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An HSUS Report: The Welfare of Calves in the Beef Industry

Abstract

Calves raised for beef often begin life unconfined, on rangeland where they are free to express their natural behavior. However, the welfare of calves can be compromised by certain specific management practices, typical on many ranching operations. These include castration of male calves, dehorning, and branding, all of which are usually performed without anesthesia or analgesia, pain relief of any kind. Welfare is also a concern during weaning, handling, auction, and transport, common stressful events that occur before calves are moved to feedlots. Techniques to minimize pain and distress should be used or further developed in order to address the customary practices in beef production that reduce the welfare of these young animals.

Introduction

The U.S. Department of Agriculture (USDA) reports that in 2010, 34.2 million cattle were slaughtered for commercial beef production in the United States.[1] Although cow/calf operations vary by structure and size, cattle raised for beef often begin life on pasture or rangeland.[2] Calves are typically weaned from their mothers and moved to feedlots, where they are intensively confined and "finished" on a grain diet to enhance weight gain and efficiency. In some cases producers may first put calves on pasture for additional grazing after weaning[3,4,5] or place them on a "backgrounding" diet, which includes both forage and limited grain feeding, before moving them to feedlots as yearlings.[6] Cattle brought to feedlots are usually six months to a year in age.[7]

Scientists assess animal welfare by examining animal health, behavior, and physiology. A drop in productivity can be a useful gauge in some situations, but high productivity does not necessarily reflect good welfare. Many different indicators—measured at the individual rather than the group level—are important for a holistic and complete analysis.[8]

While many other commercially produced animals used in agriculture, such as pigs and chickens, are raised in indoor confinement facilities,[1] young calves in the beef industry are largely permitted to roam outdoors, which, in comparison (on a freedom of movement basis), is a substantial welfare improvement. Young calves on rangeland are able to express their full repertoire of natural behavior, breathe fresh air, and stay longer with their mothers. When these calves are kept healthy, safe, and well fed, there is little doubt they experience a good quality of life. However, there are a number of concerns with conventional management practices that negatively affect the welfare of these young animals.

Abrupt Weaning

In a natural environment, the relationship between the cow and her calf can remain close for more than 14 months, especially if the cow has no other calves,[9] and they can share a social bond for years.[10] Maternal

[1] For more information, see "An HSUS Report: The Welfare of Intensively Confined Animals in Battery Cages, Gestation Crates, and Veal Crates" at www.humanesociety.org/assets/pdfs/farm/hsus-the-welfare-of-intensively-confined-animals.pdf.

bonding between mammalian mother and young is mediated by hormones and neurotransmitters that facilitate attachment and maternal behavior.[11] Weaning is normally a slow and gradual process,[12] and as calves grow they begin to incorporate more and more grass and forages into their diet until they no longer rely on milk. The natural weaning process is complete somewhere between 7-14 months of age.[13,14]

In the beef production industry however, calves tend to be weaned early. According to the USDA's National Animal Health Monitoring System "Beef 2007-08" survey, 62.6% of beef production operations weaned calves between 171-229 days (about 5.7 to 7.6 months) and the average age for weaning across all operations was 206.7 days[15] (about 6.9 months). A 1998 USDA report showed that 42.4% of operations weaned calves on the day they were sold or transported off the farm.[16]

Following abrupt separation, calves display behavior consistent with distress,[17,18] including increased walking and vocalizing, less time eating, and increased aggression.[19] The calves' vocalizations may be so protracted that their throats become irritated, increasing the risk of infection.[20] The stress due to unnatural weaning can negatively affect immune responses in calves for several weeks.[21,22,23] They lose weight and become more susceptible to disease.[24] Even with these negative effects, the majority of producers practice abrupt artificial weaning through separation of cow and calf,[25] where the calf may be marketed to an off farm location[26,27] or to a feeding pen separating the cow and calf by sight, sound, and smell.[28,29]

The weaning process is being studied in an attempt to make it less stressful. At least two separate studies show that allowing visual and auditory contact during weaning by separating cow and calf by a fence (sometimes called "fenceline weaning")[30] can reduce calves' behavioral response, causing less distress compared to abrupt weaning.[31,32] In one study, calves provided with fenceline contact with their dams had higher weight gain compared to abruptly weaned calves, [33] but another study found no difference.[34] A further study found that fenceline weaning may simply prolong the stress of weaning as indicated by the behavioral response when the cow and calf are eventually separated completely.[35]

Another method developed in an effort to reduce distress is "two-step" weaning, where calves are first fitted with a device on their muzzle that prevents them from suckling, but permits them to graze normally, and allows them to remain with their mothers. After a period ranging from a few days to weeks, the cow and calf are physically separated.[36,37,38,39] One study found that calves weaned by this two-step method eat more and walk less than calves weaned abruptly, evidence that the procedure reduces weaning stress.[40] A study of two-step weaning of dairy calves from foster mothers found similar results.[41] However, another study found observable behavioral effects immediately after the nose-flaps were inserted and then again when the calves and cows were physically separated 17 days later. The authors of this study expressed concern that prevention of suckling might lead to frustration in the calves.[42] Differences between studies may be due to such factors as duration of the nose-flap treatment, differences in weaning age,[43] and study methodology. More research should eventually clarify which weaning methods are the least stressful overall.

Even earlier weaning, where calves are weaned at less than 6 months and as early as 1½-5 months,[44,45,46] is sometimes practiced in the beef industry. Calves may also be weaned earlier if available forages are inadequate for the nutrient requirements of a lactating cow.[47,48,49] When calves are weaned abruptly at six months of age or younger, stress hormones in both dams and calves increase, as does behavior indicative of psychological stress including walking, urinating, and vocalizing, while the time that calves spend eating decreases; these signs of stress diminish if the mothers and calves are experimentally reunited.[50,51]

Weaning is often performed at the same time as additional, multiple stressors, including separation from familiar peers, handling and transport, mixing with unfamiliar animals, changes in diet (from nursing and grazing to grain-based feed), changes in environment, and painful procedures, such as castration and dehorning.[52,53,54]

Painful Procedures

From a neurological standpoint, cattle and humans perceive pain similarly.[55,56] Pain, the sensation associated with actual or potential tissue damage that elicits an unpleasant sensory and emotional experience, is a warning that damage has occurred, or may occur, and modifies physical and behavioral responses to alleviate the feeling.[57] Calves raised for beef may be subjected to castration,[58] dehorning,[59] and branding.[60] Each of these procedures is known to cause distress, fear, and pain.[61,62] The pain can be separated into three stages: acute pain at the time of surgery, pain over the subsequent few days, and chronic pain that can result from abnormal healing.[63]

Castration

Male calves (called "bulls" when intact and "steers" after castration) are typically castrated, without pain relief,[64] to reduce aggression and improve tenderness and meat quality, as muscle in steers has more fat at an earlier age.[65,66,67] Also, marketing of intact males is problematic because bulls are more likely to fight, especially while waiting for slaughter in a unfamiliar environment or if mixed with other unfamiliar bulls. Fighting prior to slaughter uses up energy stores and results in meat that may be coarsely textured, darker in color, higher in pH value and has a poorer shelf life; a condition known as "dark cutting" meat.[68]

The average age at which calves are castrated is 77 days.[69] Late castration can cause a growth setback, and may affect the health of calves. Castrating calves at six to eight months of age[70] or upon arrival at the feedlot[71] can decrease their average daily weight gain. Compared to calves castrated before entering the feedlot, calves castrated at the feedlot may suffer a 92% increase in morbidity and a 3.5% increase in mortality.[72,73]

There are three typical castration methods. In the first, the testicles are removed surgically. The scrotum is first cut with a scalpel, the testicles are dissected out, the cord and veins connecting the testicles are cut and the testicles are removed.[74,75,76] Castration may also be performed by crushing the spermatic cords with a pliers-like clamp (the Burdizzo method) or applying a rubber ring to constrict the scrotal blood supply. Using the Burdizzo method, the spermatic cord, scrotum, nerves, and vessels of each testis is crushed without breaking the skin. The clamp is held in place for several seconds and may be applied twice per testicle.[77,78,79,80,81] Alternatively, applying a tight rubber ring to the scrotum above the testicles results in lack of blood flow, killing the testicles, which fall off after two to four weeks.[82,83,84,85,86] The 2007-08 USDA survey found that surgical castration was used on 49.2% of operations, rubber ring on 47.3% of operations (39.5% for calves younger than 3 months of age and 7.8% for calves older than 3 months), and clamp/Burdizzo on 3.5% of operations. Larger operations used surgery more and rubber ring less for castration than smaller operations.[87]

Calves experience pain with all three castration methods, both at the time the procedure is performed and in the hours and days following.[88,89,90] The evidence that castration is painful comes from experiments in which behavior and cortisol (a hormone secreted from the adrenal glands during stress) are measured, and studies demonstrating that pain relieving medications reduce or eliminate these responses.[91,92] In calves up to six months of age, rubber ring castration is thought to be the most painful, surgery intermediate, and the Burdizzo method, when correctly applied, least painful.[93,94,95] Due to concerns about increased chronic pain, The American Veterinary Medical Association discourages the use of rubber rings.[96]

When choosing a castration method, other factors in addition to the painfulness of the procedure should also be considered. These include the rate of wound healing, level of staff training, and possible side effects,[97] which can include hemorrhage, swelling, and edema.[98]

Though surgical castration may be more painful to calves than use of Burdizzo clamps, Kevin Stafford, professor of applied ethology and animal welfare, and David Mellor, professor of applied physiology and bioethics, professor of animal welfare science, and Director of the Animal Welfare Science and Bioethics Centre, both at Massey University in New Zealand, suggest that the rapid healing of surgical wounds may, in the

long term, cause less overall pain.[99] There has been objection to Burdizzo castration because the associated swelling may cause significant post-procedural pain.[100] One study found no significant difference in behavior of calves in the weeks following castration by surgery and Burdizzo clamping compared to control bulls, but rubber ring-castrated caves showed increased concern for the castration site, increased licking, and abnormal standing. These behavioral changes indicate that chronic pain, irritation and wound healing could possibly last for 42 days post-procedure.[101]

Though calves are not commonly given pain relief,[102] the use of anesthetics and analgesics following castration by rubber ring or Burdizzo clamp can drastically reduce the associated pain and stress.[103] Local anesthetic can also minimize the pain associated with surgical castration. The injection itself may cause pain to the calves,[104] but this pain is thought to be minimal in comparison to the pain caused by castration without the use of anesthetics or analgesics.[105] Other routine and painful procedures, such as dehorning, may also occur at the time of castration, making pain relief critically important during this time period.[106]

Not only does pain relief improve welfare, but science is beginning to show health and subsequent economic benefits to providing pain medication for castration procedures. One study found reduced *E. coli* populations in the gut of calves, a sign of stronger immune status, when they were provided with xylazine and flunixin meglumine during banding.[107] In another study, oral meloxicam was shown to reduce the incidence of respiratory disease experienced by cattle in feedlots, thus potentially reducing the need for antimicrobial therapy and lowering the cost of treating cattle for bovine respiratory disease.[108] Continued research is needed to further elucidate the effects of pain control on the health of calves, but initial results are promising.

Horn Bud and Horn Removal

When confined in enclosures such as yards and feedlots, and during transport, animals with horns may cause injuries and bruising.[109,110] In order to prevent these injuries and to facilitate easier handling, the horn buds or horns are often removed.[111,112] These procedures are commonly performed without pain relief,[113,114] though both disbudding and dehorning result in physical pain and are stressful to the calves.[115] Genetic options exist, however, which make this procedure unnecessary.[116,117,118]

In calves, horn-producing cells in the skin form buds. When the animals are approximately two months old, the buds attach to the skull and the horns begin growing. Horns are considered extensions of the skull and their hollow core opens into the skull's frontal sinus.[119,120] The horn bud, the horn, and its base are innervated.[121] "Disbudding" is the destruction of these horn-producing cells before the bud attaches to the skull, when the horn buds are 0.5-1.0 cm (0.2-0.4 in) long.[122] Once the horn begins to grow, the procedure is referred to as "dehorning." According to the 2007-08 USDA survey, only 23.4% of U.S. beef production operations performed the procedure before 61 days of age,[123] which means the majority of facilities dehorned calves only after the horns began growing.

The 2007-08 USDA survey found that on average, cattle are dehorned at 119 days old. The following tables indicate the percentage of operations 1) disbudding or dehorning in different age ranges and 2) using different methods:

Age Ranges and Percentages of Operations Disbudding / Dehorning[124]					Disbudding / Dehorning Method Used[125]	
1-31 days	6.2%		123-153 days	7.6%	Saws, scoop, or keystone (guillotine or shears)	39.2%
32-61 days	17.2%		154-183 days	15.8%	Spoons or gouges	30.6%
62-92 days	19.6%		184-214 days	7.8%	Electric dehorner/disbudder or hot iron	24.5%
93-122 days	7.8%		≥215 days	18%	Caustic paste	5.7%

Disbudding is typically performed using "mechanical" methods or, less commonly, with a "bloodless" method that causes chemical burns.[126,127] Mechanical methods remove the horn bud and surrounding skin with a sharp object. Spoons, gouges, or knives cut out the horn bud, and the resulting skin may then be treated with caustic chemicals. Cups or scoops operate in a scissor-like fashion—the tool is placed over the horn bud, pushed down into the head with force, and then lever arms close, cutting out the bud with some surrounding skin.[128,129] This causes a distinct behavioral response,[130] elevated cortisol levels, and has been linked to pain-induced distress lasting for up to nine hours.[131] The bloodless method involves use of caustic paste, which cauterizes the wound with chemicals or heat. The paste is applied on the horn bud and surrounding skin in multiple applications with a paddle, allowing for drying of the paste between applications.[132] It has been shown that disbudding with a chemical paste increased the number of headshakes and head rubbings; both behavioral responses were highest in the first four hours following disbudding,[133,134] and caused cortisol levels to rise.[135] The paste can leak caustic chemicals from the site of application, damaging the skin and eyes of the calves, the udder of mother cows, and even other calves.[136,137]

Cautery, or hot-iron, disbudding is performed with a glowing, red-hot, cup-tipped tool that is placed on and slowly rotated over the horn bud for about 10 seconds, burning through the skin and destroying the tissue that generates the horn.[138] The resulting tissue is either left to fall off or is removed by blunt impact.[139] Cautery disbudding is associated with significantly increased cortisol levels[140] and incites escape behavior, such as falling down, rearing, head jerking, and pushing, which are associated with intense pain.[141] Cautery disbudding also causes an increased frequency of head shakes and ear flicking, with a peak in both behavioral responses six hours after disbudding.[142] Further, tail wagging, tripping, head shaking, rearing, and abnormal backward locomotion are displayed at higher than normal frequencies as a result of this procedure.[143]

Physiological parameters indicative of stress have also been found to be higher after chemical and hot-iron disbudding compared to basal levels,[144,145,146] and scoop disbudding is reportedly more painful than hot-iron or chemical cautery.[147] Use of an anesthetic diminishes the severity of struggling and escape behavior during disbudding.[148] The Farm Animal Welfare Council (FAWC), an organization established to advise the U.K. government on issues regarding the welfare of farm animals, recommends that disbudding with a chemical paste should never be used,[149] and the European Food Safety Authority's Scientific Veterinary Committee (SVC) states that hot-iron disbudding is the preferred method.[150]

When horns begin to grow, calves can no longer be disbudded. Instead, horns are removed through amputation dehorning[151,152] wherein a saw or large guillotine or shears is used to cut the horn near its base. Some of the surrounding skin is removed as well. Guillotine or shears can fracture the skull during dehorning.[153,154]

Calves between six weeks and six months of age show increased cortisol concentrations after amputation dehorning.[155] Behavioral and cortisol response monitoring of calves after this procedure suggests that pain lasts for a minimum of seven to nine hours.[156,157] During the post-dehorning period, calves show more tail, head, and ear shaking,[158] more lying and scratching, and less grazing, rumination, and grooming behavior,[159] all of which

are behavioral signs that may indicate pain. The cortisol response to amputation dehorning is significantly greater than the response to chemical or cautery disbudding.[160]

Injecting a local anesthetic before dehorning can prevent pain-related behavioral and cortisol responses;[161,162] however, an anesthetic alone may only delay the cortisol response while it is functioning.[163,164] Conversely, Non-steroidal Anti-inflammatory Drugs (NSAIDs), a type of analgesic, may not be effective immediately, but can eliminate the cortisol response due to long-term inflammatory pain.[165] Cauterization of the wound (burning the skin and destroying the nerve endings that convey pain signals) after dehorning, combined with a local anesthetic will also prevent the normal rise in cortisol.[166] Using either a combination of anesthetic and NSAID, or anesthetic and cautery, the cortisol response can be significantly reduced for approximately nine hours after dehorning,[167,168] and appears to be the most effective method of controlling pain during and after the dehorning procedure. Use of pain relieving drugs has been recommended[169,170] by experts such as the U.K. FAWC and the European Food Safety Authority's SVC,[171,172] yet providing anesthetics and long-acting analgesics remains relatively uncommon.

Disbudding and Dehorning Procedures and Acute Cortisol Response[173]

Procedure	Acute cortisol response
Amputation dehorning	100%
Amputation dehorning with prior local anesthetic**	100% and delayed*
Caustic disbudding	> 55%*
Cautery disbudding	55%*
Cautery disbudding with prior local anesthetic**	55%*
Caustic disbudding with prior local anesthetic	< 55%*
Amputation dehorning with prior NSAID	35%*
Amputation dehorning with prior local anesthetic** and NSAID	25%*
Amputation dehorning with wound cautery and prior local anesthetic**	25%*

* percentage of the acute cortisol response to amputation dehorning in each study
** injected near the corneal nerve supplying each horn bud

Ample scientific evidence shows that the customary practices of disbudding and dehorning without pain relief are known to reduce the welfare of animals. These procedures should be discontinued.

Polled Cattle

The use of cattle without horns, known as "polled" cattle,[174,175] can address problems with injury and bruising without the welfare problems associated with painful horn or horn bud removal. Indeed, as with disbudded and dehorned cattle, handling of polled cattle is easier and safer, and the animals are less likely to injure other cattle.[176,177,178] Horns are a recessive trait. As such, breeding polled cattle is not complicated,[179] and in a single breeding season an entire herd of polled calves could be produced simply by breeding horned cows to a polled bull (homozygous for the polled genetic trait).[180] One sign indicates that the U.S. beef industry may be moving in this direction: the aforementioned 2007-08 USDA survey reports that the number of calves born who were expected to develop horns has decreased from 29.3% in 1992-93 to 12.4% in 2007-08.[181]

In a review of the veterinary literature on horned and polled cattle, Kishore Prayaga, a geneticist formerly with the Livestock Industries division of Australia's Commonwealth Scientific and Industrial Research Organisation, concluded that "[s]cientific evidence suggests that there are no significant differences between polled and horned animals in any of the productive and reproductive traits as demonstrated in many studies that validly compared polled and horned animals,"[182] a finding corroborated by other scientists.[183,184,185]

Stafford and Mellor write that, although there are long-term benefits to not having horns, "disbudding and dehorning without local anaesthesia, sedation or systemic analgesia is painful and distressing to cattle,"[186] and Joseph Stookey, Professor of Applied Ethology in the Department of Large Animal Clinical Sciences at Western College of Veterinary Medicine, University of Saskatchewan, recommends that "[f]rom an animal welfare perspective alone, we should be moving towards dehorning beef cattle via genetic selection."[187]

Branding

To provide proof of ownership and identification, cattle raised for beef are often branded. This practice is especially prevalent in the western United States where cattle from different operations commingle.[188] Hot-iron and freeze branding are the two most common methods.

Hot-iron brands are applied with a heated branding iron of approximately 520°C (968°F), pressed into the skin for approximately 5 seconds.[189] This process burns the hide and underlying tissue, leaving a hairless, permanent scar on the hide.[190,191]

Freeze branding is performed in a similar way, but instead with a very cold iron. Freeze branding destroys the cells that produce pigment and turns the hair white without damaging the hide.[192] The hair is first trimmed from the area where the brand is to be applied,[193] and then methanol is applied liberally to the clipped area. An iron cooled with either liquid nitrogen or dry ice and alcohol is held to the skin. Liquid nitrogen-chilled irons are cooled to -196°C (-321°F) and held to the skin for approximately 10 seconds for month-old cattle or up to 25 seconds for adults; irons cooled with dry ice and alcohol are chilled to -78.5°C (-109.3°F) and held in contact with the hide for an additional 10 seconds.[194,195]

The 2007-08 USDA survey found that 40.4% of operations used some type of herd identification and 61.3% of cattle and calves were marked: 44.8% of herds were hot-iron branded and 1.0% were freeze branded (another 27.6% had plastic ear tags, 16.2% had ear notches, 3.2% were given ear tattoos, 1.1% metal ear tags, 0.6% had electronic ID or microchips, and 0.4% were marked with an 'other method').[196]

Although both hot iron and freeze branding methods are known to cause pain, increased heart rate, a cortisol response, vocalizations, and other behavioral responses,[197,198,199,200] hot-iron branding will often elicit responses that indicate it is more painful and stressful for animals than freeze branding.[201,202] Freeze branding increases the heart rate for a longer period after application than hot-iron branding, and this is thought to be associated with thawing of the brand site and perhaps linked to a prolonged pain sensation.[203,204] However, studies comparing the two methods found that hot-iron branding evoked a stronger cortisol and heart-rate response, more vocalizations, and greater behavioral response associated with pain compared to freeze branding.[205,206,207]

Age Effects

Because the nervous system of neonatal animals continues to mature after birth, it has been argued that they experience less pain than older animals.[208] Interestingly, the same arguments were once used by health care providers, and partly as a consequence of this misunderstanding, many neonatal surgical and other invasive procedures were historically performed on human infants without analgesia or anesthesia. Medical practitioners now recognize that not only do infants experience pain, but that they may also experience it more acutely than adults,[209] and the same is likely true of animals.[210] In fact, there is now growing concern that pain experienced

by human infants and young animals may have long-term adverse consequences, including altered neurological development and heightened pain sensitivity later in life.[211,212,213]

Young animals may respond in a different behavioral and physiological way to pain, and this can make it difficult to identify painful experiences. For example, in a study of calves less than one week old, some of the abnormal lying and standing postures normally associated with pain in older calves were not readily apparent after castration.[214] As an anti-predator response, young calves may also "freeze" during painful procedures, leading handlers to presume that they don't feel pain.[215] The developing nervous system and changing sensitivity of the hypothalamic-pituitary-adrenal axis can complicate the measurement of pain experienced by young animals during research trials.[216]

Despite these difficulties, researchers have still been able to demonstrate that young calves do indeed feel pain. In a study of calves under one week of age, castration using the Burdizzo method (chosen because it is thought to produce the least amount of pain) caused struggling behavior consistent with a painful experience. Further, local anesthesia reduced the struggling behavior during castration and calves that received this pain relief had lower cortisol levels. The researchers in this study concluded that these very young calves were able to perceive and respond to pain.[217] In an exhaustive review of the research literature, The Scientific Committee on Animal Health and Animal Welfare, an advisory body to the EU Commission, concluded that "[v]ery young animals feel pain and show signs of distress, and may feel pain more than adults."[218]

Pain Relief

To prevent suffering, anesthetics and analgesics should be provided to control immediate and long-lasting pain, respectively. When injected near nerves that relay pain signals, anesthetics will temporarily diminish the painful experience by blocking nerve transmission,[219] but once the anesthetic wears off, the "pain impulse traffic" from the damaged tissue may resume and the animal will likely begin to feel pain again.[220] Therefore, pain during the procedure should be minimized using anesthetics, and long-term pain should be alleviated using anti-inflammatory drugs.[221, 222] Pain relief provided during and after these surgeries not only reduces the sensation of pain but also decreases the potential for surrounding areas to become hypersensitive to further pain (hyperalgesia),[223] a common outcome of tissue injury.

Despite the fact that procedures are painful, providing pain relief is uncommon due to a number of factors, including cost, tradition, lack of knowledge, and fear of drug residues in meat.[224] A further barrier is the fact that there are presently no drugs approved by the U.S. Food and Drug Administration for pain relief in animals raised for food.[225,226] However, producers working closely with veterinarians can provide pain relief to prevent animal suffering with "extra-label" drug use under the Animal Medicinal Drug Use Clarification Act (AMDUCA) of 1994.[227] Recommended withdrawal periods for some drugs that can be used extra-label have been established,[228] and these recommendations can be further extended to be sure that no residues remain in the meat.[229] The American Veterinary Medical Association acknowledges the pain associated with dehorning and castration procedures, and recommends that pain relief be provided. The AVMA policy states:

> Because castration and dehorning cause pain and discomfort, the AVMA recommends the use of procedures and practices that reduce or eliminate these effects, including the use of approved or AMDUCA-permissible clinically effective medications whenever possible. Studies indicate that preoperative use of non-steroidal anti-inflammatory agents and local anesthetics reduces pain and distress associated with castration and dehorning.[230]

Even though analgesics are uncommon, some are used on occasion, and the most widely administered are non-steroidal anti-inflammatory drugs (NSAIDs), which can significantly reduce the post-procedural cortisol response.[231] Continued research is needed to identify practical, affordable and easily accessible pain relieving drugs for animals raised for food production.

Cauterizing wounds, by destroying tissue and pain-receiving nociceptors with heat, has also been used to reduce pain, blood loss, and infection. Wound cautery destroys nerves that transmit painful sensations to the brain, so that after the pain from the burn has subsided, transmission of pain through surrounding nerves is diminished. Procedures involving cautery produce lower cortisol responses and distress from pain.[232] However, since anesthetics used with cautery reduce both cortisol distress and behavioral indicators associated with pain,[233,234] cautery should not be performed without them.

Calf Transport

Calves raised for beef production are born on ranches that are widely distributed throughout the United States, wherever grasslands are abundant.[235,236] However, since 65% of calves are fattened in feedlots in Texas, Kansas, Nebraska, and Colorado,[237] many calves are shipped from distant states[238] usually by truck.[239] Nearly two-thirds (62.5%) of cattle and calves raised for beef are sold through an auction barn after leaving the farm,[240] thus many calves are moved twice before arrival at a feedlot. Transportation causes stress that can result in an increase in morbidity and mortality.[241]

Transport stress takes a toll on calves physically, physiologically, and psychologically.[242,243] Known transport related stressors include pre-transport management factors (e.g. weaning),[244,245] and conditions associated with transport itself, including unfamiliar surroundings, novelty, noise, vibration, social regrouping, environmental changes, loading and unloading, temperature extremes, exposure to new pathogens, prolonged transit times, and feed and water deprivation.[246,247,248] In research trials, stress from transport is indicated by increased heart and respiration rate, body temperature, blood cortisol,[249,250] and catecholamine concentrations,[251] and a commonly observed weight drop,[252,253] all of which are physiological signs of reduced welfare. Loading and unloading are particularly stressful.[254,255]

Transport can have a marked effect on the behavior of cattle. Calves may spend less time lying and ruminating while being moved on a truck; in one study transported calves spent only 5.7% of the in-transit time lying compared to 31% for calves who were not transported, and 1.4% ruminating compared to 20.7% in non-transported calves.[256] Researchers have noted that in journeys lasting over 12 hours some animals begin to fall down due to fatigue.[257]

Transport is also known to decrease cattle's immunocompetence, leading to an increase in disease susceptibility[258,259,260] and may increase the shedding of pathogens.[261,262] Shipping fever, also called bovine respiratory disease, is associated with transport stress-induced immunosuppression.[263] Associated symptoms include fever, dyspnoea (labored respiration), fibrinous pneumonia,[264] and less commonly gastroenteritis and internal hemorrhage.[265] Shipping fever usually occurs 7-10 days after arrival at the feedlot[266] and may be responsible for 75% of feedlot morbidity and 50% of mortality.[267] The annual cost of shipping fever to the U.S. beef industry has been estimated at $500 million.[268] Young cattle may be particularly susceptible to disease due to their extreme sensitivity to stress.[269] Despite the toll that shipping fever regularly takes on animal health and welfare, 60% of operations do not vaccinate against respiratory disease.[270]

When transport immediately follows weaning, the stress of both events is compounded. Both weaning and transport cause a rise in cortisol. However, in one study, cortisol levels returned to baseline within two days in weaned calves, but not until at least four days and as long as seven days in calves who were both weaned and immediately transported. The authors concluded that transporting and handling calves immediately following weaning may be an important factor in the development of shipping fever.[271] This conclusion is supported by other studies: one group of researchers that found acute-phase protein concentrations (an early physiological response to disease and inflammation) increased in newly weaned calves.[272] Another group found that transportation and weaning had an affect on immunoglobulin levels of calves, an effect that persisted for several weeks.[273] Colorado State University Professor of Animal Science, Temple Grandin, has stated that calves who are "unvaccinated and have not recovered from weaning stresses are not fit for transport."[274]

The practice of "preconditioning" calves prior to transport can improve their tolerance of handling and transport stress. Preconditioned calves are weaned for at least 45 days prior to loading for transport and are trained to eat from a bunk feeder before they arrive at the feedlot.[275] Some preconditioning programs also require calves to be vaccinated.[276] By vaccinating calves, and castrating and dehorning them early, the effects of additive stressors at the time of transport can be reduced. Preconditioned calves are then better able to tolerate the stress of handling and transport to a feedlot.[277] In addition to improving the welfare of the calves, preconditioning combined with reduced transport time has been shown to reduce fecal shedding of *E. coli* O157:H7, a bacteria of significant public health concern.[278]

The U.S. Federal 28-Hour Law limits the length of time that animals can be hauled without food, water and rest. The law generally requires that animals traveling longer than 28 hours be unloaded for at least five hours, fed and provided with water before continuing on a longer journey. The time spent loading and unloading animals is not included in the time limit, and if requested in writing, animals may be confined even longer, for up to 36 hours during transport.[279] The 28-Hour Law is the only federal regulation protecting animals prior to their arrival at a slaughter house. Despite this, the law has been under-enforced, as demonstrated by the fact that there are no reported USDA administrative decisions involving USDA enforcement of this law since 1977, and no reported federal cases involving enforcement since 1960.

Conclusion

Many animals kept for meat, milk, and egg production are intensively confined in indoor housing environments, but calves raised for beef production commonly begin life in an extensive, pasture-based system where they are free to express important natural behavior. Thus the early life experience of calves has high welfare potential. However, painful and stressful events, especially when experienced concurrently, are deeply concerning. Abrupt weaning of young animals, surgical procedures without pain relief, and branding are serious issues that must be addressed. Refined weaning processes are needed. Approved pain-relieving medications that are easy to administer and widely available should be a priority for the beef industry. The use of polled cattle should be encouraged so that disbudding and dehorning become unnecessary. Calves should be preconditioned prior to transport, and the number of trips and journey length should be limited. Where possible, calves should remain on their natal farms from birth to slaughter. Given the weight of the substantial scientific evidence that calves suffer during routine management practices, it is incumbent upon the beef industry to address the welfare issues in beef production.

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