, the cow would have to produce 353 liters of extra milk to cover expenses. At least in short term, producers

would tend to balance this additional expense with traditional ways of ignoring pain. Developing less expensive analgesics that require a short withholding time, or no withholding time, definitely will improve the chance of their use at the farm level. The cost of medicine for treating pain becomes more of a deterrent as the value of the individual animal decreases. Because the value of individual sheep is less than that of cattle, cost of analgesics in species such as sheep may be a discouraging factor (Chambers et al., 2002).

THE WAY FORWARD: FARM-LEVEL STRATEGIES FOR PAIN ALLEVIATION

Pain needs to be identified before it can be alleviated. As in any scientific measurement, a tool for pain assessment must have easy-to-use, objective, reliable, and valid components. It is difficult to have such a tool that can be used by producers under farm conditions. However, pain in farmed animals cannot be ignored. To do so can be detrimental both in economic (Paul-Murphy et al., 2004) and in welfare terms. The producer needs to identify and quantify pain to evaluate usefulness of in-place, pain management strategy and to determine when to discontinue treatment.

Although extrapolating from one species to another is not ideal, anthropomorphism may appear to be a beginning point in any animal pain assessment strategy at the farm level. Subjective assessment remains a major tool for pain identification and assessment even in clinical situations (Barnett, 1997). Furthermore, even in pain assessments involving objective measures such as heart rate, plasma cortisol, and plasma beta endorphin, conclusions on the meaning of changes with respect to pain are arrived at subjectively (Mellor & Stafford, 2000; Mellor, Cook, & Stafford, 2000). The measured physiological, pathological, and chemical processes represent only the underlying events that give rise to the perception of the subjective feelings of pain (Bath, 1998). More often than not, welfare assessment is a value judgment (Barnett,1988), Furthermore, it does not mean that subjective judgments are less accurate than those based on verifiable evidences (Rutherford, 2002).

A single tool may not identify and assess pain accurately in animals. However, using multiple measures can improve the identification and assessment (Barnett, 1988; Molony & Kent 1997). Anil et al. (2002) concluded that a combination of several indicators, such as changes in behavioral patterns, appearance, posture, gait, appetite, physiological and biochemical parameters, response to handling, and feed intake, will help one make an informed judgment as to whether an animal is experiencing pain.

Qualitative observation by an experienced observer can identify behavioral changes largely associated with pain (Rutherford, 2002). Many reports have highlighted the importance of behavior as an indicator of pain in animals (Bateson,

1991; Chapman, 1992; Morton & Griffiths, 1985; Short, 1998). Deviation from normal behavior is the most important single indicator of pain. Isolation from group members can be an early symptom of pain. The presence of more than one behavioral indicator of pain (postures, facial expressions, stereotypical movements, and vocalizations) helps to confirm pain.

Depending on the species concerned, behaviors on which to focus may include—but are not limited to—sleeping, feeding, drinking, locomotion, grooming, exploration, social interactions, and dominance–subordinate behavior within the social system. Behavioral signs of acute pain may include protecting the painful area; vocalizing (especially when handled or moved); and licking, biting, scratching, or shaking the painful area. Additional signs may include restlessness, lack of mobility, abnormal postures, or lack of normal interest in surroundings.

There are other indications of well-being that positively suggest the absence of pain. In pigs, signs of contentment may include play (including playful fighting, nudging and running, nibbling at bedding, or grabbing and biting chains or other toys); vocalization (including "conversational" grunting within groups or houses and the characteristic grunting of sows calling their piglets to suckle or encouraging suckling); and good health, along with good growth and condition (Oldham, 1985).

Analgesics have been used successfully to confirm pain when pain is suspected. Analgesics and anesthetics are used in pain assessment in lame horses (Wyn-Jones, 1988) and in lambs (Thornton & Waterman-Pearson, 1999). Presence of pain can be confirmed if abnormal behavior or physiological responses are restored by an analgesic. However, care must be taken to ensure that the substances used are analgesics and not a substance that prevents the animal from expressing pain (Wall, 1992). Although analgesics can be used to confirm pain, primarily they are intended to minimize pain. Thus, every effort needs to be made to use them to prevent pain before pain occurs. If a condition or procedure is known to be—or likely to be—painful, analgesics may be used in advance to prevent pain.

Although the link between injury and pain may not be direct (Wall, 1979), the presence of physical injury obviously is a reliable indicator of pain (Dantzer, 1986). More often than not, pain increases with increasing injury; therefore, the degree of injury may indicate the amount of expected pain (Rutherford, 2002).

More important, better production practices, such as proper housing, handling, movement; and genetic selection for calmness, temperament, and low excitability, can minimize instances of pain (Underwood, 2002). Performing procedures for the right reason and using the best method and correct equipment at the right time and for the right class of animal substantially can minimize the pain associated with routine farm procedures (Bath, 1998).

Factors such as the notion that farm animals are less sensitive to pain, lack of available drugs, issues of food safety, low market demand for analgesics for farmed animals, and the consequent reduction in research efforts, have an additive effect on the minimal use of analgesics in farmed animals (Lee, 2002). Although it

is acknowledged that many conditions are likely to be painful, farm pain control measures, given their cost and effort, often are not pursued. Therefore, the development of cheap, safe, and simple medications and techniques is a prerequisite for widespread adoption of on-farm pain management.

CONCLUSIONS

One cannot deny that food animal production is an economic enterprise; hence, unlike the case with companion animals, there is a need for a balance between economics and animal well-being. Thus, although warranted, any intervention to minimize pain in farmed animals should be based on the animal, the production system, and on the economic consequence of interventions. Informing all concerned parties about animal pain must precede any such activity; ultimately, their support through the market is vital for sustainability of animal agriculture.

A change in perception based on emerging knowledge of pain in farmed animals can go a long way toward altering demand and influencing pharmaceutical companies to invest more in research and registration for effective and safe drugs to treat pain in farmed animals. The personnel caring for animals must be provided with adequate skills to identify and assess pain in the species concerned. Finally, necessary medicines and equipment should be made available through concerted efforts of the research community, veterinarians, and support personnel. Producer-developed guidelines for pain alleviation at the farm level may be the way forward. Practically and financially unrealistic proposals are less likely to be adopted.

The disadvantages discussed so far, are associated with a lack of pain alleviation in farmed animals and are confined to the farm, pertain more or less to producers. However, the issue may gain a wider impact through the market. Future market pressure to ensure farmed animal welfare may mandate satisfactory pain relief measures at the farm level similar to conditions for space allowance and type of housing.

REFERENCES

American Animal Hospital Association. (2002, August). Pfizer to conduct "landmark" study on pain. *DVM Newsmagazine*, pp. 18–19.

Anand, K. J. S. (1986). Hormonal and metabolic functions of neonates and infants undergoing surgery. *Current Opinion in Cardiology*, *1*, 681–689.

Anand, K. J. S., Carr, D. B., & Hickey, P. R. (1987). Randomized trial of high-dose sufentanil anesthesia in neonates undergoing cardiac surgery: Hormonal and hemodynamic stress responses. *Anesthesiology*, *67*, A50.

Anand K. J. S., & Hickey, P. R. (1987a). Pain and its effects in the human neonate and fetus. *New England Journal of Medicine*, *317,* 1321–1329.

Anand, K. J. S., & Hickey, P. R. (1987b). Randomized trial of high-dose sufentanil anesthesia in neonates undergoing cardiac surgery: Effects on the metabolic stress response. *Anesthesiology*, *67*, A502.

Anil, S. S., Anil, L., & Deen, J. (2002). Challenges of pain assessment in domestic animals. *Journal of the American Veterinary Medical Association*, *220*, 313–319.

Animal Welfare Act of 1966. U.S. Code 7 Agriculture, Chapter 54: Transportation, sale, and handling of certain animals, §§ 2131–2156 (1966).

AWIC Bulletin. (2000). Animal welfare: Definitions for and reporting of pain and distress. *Animal Welfare Information Center Bulletin*, *11*(1), 2. Retrieved February 10, 2005, from http://www.nal.usda.gov/awic/newsletters/v11n1/11n19cfr.htm

Barnett, J. L. (1988). Surgery may not be preferable to rubber rings for tail docking and castration of lambs. *Australian Veterinary Journal*, *65*, 131.

Barnett, J. L. (1997). Measuring pain in animals. *Australian Veterinary Journal*, *75*, 878–879.

Bateson, P. (1991). Assessment of pain in animals. *Animal Behaviour*, *42*, 827–839.

Bath, G. F. (1998). Management of pain in production animals. *Applied Animal Behavior Science*, *59*, 147–156.

Bengtsson, B., Menzel, A., Holtenius, P., & Jacobsson, O. (1996). Cryosurgical dehorning of calves: A preliminary study. *The Veterinary Record*, *138*, 234–237.

Benson, G. J., & Thurmon, J. C. (1987). Species difference as a consideration in alleviation of animal pain and distress. *Journal of the American Veterinary Medical Association*, *191*, 1227–1230.

Bermond, B. (1997). The myth of animal suffering. In M. Dol, S. Kasamoentalib, S. Lijmbach, E. Rivas, & R. van den Bos (Eds.), *Animal consciousness and animal ethics: Perspectives from The Netherlands* (pp. 125–143). Assen, The Netherlands: Van Gorcum.

Bessler, H., Sztein, M. B., & Serrate, S. A. (1990). Beta-endorphin modulation of IL-1 induced IL-2 production. *Immuno Pharmacology*, *19,* 5–14.

Blecha, F., & Baker, P. E. (1986). Effect of cortisol *in vitro* and *in vivo* on production of bovine interleukin-2. *American Journal of Veterinary Research*, *47*, 841–845.

Chambers, J. P., Stafford, K. J., & Mellor, D. J. (2002). Analgesics: What use are they in farm animals? *Proceedings of the New Zealand Society of Animal Production*, *62*, 359–362.

Chambers, J. P., Waterman, A. E., & Livingston, A. (1994). Further development of equipment to measure nociceptive thresholds in large animals. *Journal of Veterinary Anaesthesia*, *21*, 66–72.

Chapman, C. R. (1992). Suffering in animals: Towards comprehensive definition and measurement for animal care. In T. R. Kuchel, M. Rose, & J. Burrell (Eds.), *Animal pain: Ethical and scientific perspectives—The proceedings of a conference held at the Barossa Valley, Adelaide, April, 1990* (pp. 19–25). Glen Osmond, South Adelaide: Australian Council on the Care of Animals in Research and Teaching.

Dantzer, R. (1986). Assessing pain by studying neuroendocrine responses. In I. J. H. Duncan & V. Molony (Eds.), *Assessing pain in farm animals—Proceedings of a workshop held in Roslin, Scotland, 25 and 26 October 1984* (pp. 39–48). Luxembourg, Switzerland: Office for Official Publications of the European Communities.

European Commission. (2005). *Attitudes of consumers towards the welfare of farmed animals*. Directorate General Health and Consumer Protection and Coordinated by Directorate General Press and Communication, European Commission. Retrieved September 10, 2005, from http://europa.eu.int/comm/public_opinion/archives/ebs/ebs_229_en.pdf

Faulkener, P. M., & Weary, D. M. (2000) Reducing pain after dehorning in dairy calves. *Journal of Dairy Science*, *83*, 2037–2041.

Fisher, A. D. (2002). Pain—Its effects on immune function and growth in animals. *Proceedings of the New Zealand Society of Animal Production*, *62*, 363–367.

Fisher, A. D., Crowe, M. A., de la Vagra, M. E. A., & Enright, W. J. (1996). Effect of castration method and the provision of local anaesthesia on plasma cortisol, scrotal circumference, growth and feed intake of bull calves. *Journal of Animal Science*, *74*, 2336–2343.

Fitzgerald, M. (1991). Development of pain mechanisms. *British Medical Bulletin*, *47*, 667–675.

Fitzgerald, M. (1995). Developmental biology of inflammatory pain. *British Journal of Anaesthesia*, *75*, 177–185.

Fitzgerald, M., Millard, C., & MacIntosh, N. (1988). Hyperalgesia in premature infants. *The Lancet*, *331*, 292.

Fitzgerald, M., Millard, C., & MacIntosh, N. (1989). Cutaneous hypersensitivity following peripheral tissue damage in newborn infants and its reversal with topical anaesthesia. *Pain*, *39*, 31–36.

Fitzpatrick, J. L., Yong, F. J., Eckersall, D., Logue., D. N., Knight, C. H., & Nolan, A. M (1998). Recognizing and controlling pain and inflammation in mastitis. In *Proceedings of the British Mastitis Conference* (pp. 36–44). Stoneleigh, England: Axient/Institute for Animal Health, Milk Development Council/Novartis Animal Health.

Flecknell, P. A. (2000). Animal pain—An introduction. In P. A Flecknell & A. Waterman-Pearson (Eds.), *Pain management in animals* (pp. 1–7). New York: Saunders.

Fraser, D., & Leonard, M. L. (1993). Farm animal welfare. In J. Martin, R. J. Hudson, & B. A. Young (Eds.), *Animal production in Canada* (pp. 253–270). Edmonton, Alberta, Canada: University of Alberta.

George, L. W. (2003). Pain control in food animals. In E. P. Steffey (Ed.), *Recent advances in anesthetic management of large domestic animals*. New York: International Veterinary Information Service. Retrieved September 10, 2005, from http://www.ivis.org/advances/Steffey_Anesthesia/george/IVIS.pdf

Gibson, T. E. (1985). Summary and conclusions. In T. E. Gibson (Ed.), *The detection and relief of pain in animals* (pp. 127–130). London: British Veterinary Association Animal Welfare Foundation.

Griesen, J., Hokland, M., Gr∅fte, T., Hansen, P. O., Jensen, T. S., Vilstrup, H., & T∅nnensen, E. (1999). Acute pain induces an instant increase in natural killer cell cytotoxicity in humans and this response is abolished by local anaesthesia. *British Journal of Anaesthesia*, *83*, 235–240.

Grondahl-Nielsen, C., Simonson, H. B., Lund, J. D, & Hesselholt, M. (1999). Behavioural, endocrine and cardiac responses in young calves undergoing dehorning without and with use of sedation and analgesia. *Veterinary Journal*, *158*, 14–20.

Guard, C. (2004). Animal welfare and claw diseases. In B. Zemlijic, *Proceedings of the 13th International Symposium and 5th Conference on Lameness in Ruminants* (pp. 155–158). Ormož, Ungula: Zemlijic.

Hellebrekers, L. J. (2000). Pain in animals. In L. J. Hellebrekers (Ed.), *Animal pain: A practice oriented approach to effective pain control in animals* (pp. 11–16) Utrecht, The Netherlands: Van Der Wees Uitgeverij.

Humane Methods of Slaughter Act of 1958. U. S. Code 7 Agriculture, Chapter 48: Humane methods of livestock slaughter, §§ 1901–1907 (1958).

International Association for the Study of Pain. (1979). Report of International Association for the Study of Pain subcommittee on taxonomy. *Pain*, *6*, 249–252.

International Association for the Study of Pain. (2005). *Pain—Clinical updates*. Retrieved March 17, 2005, from http://www.iasp-pain.org/PCU05-1.pdf

Jarvis, S., McLean, K. A., Chirnside, J., Deans, L. A., Calvert, S. K., Molony, V., & Lawrence, A. B. (1997). Opioid-mediated changes in nociceptive threshold during pregnancy and parturition in the sow. *Pain*, *72*, 153–159.

Johnson, R. W. (1997). Inhibition of growth by pro-inflammatory cytokines: An integrated view. *Journal of Animal Science*, *75*, 1244–1255.

Kehrli, M. E., Jr., & Burton, J. L. (1995). *Effects of glucocorticoids on the bovine immune system* (ISU Dairy Report DSL-45). Retrieved March 17, 2005, from http://www.extension.iastate.edu/Pages/dairy/ report95/health/dsl-45.pdf.

Kent, J. E. (1999). Mutilations: A necessary evil. *Veterinary Journal*, *158*, 1–3.

Kent, J. E., Molony, V., & Robertson, I. S. (1993). Changes in plasma cortisol concentration in lambs of three ages after three methods of castration and tail docking. *Research in Veterinary Science*, *55*, 246–251.

Khan, Z. P., Ferguson, C. N., & Jones, R. M. (1999). Alpha-2 and imidazoline receptor agonists—Their pharmacology and therapeutic role. *Anaesthesia*, *54*, 146–165.

Knight, T. W., Cosgrove, G. P., Death, A. F., Anderson, C. B., & Fisher, A. D. (2000). Effect of method of castrating bulls on their growth rate and live weight. *New Zealand Journal of Agricultural Research*, *43*, 187–192.

Leake, J. (2005, February 27). The secret life of moody cows. *The (Britain) Sunday Times*, p. 13.

Lee, B. H. (2002). Managing pain in human neonates—Applications for animals. *Journal of the American Veterinary Medical Association*, *221*, 233–237.

Lester, S. J., Mellor, D. J., Holmes, R. J., Ward, R. N., & Stafford, K. J. (1996). Behavioral and cortisol responses of lambs to castration and tailing using different methods. *New Zealand Veterinary Journal*, *44*, 45–54.

Lester, S. J., Mellor, D. J., Ward, R. N., & Holmes, R. J. (1991). Cortisol responses of young lambs to castration and tailing using different methods. *New Zealand Veterinary Journal*, *39*, 134–138.

Ley, S. J., Livingston, A., & Waterman, A. E. (1989). The effect of chronic clinical pain on thermal and mechanical thresholds in sheep. *Pain*, *39*, 353–357.

Livingston, A. (2002). Ethical issues regarding pain in animals. *Journal of the American Veterinary Medical Association*, *221*, 229–233.

Livingstone, A., Waterman, A. E., Nolan, A., & Amin, A. (1992). Comparison of thermal and mechanical antinociceptive actions of opioids and a2-adrenoreceptor agonists in sheep. In C. E. Short & A. V. Poznak (Eds.), *Animal pain* (pp. 372–377). New York: Churchill Livingstone.

Livingstone, A., Waterman, A. E., Nolan, A., Morris, R., Ley, S. J., & Headley, P. M. (1992). The sheep as model for the experimental pain studies. In C. E. Short & A. V. Poznak (Eds.), *Animal pain* (pp. 364–371). New York: Churchill Livingstone.

Logan, H. L., Lutgendorf, S., Kirchner, L., Rivera, E. M., & Lubaroff, D. (2001). Pain and immunologic response to root canal treatment and subsequent outcomes. *Psychosomatic Medicine*, *63*, 453–462.

McMeekan, C., Stafford, K. J., Mellor, D. J., Bruce, R. A., Ward, R. N., & Gregory, N. (1999). Effects of local anaesthetics and non steroidal anti-inflammatory analgesics on the behavioural responses of calves to dehorning. *New Zealand Veterinary Journal*, *47*, 92–96.

McMillan, F. D. (2003). A world of hurts—Is pain special? *Journal of the American Veterinary Medical Association*, *223*, 183–186.

Mellor, D. J., Cook, C. J., & Stafford, K. J. (2000). Quantifying some responses to pain as a stressor. In G. P. Moberg & J. A. Mench (Eds.), *The biology of animal stress—Basic principles and implications for animal* welfare (pp. 171–198). Wallingford, England: Commonwealth Agricultural Bureau International.

Mellor, D. J., & Gregory, N. G. (2003). Responsiveness, behavioural arousal and awareness in fetal and newborn lambs: Experimental, practical and therapeutic implications. *New Zealand Veterinary Journal*, *51*, 2–13.

Mellor, D. J., Molony, V., & Robertson, I. S. (1991). Effects of castration on behaviour and plasma cortisol concentrations in young lambs, kids and calves. *Research in Veterinary Science*, *51*, 149–154.

Mellor, D. J., & Murray, L. (1989). Effects of tail docking and castration on behaviour and plasma cortisol concentrations in young lambs. *Research in Veterinary Science*, *46*, 387–391.

Mellor, D. J., & Stafford, K. J. (2000). Acute castration and tailing distress in lambs. *New Zealand Veterinary Journal*, *48*, 33–43.

Molony, V. J., & Kent, J. E. (1997). Assessment of acute pain in farm animals using behavioral and physiological measurements. *Journal of Animal Science*, *75*, 266–272.

Morton, D. B., & Griffiths, P. H. M. (1985). Guidelines on the recognition of pain, distress and discomfort in experimental animals and an hypothesis for assessment. *Veterinary Record*, *116*, 431–436.

Nolen, R. S. (2001). The problem with pain—Veterinarians are making a thorny issue a priority. *Journal of the American Veterinary Medical Association*, *219*, 288–289.

Oldham, J. G. (1985). Clinical measurement of pain, distress and discomfort in pigs. In T. E. Gibson & D. A. Paterson (Eds.), *The proceedings of the Animal Welfare Foundation's second symposium—The detection and relief of pain in animals* (pp. 89–91). London: British Veterinary Association Animal Welfare Foundation.

Page, G. G., Ben-Eliyahu, S., Yirmiya, R., & Liebeskind, J. C. (1993). Morphine attenuates surgery induced enhancement of metastatic colonization in rats. *Pain*, *54*, 21–28.

Paul-Murphy, J., Ludders, J. W., Robertson, S. A., Gaynor, J. S., Hellyer, P. W., & Wong, P. L. (2004). The need for a cross-species approach to the study of pain in animals. *Journal of the American Veterinary Medical Association*, *224*, 692–697.

Phan-Huy, S. A., & Fawaz, R. B. (2003). Swiss market for meat from animal-friendly production-responses of public and private actors in Switzerland. *Journal of Agricultural and Environmental Ethics, 16*, 119–136.

Pharmacia and Upjohn Company. (2004). *Predef2X.* Retrieved May 9, 2004, from http://www.pfizerah.com/PAHimages/compliance_pdfs/US_EN_ PX_compliance.pdf

Prunier, A., Mounier, A. M., & Hay, M. (2005). Effects of castration, tooth resection, or tail docking on plasma metabolites and stress hormones in young pigs. *Journal of Animal Science*, *83*, 216–222.

Rady, M. Y., Kirkman, E., Cranley, J., & Little, R. A. (1993). A comparison of the effects of skeletal muscle injury and somatic afferent nerve stimulation on the response to hemorrhage in anesthetized pigs. *Journal of Trauma*, *35*, 756–761.

Rady, M. Y., Little, R. A., Edwards, J. D., Kirkman, E., & Faithful, S. (1991).The effect of nociceptive stimulation on the changes in hemodynamics and oxygen transport induced by hemorrhage in anesthetized pigs. *Journal of Trauma*, *31*, 617–622.

Raekallio, M., Heinonen, K. M., Kuussaari, J., & Vainio, O. (2003). Pain alleviation in animals: Attitudes and practices of Finnish veterinarians. *Veterinary Journal*, *165*, 131–135.

Robertson, I. S., Kent, J. E., & Molony, V. (1994). Effects of different methods of castration on behaviour and plasma cortisol in calves of three ages. *Research in Veterinary Science*, *56*, 8–17.

Robertson, S. A. (2002). What is pain? *Journal of the American Veterinary Medical Association*, *221*, 202–205.

Rose, J. D. (2002). The neurobehavioral nature of fishes and the question of awareness and pain. *Reviews in Fisheries Science*, *10*, 1–38.

Roth, J. A. (1985). Cortisol as mediator of stress-associated immunosuppression in cattle. In G. P. Moberg (Ed.), *Animal stress* (pp. 225–243). Bethesda, MD: American Physiological Society.

Rowan, A. N., O'Brien, H., Thayer, L., & Patronek, G. J. (1991). *Farm animal welfare: The focus on animal protection in the USA in the 21st century*. Tufts Center for Animals and Public Policy, School of Veterinary Medicine, Tufts University. Retrieved February 5, 2005, from http://www.tufts.edu/vet/cfa/faw.pdf

Rutherford, K. M. D. (2002). Assessing pain in animals. *Animal Welfare*, *11*, 31–53.

Salak-Johnson, J., McGlone, J. J., & Norman, R. L. (1996). *In vivo* glucocorticoid effects on porcine natural killer activity and circulating leukocytes. *Journal of Animal Science*, *74*, 584–592.

Scott, J. P. (1967). The development of social motivation. In D. Levine (Ed.), *Nebraska symposium on motivation* (pp. 111–132). Lincoln: University of Nebraska Press.

Short, C. E. (1998). Fundamentals of pain perception in animals. *Applied Animal Behavior Science*, *59*, 125–133.

Short, C. E. (2003). The management of animal pain: Where have we been, where are we now, and where are we going? *Veterinary Journal*, *165*, 101–103.

Stafford, K. J., & Mellor, D. J. (1993). Castration, tail docking and dehorning—What are the constraints? *Proceedings of the New Zealand Society of Animal Production*, *53*, 189–195.

Stafford, K. J., & Mellor, D. J. (2005). Dehorning and disbudding distress and its alleviation in calves. *Veterinary Journal*, *169*, 337–349.

Stookey, J. (2004, Fall). Reducing farm animal pain. *Western Hog Journal.* Retrieved June 26, 2005, from http://www.albertapork.com/news.aspx?NavigationID=1425

Taylor, A. A., Weary, D. M., Lassard, M., & Braithwaite, L. (2001). Behavioural responses of piglets to castration: The effect of piglet age. *Applied Animal Behaviour Science*, *73*, 35–43.

Thornton, P. D., & Waterman-Pearson, A. E. (1999). Quantification of pain and distress responses to castration in young lambs. *Research in Veterinary Science*, *66*, 107–118.

Underwood, W. J. (2002). Pain and distress in agricultural animals. *Journal of the American Veterinary Medical Association*, *221*, 208–211.

U. S. Law of 1873. U.S. Code 49 Transportation, Chapter 805 Miscellaneous, § 80502. Transportation of animals (1873).

Verbeke, W. A. J., & Viaene, J. (2000). Ethical challenges for livestock production: Meeting consumer concerns about meat safety and animal welfare. *Journal of Agricultural and Environmental Ethics*, *12*, 141–151.

Wall, P. D. (1979). On the relation of injury to pain. *Pain*, *6*, 253–264.

Wall, P. D. (1992). Defining pain in animals. In C. E. Short & A.V. Poznak (Eds.), *Animal pain* (pp. 63–79). New York: Churchill Livingstone.

Watts, S. A., & Clarke, K. W (2000). A survey of bovine practitioners attitudes to pain and analgesia in cattle. *Cattle Practice*, *8*, 361–362.

Weary, D. M., & Fraser, D. (1999). Partial tooth-clipping of suckling pigs: Effects on neonatal competition and facial injuries. *Applied Animal Behaviour Science*, *65*, 21–27.

Weisner, B. P., & Sheard, N. M .(1933). *Maternal behavior in the rat* (pp. 121–123). Edinburgh, Scotland: Oliver and Boyd.

Whay, H. R., Waterman-Pearson, A. E., & Webster, A. J. F. (1998). The use of ketoprofen in the modulation of hyperalgesia associated with hind limb lameness in dairy cattle. In C. J. Lischer & P. Ossent, *Proceedings of the 10th International Symposium on Lameness in Ruminants* (pp. 305–306). Lucerne, Switzerland: University of Zurich.

Whay, H. R., Waterman, A. E., Webster, A. J. F., & O'Brien, J. K. (1998). The influence of lesion type on the duration of hyperalgesia associated with hindlimb lameness in dairy cattle. *Veterinary Journal*, *156*, 23–29.

Wiese, A. J., Muir, W. W., III, & Wittum, T. E. (2005). Characteristics of pain and response to analgesic treatment in dogs and cats examined at a veterinary teaching hospital emergency service. *Journal of the American Veterinary Medical Association*, *226*, 2004–2009.

Wyn-Jones, G. (1988). *Equine lameness*. Oxford, England: Blackwell Science.