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Discussion

Why pain is still a welfare issue for farm animals, and how facial expression could be the answer.

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Abstract: Pain is a sensory and emotional experience that significantly affects animal welfare and has negative impacts on the economics of farming. Pain is often associated with common production diseases such as lameness and mastitis, as well as introduced to the animal through routine husbandry practices such as castration and tail docking. Farm animals are prey species which tend not to overtly express pain or weakness, making recognizing and evaluating pain incredibly difficult. Current methods of pain assessment do not provide information on what the animal is experiencing at that moment in time, only that its experience is having a long term negative impact on its behavior and biological functioning. Measures that provide reliable information about the animals' affective state in that moment are urgently required; facial expression as a pain assessment tool has this ability. Automation of the detection and analysis of facial expression is currently in development, providing further incentive to use these methods in animal welfare assessment.

Keywords: Pain; production animals; facial expression; welfare.

1. Introduction

The welfare of farm animals is receiving increased attention from the general public with a rise in the number of people concerned about how animals are used to produce food [1]. Allowing an animal to experience pain that could be alleviated, or performing painful practices intentionally on animals are amongst the highest concerns the public has about animal welfare [2–8]. Farm animals are recognized as sentient beings that have the ability to experience both pleasurable and aversive states [9], and there is legislation around the world protecting animals from pain and suffering, albeit inconsistent in level of protection and enforcement; for example, the UK's Animal Welfare Act 2006 protects farm animal welfare by preventing unnecessary suffering caused by an act or failing to act when required, whereas France's Rural and Maritime Fishing Code and the Penal Code, although offers some protection from deliberate cruelty or neglect to captive animals, it does not cover wild animals and it provides exemption for traditions such as bull fighting, cock fighting and the force feeding of ducks and geese to produce foie gras. Despite legislation in place, pain is still a welfare problem in farm animals who are routinely subjected to painful practices, and experience production related diseases that cause pain and distress. Pain is likely the most significant affective state to impact farm animal welfare as it has significant negative effects on production and an animal's quality of life.

As a prey species, it is evolutionarily advantageous for farm animals not to overtly express any weakness, and thus one of the most common reasons why farm animals still experience pain is a lack of human ability to recognize it [10]. Effective assessment and alleviation of pain are intrinsically linked, meaning that unless we can recognize it we cannot judge its severity and thus cannot manage it successfully. There is an inherent need for a valid and feasible pain assessment tool that can reliably recognize and evaluate the pain experienced by the animal.

The aim of this paper is to briefly discuss some of the reasons why farm animals still experience pain, and to highlight current obstacles hindering the ability to prevent and alleviate pain effectively. It is not intended to be a comprehensive review of the literature on pain in farm animals, but a conceptual and practical discussion. The paper will discuss relevant current pain assessment methods available, highlighting the potential of facial expression as a new technique to recognize and evaluate pain. It will also highlight the potential for facial expression measurement to become an automated system for the early detection of pain.

2. Anatomy and physiology of pain

Pain is a complex phenomenon, often involving actual or potential tissue damage and involves both a sensory and affective component [11–13]. The sensory component refers to the transmission of information from specialized peripheral pain receptors (nociceptors) about tissue damage, to the brain via the afferent nerve pathway. The affective component of pain refers to the actual experience of pain, and is what the animal feels [11]. Pain often comes in two different forms: acute or chronic. Acute pain, mainly caused by injury, infection or inflammation, is often short-lived and responds to effective pain relief. Chronic pain is longer lasting, even beyond the healing process. Where there is sustained activation of nociceptors, nerve damage, or neural dysfunction, neuropathic pain can present itself as hyperalgesia (increased sensitivity to pain) or allodynia (pain experienced from a normally non-painful stimuli) [14,15]. Neuropathic pain can be difficult to manage [16] and chronic pain is associated with a greater degree of emotional distress, significantly impacting on an animals' quality of life [17,18]. The changing nature of the signal transmitted to the brain complicates our understanding of the sensory component, making diagnosis of possible causes, as well as the effective management of the pain, extremely difficult [16]. Moreover,

it will have a significant impact on the affective experience of pain and the associated suffering.

3. Causes of pain in farm animals

In order to improve our understanding of why pain is still a welfare issue for farm animals, a brief exploration of known or potential causes of pain, is required (for an in-depth review, see Guatteo et al. [19]). Pain in farm animals can be caused by disease (infectious and non-infectious), injuries caused by poor housing or handling, poor hygiene and housing management, and routine husbandry practices such as castration and tail docking, or natural processes such as parturition. Many of these factors can be reduced or even eliminated through changes in management practices.

3.1 Disease

Disease is a major cause of pain in farm animals. Disease can have multiple origins; some painful diseases relate to intensified production or are a consequence of poor environmental management, whilst others may be related to infectious agents. Understanding the pathology and epidemiology of the disease is vital to understanding the negative effects it may have on the animal, and this should be considered in detail when assessing the potential pain being experienced. Whilst it is beyond the scope of the current paper to detail every disease that might possibly cause pain in farm animals, there are a few diseases that are common to multiple species and are known to be painful, such as lameness and mastitis.

Lameness can be caused by a variety of factors including infectious and non-infectious agents, poor conformation, or injury. Not all lameness is painful and so it is important to investigate the underlying cause. Lameness caused by infectious agents such as *Dichelobacter nodosus* (Beveridge 1941, Mraz 1963, Dewhirst et al. 1990) and *Fusobacterium necrophorum* (Flügge 1886, Moore & Holdeman, 1969) are a common

condition in cattle, sheep, and goats [20]. In sheep *D. nodosus* and *F. necrophorum* cause footrot which causes chronic pain that is still present after disease resolution [21]; this is likely to be the same in goats and cattle. Digital dermatitis (DD) is another disease that causes significant lameness and chronic hyperalgesia [22] in dairy cattle. DD is one of the most prevalent foot health problems in dairy cattle across Europe, USA, Africa, Australia and South America [23], caused by a number of infectious agents, as well as being related to management and environmental factors (see Refaai et al. [23], for a review).

On the other hand, some lameness is a result of increased intensification and genetic modification of the animal. The extent of growth rates in broiler chickens has led to skeletal pathologies causing weakness in the legs and is one of the major causes of lameness in chickens [24]. This in turn causes the birds to sit more as their activity is reduced [19,25], increasing the chances of painful dermatitis lesions, which are also a major cause of severe pain for these animals [26,27].

Another common disease that causes severe pain in farm animals is mastitis, an inflammatory condition of the mammary glands. Pathogens such as *Staphylococcus aureus* (Rosenbach, 1884) cause painful lesions in the teat canal [28,29], and both sheep [30] and cattle show hyperalgesia [31] in the local area. The facial expression of both sheep [32] and cattle [33] have also been observed to change in response to mastitis, with sheep showing a significant change in facial expression in response to effective treatment with antibiotics and NSAIDs [32], providing support for the painful nature of the condition.

3.2. Housing and handling

Some forms of housing can cause injuries to animals leading to pain. Slatted flooring, although useful for maintaining cleanliness and hygiene, can lead to animals developing bursitis and skin lesions [34], as well as increasing the chances of an animal becoming severely lame, by as much as nearly fourfold in one study [35]. Proper maintenance of these

floor types can decrease the chance of skin lesions and lameness [36], improving animal welfare. Changing some of the materials used in animal housing can also have a positive effect on welfare, for example Brscic et al. [37], covered concrete slats with a synthetic rubber, reducing the number of beef cattle needing treatment for locomotor problems. Stratmann et al. [38] also reduced the number of keel bone fractures in laying hens by adding a polyurethane material around metal perches in an aviary system.

The design of the housing and handling facilities, is also important to consider for preventing pain in farm animals. Many facilities are designed with right-angled bends which are difficult to move around for many farm species and can cause bruising to animals on impact [39]. The introduction of curved chutes and round pens should ease the movement of animals, reducing impacts that cause pain [40]. Faults in the design also include projecting fittings which can cause significant injuries if animals are to collide with them [39]. Slips, trips and falls can also be reduced by ensuring that floors are properly maintained [41]. It is important for facilities to be designed so as to prevent animals getting their legs caught in fences or gates [41,42] which can lead to significant tissue injury or even breaking of bones.

Improper handling has the potential to cause pain, especially when combined with poor facility design. Rushing of animals increases the potential for them to slip and fall, whilst some animals may attempt to escape, running into or attempting to jump fences. Poor handling of spent hens when loading and shackling can also cause leg bone breakages and dislocations of wings [43]. For sheep, pulling on the wool or skin folds is a common inappropriate handling technique [42] that causes pain, and bruising of the carcass [44]. In cattle, the tail twist is often used to move the animal forward. This technique is aversive [45] and if care is not taken, the tail can be twisted too far causing breakages.

Moving aids such as electric goads or sticks have clear potential to be used inappropriately and inflict pain [46]. Not only can they inflict pain directly, but their use increases the chances of cattle falling or stumbling when being moved [47]. Electric goads

are highly aversive [45,48], and many countries have strict regulations about their application to animals. Often, simple changes in the design of facilities, or improved education of handlers can significantly reduce the need for the use of electric goads, or other moving aids [40,48–50], improving animal welfare.

3.3 Routine practices

Part of caring for farm animals involves carrying out certain procedures that are painful. These procedures can be carried out for a number of reasons including reducing the risk of injury and disease, and improved handling control (see table 1 for a summary of procedures and reasons for each species). When and how these procedures are carried out differs across farms, and countries, but many are carried out in the first few days of life. There is some thought that neonates do not experience pain due an underdeveloped nervous system, and so anesthesia and analgesia are very often not administered. This is not the case; each method causes pain to the animal demonstrated through changes in behavior and physiology [51–53], irrespective of age [54]. The pain caused by these procedures can be acute [55], lasting only a few days, or it can be longer lasting (up to 42 days [56]), and thus chronic. Early experience of pain can have long lasting effects on an animal, even potentially being transferred generationally; for example, Clark et al. [57] found that pain experienced by ewes when they were lambs, changed the way their own lambs behaved to a painful experience. Husbandry practices that are carried out without pain relief are counterproductive to farm production and a significant welfare concern.

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Table 1. Routine husbandry practices carried out on farm animals and their reasons.

Procedure	Methods	Reason	Species
Castration	Rubber ring, surgical removal, clamping/crushing of the spermatic cord	Reproduction control, enhance carcass quality e.g. tainting, reduce aggressive behavior, improve ease of handling	Cattle, sheep, goats, pigs
Tail docking	Rubber ring, surgical removal, or cautery iron	Reduce undesired behavior e.g. tail biting in pigs, reduce chances of fly strike (e.g. sheep), reduce disease spread (e.g. cattle)	Cattle, sheep, pigs
De-horning/ disbudding	Cauterization, caustic chemical disbudding, surgical disbudding, amputation dehorning	Reduce chances of injury to others (animal and humans), prevent carcass damage such as bruising	Sheep, cattle
Ear tagging/ notching	Tagging machines, punching hole in the ear, ear notching	Identification	Cattle, sheep, goats, pigs
Branding/ freeze-branding	Hot iron, freeze branding using liquid nitrogen	Identification	Cattle, pigs
Mulesing	Cutting away skin folds around perianal region	Reduce chances of fly strike (e.g. sheep)	Sheep
Teeth grinding/clipping	Electrical grinding, manual clippers	Prevent carcass damage such as bruising	Pigs
Nose ringing	Specialized equipment to punch hole in septum	Reduce damage to environment	Pigs, cattle
Beak trimming	Cauterizing blade, infrared beam	Reduce feather pecking and carcass damage	Chickens

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Some of these procedures are also carried out to resolve behavioral problems associated with how the animals are managed. Tail biting and feather pecking are prime examples of behaviors that are controlled by subjecting animals to painful practices such as tail docking, teeth clipping/grinding or beak trimming, rather than solving the cause of the behavioral problem. In the European Union (EU), there have been recent changes to tail docking procedures, where it is no longer permitted to be carried out routinely. Producers need to demonstrate that they have attempted to change the housing and environment for their pigs before they can tail dock them, and only then can it be carried out under the supervision of a veterinarian or by other trained personal (EU directive 2008/120/EC). This is a significant advancement in how these procedures and abnormal behaviors are considered. Clear justification for carrying out these routine procedures must be demonstrated, and every effort must be made to minimize the pain experienced by these animals.

3.4 Parturition

Parturition is reported to be an incredibly painful experience in women [58,59], and it is likely that parturition is also painful in other mammals. Women are provided with pain relief either through gas and air, or via an epidural during labor; however, this is not possible in animals as there is concern that the animal would no longer feel contractions and stop pushing. Difficulties during parturition are considered painful enough to administer analgesics post-partum, particularly in dairy cattle [60]. Cattle receiving post-partum analgesia tended to feed quicker [61,62] and resume activity sooner [63] compared with controls, highlighting the importance of considering the effect of parturition on animal welfare. There is limited literature on the use of analgesics in other farm species around the time of parturition, and of the effect of any assistance given during the birth if required. This could mean that there are times when many farm animals maybe experiencing unnecessary pain, for longer.

4. Impacts of pain on animal behavior, production and economics

Pain can result in pathological changes to an animals' physiology and behavior, reducing quality of life and causing suffering [64,65]. Pain disrupts sleep [66–68], decreases food and water intake [69,70], and reduces key behaviors such as grooming [71–73] and play [55,74,75]. Behaviors such as sleep, and food and water intake are essential to an animal's survival. When food and water intake are affected by pain this can slow recovery from disease or other tissue damage, as animals will not gain the vital nutrients that they need [76]. Sleep deprivation in animals can have severe consequences to an animals normal functioning, including negatively affecting their immune system [77]. Behaviors such as grooming and play are positive in nature and self-rewarding [78]. They could be considered an ethological need and thus deprivation of these needs caused by pain can have a severe impact on an animals' quality of life [79].

In the case of farm animals, pain causes a reduction in production/growth levels [80], directly conflicting with the aim of farming. Diseases such as lameness and mastitis not only have costs associated with their treatment, but there are costs associated with production losses. In 2005, the annual total cost of footrot in sheep was estimated at £24 million in the UK [81]. Production losses and losses due to culling totaled £8 million/annum [81]. Wassink et al. [82], demonstrated prompt treatment of individual lame sheep ensured better productivity of the ewes meaning more lambs were finished, and the gross margin increased by £630 in the year. These results show a clear economic benefit to reducing pain through effective and prompt treatment of individuals showing indications of lameness. Unfortunately, this is often not what happens on farm, with 30% of UK farmers reported to take more than a week to catch and treat individual sheep, with 14% not catching them at all and only treating them during routine gatherings [83]. This leaves animals in pain, reduces overall production, and with a highly contagious disease such as footrot, exposes other animals to the disease increasing the negative impact on both production and animal welfare.

For mastitis, again prompt treatment with antibiotics has been demonstrated to reduce the total cost of the disease (including lost production) by as much as three-fold when compared with just supportive treatment [84]. The changes in the behavior of cattle with mastitis have a knock-on impact to production; cattle with mastitis reduce their feed intake [70] and they tend to lie down less, especially on the side of the infected udder [85], indicative of the pain associated with this area. These two behaviors of eating and lying down are key to high milk production [86,87], and so when prevented through disease, production and welfare suffer.

Pain caused by poor handling can have a negative impact on production. Tail twisting in cattle has been shown to negatively impact on productivity and increase the milk bulk tank somatic cell counts (BTSCC) [88]. High BTSCC are likely to have penalty costs associated with them [89] as dairies will not want to lower their milk quality. In addition, high cell counts are often used to detect subclinical mastitis, suggesting that the tail twisting may have additional impacts on the animal's health, predisposing them to a higher chance of mastitis.

Mother-offspring bonds are also affected by pain. Ewes with mastitis, show a decrease in the number of vocalizations to call offspring to suckle and increasingly hinder suckling [90]. The lack of suckling will reduce the bond between the ewe and her lamb as the lambs find resources elsewhere, spending less time with their mothers. This will have a knock-on impact of overall production with lambs not receiving enough milk to grow properly.

5. Assessing pain in farm animals

Current methods used to assess pain in farm animals focus on changes in behavior, physiology and production/bodily functions. For example, a reduction in play behavior was noted after castration in lambs [55], and after disbudding in calves [74]. Devant et al. [53], noted feed intake declined after castration, as did lying behavior and overall activity levels. Bonastre et al. [91], assessed the physiological responses of piglets to castration, finding surface skin temperatures to drop immediately after castration independent of any anesthesia

or analgesia given. They also found glucose concentration to increase in response to castration, and cortisol concentrations to differ in response to castration with or without anesthesia and analgesia. There are also a number of studies demonstrating the significant negative impact of lameness in dairy cattle on milk yield [92–95]. It must be remembered that there are a number of other possible factors that can affect production, and not just pain, making productivity an unreliable measure of current affective state.

There are numerous limitations to the collection and interpretation of these measures. Many of these measures act more as a long-term indicator of the impact of pain, meaning that they cannot provide a true reflection of how an animal may be feeling at that moment. Collection of some of the physiological measurements require the animal to be restrained, compromising the ability to interpret changes as painful as opposed to stressful. Other pain assessment systems have been developed in response to this, and they rely on monitoring short-term behaviors such as vocalizations [96], escape attempts [97], lameness [94], or posture changes [57,98] where animals try to adopt a position that limits the pain experienced. Many of these indicators are not pain specific and can be seen in response to other affective states such as fear or stress, or even positive states such as joy.

For any pain assessment tool to be of value, it must be valid, reliable and feasible [52,99]. It must enable recognition, assessment and evaluation of any pain experienced in a sensitive and specific manner. The pain should change in response to analgesics in a dose dependent manner [100] to demonstrate that pain is present and that it is ameliorated with pain relief; this can be particularly problematic in farm animal's due to the lack of licensed pain relief and a lack of literature of the effectiveness of the available drugs. Any new assessment tool must be tested against an already existing, validated tool; in humans, this is verbal confirmation of their experience. Animals are unable to verbally confirm their experience with humans, and therefore validation can become difficult, particularly with new diseases or conditions. A

measurement must also be feasible for use on farm being non-invasive, easy to use without the need for any specialist equipment, and needing only minimal training.

Pain is highly complex and multifaceted, so any measure must be able to consider the intensity, frequency, and duration of pain experienced [101]. This can be particularly difficult due to a number of other factors affecting how an individual may perceive the pain experienced, including any previous experience of pain they may have had, and when this experience occurred [57,102,103]. An individual's personality may also affect their perception of pain [104], along with their sex [54].

5.1. The use facial expression to identify and evaluate pain in farm animals

Facial expression has been used extensively in human research and medicine as a way to assess pain in non-verbal patients. Facial expression is the measurement of changes in the face or groups of muscles, known as “action units” to an emotional stimulus. Facial expression is considered to be an honest signal of the affective state and intensity of the pain [105,106]; it becomes increasingly difficult to “hide” the expression of pain in the face [106], and faked pain expression is easily identified [107,108]. Aversive feelings are expressed differently within the face [109], and there is evidence for both the affective and sensory component of pain to be expressed within the face through different action unit movements [110]. The expression, and sensitivity of the expression of pain, is also conserved across development in humans [111,112].

It has only been in the last decade that facial expression has been developed for use in animals as a pain assessment tool (mice [113], rats [114], rabbits [73], horses [71]), including some farm species (sheep [32,115], lambs [116] and piglets [117]). Across the different species, there are similar facial movements and action units expressed in the presence of pain, demonstrating an evolutionary stability in pain expression across mammalian species [118]. Langford et al. [113], were also able to demonstrate that facial expression of pain could be

separated from the sensory (abdominal writhing) expression of pain in mice, albeit in a small sample size (n=6).

Facial expression allows for immediate and spontaneous identification and assessment of pain in animals which is vital for effective pain management; this is a distinct advantage over a number of other pain assessment tools which rely on retrospective assessments. In addition, observers are naturally drawn towards the facial area [119] making facial expression as a pain assessment tool, particularly good. Minimal training is required, and once the “grimace scale” has been learnt the technique is easy to use, without the need for specialist equipment. The scales have been shown to be valid and have high inter-observer reliability scores, ranging from 85% [71] to 97% [117]. High reliability should mean that veterinarians, paraprofessionals such as veterinary nurses, and animal carers assess pain in a systematic and consistent manner, ensuring that the animal receives consistent care and management of its pain [120]. This also means that both vets and farmers should be able to monitor and assess pain in their animals the same way, allowing for a more agreed take on the pain experienced enabling appropriate treatment.

It is likely that facial expression is an involuntary response to pain experienced by an animal [113], leading to a higher sensitivity of pain assessment compared with other assessment tools. The use of the scales also provides a more accurate assessment of the pain than the more subjective global assessment of pain [32]; this is likely due to the removal of a need to make a decision about the animal. The scales assess each part of the face and observers only need to decide on a score for each specific part, rather than the animal as a whole. Facial expression also allows for the assessment of the temporal nature of pain; whether there is a high degree of fluctuation or if there is constant pain. Measuring the temporal nature will allow for observers to have a better understanding of the frequency and duration of the pain, enabling the development of a better pain management strategy. It also allows observers to monitor the

effects of any pain relief that has been provided and to adjust it accordingly. Prompt recognition of pain allows for prompt management of the pain, improving animal welfare.

Some of these scales have also provided an intervention threshold [32], again removing the need for observers to make a decision about the need to give pain relief or not. Having a scale that can objectively identify and assess pain and provide guidance on when to give pain relief will improve the chances of that animal receiving treatment. Pain relief should change the facial expression of animals in pain [113,114] demonstrating if it is working or not. This can be particularly useful when giving pain relief to animals that do not have a licensed drug, or where there is limited research into the effectiveness of the drug.

Individuals experience pain differently. Facial expression gives the ability to assess each individual as such. The facial expression scales provide a more feasible long-term assessment of pain, capturing any fluctuations in pain experienced. Keeping records of an animal's facial expression over time will allow for a better understanding of how that individual may be coping, and whether more pain relief is required, or a different drug needed. Facial expression provides a valid and reliable technique to assess pain in farm animals; however, many of these scales are in their early stages of development and require feasibility testing. In addition, there are some farm animal species missing a validated scale, such as cattle. The technique is more likely to be utilized as a pain assessment tool on farm in real-time once there is data showing its feasibility.

5.1.1 Automation of facial expression detection in sheep

Manual scoring of the facial expression of any animal has the potential to be biased by other knowledge about the subject such as the presence of disease, lameness, or other behaviors and postures which may provide conflicting information. Although the technique is not as time consuming as other behavioral, physiological or production related measures, it still at present requires time for the farmer or veterinarian to observe the animal. The automation of the

analysis of facial expression would improve efficiency as it would not require someone to be present to assess the animals, and it would ensure consistency in the estimation of pain [121] by removing the subjectivity of the assessment. Automation would also mean that farmers would not need to spend their limited time learning individual facial expressions; the automated system would do this. The author currently collaborates with a team in the Computer Laboratory, University of Cambridge who are developing an automated system for the detection and analysis of facial expression in sheep using data collected by the author. The system is currently in the early stages of development and utilizes technology developed for human emotion detection. It can currently detect individual faces of sheep, localize facial landmarks, normalize and then extract facial features [122]. Currently the approach can successfully detect action units and assess pain level in sheep using forward facing pictures (frontal), but is still not yet capable of assessing animals via portrait view (see Lu et al. [121] and Mahmoud et al. [122] for full details of the working models). The data set available is currently limited, but with more data, the automated approach of assessing pain in sheep will be viable to use on-farm in real-time. It is envisaged that multiple cameras and electronic identification tag readers will be placed at key feeding, water, and resting stations used by sheep around housing or fields. The tag readers will link the identification of the sheep and the image taken. Cameras will monitor the facial expression of sheep visiting these stations, learning the individual appearance over time and identifying any sheep that shows indications of abnormal feature position as described in the Sheep Pain Facial Expression Scale (SPFES) [32], alerting the farmer to any animal that registers a facial expression score at or above the pain threshold detailed in McLennan et al. [32]. It also has the potential to be applied to different mammals and across different situations e.g. on farm or at market [121].

The use of technology to optimize production and management of each individual animal is becoming key in efficient and effective farming. Many technologies are currently available

for use on farm, learning about the individual [123], and getting to know what is normal for each individual, rather than a general herd assessment. An automated detection of the facial expression of a sheep would improve the chances of detecting a change in the sheep's normal facial expression suggesting the presence of pain. This would allow for intervention and provision of treatment to that individual earlier than what might have otherwise occurred when there was a need to assess in person. Early detection of any health problem will ensure that the animal can get back on track to full health as soon as possible, reducing the impact on welfare and productivity.

6. Preventing and managing pain

Being able to recognize pain plays only part of the reason why farm animals still experience pain. Prevention and/or better management of pain also play an important role in reducing pain experienced by farm animals, but a number of factors can impact upon possible strategies.

6.1. Preventing pain from occurring

Pain caused by routine procedures could easily be prevented by simply not carrying them out; however, at present, eliminating some of these procedures completely would be impractical and unsafe. Although there are examples of different means to eliminate the need for such procedures such as genetic development of breeding only polled cattle rather than having to perform disbudding or de-horning, they are still not widely used. Careful genetic refinement still needs consideration. Previous genetic improvements to increase yield in cattle and chickens have led to pain being experienced by these animals.

If painful procedures are to be carried out, careful consideration as to what the benefits truly are need to be given; research into tail biting in pigs has demonstrated that refinement in how animals are managed and housed, prevents the need to tail dock [124–126]. If procedures

are still to be carried out, pre-emptive and long-term pain management must be considered, and careful consideration to how the animals are subsequently handled should also be given.

Other causes of pain such as disease can also be reduced or eliminated with changes in how animals are cared for. Diseases such as footrot which cause significant pain in ruminants, should be targeted for eradication, as has been done in some countries (e.g. Norway [127] and Australia [128]); this is a very effective way of preventing pain and suffering. Incidence of mastitis can be prevented through good housing and hygiene management in the milking parlour as well as in bedded areas [129–131]. Disease prevention also comes from early treatment of the disease so as to prevent the spread of infection, reducing the number of animals affected, but also reducing the amount of time animals with the disease will experience pain. Early treatment requires early indicators of disease, which still require research and development.

Sources of pain from improper handling can and should be eliminated through improved education of handlers, as well as improvements in handling facilities. These are simple measures which can be taken and there are very limited excuses as to why pain caused in this manner cannot be completely eliminated.

6.2. Pain management

There are a number of products available to mitigate pain in animals, including local and regional anesthetics, opioids, and non-steroidal anti-inflammatory drugs (NSAIDs); however, in the UK and New Zealand, there is no licensed pain relief product for sheep and any analgesics must be used off-label [10], and up until very recently, in the US there had been no approved pain relief treatments in livestock at all [132,133]. Without access to appropriate anesthesia and analgesia, the use of such products will be limited.

Where there are licensed drugs available, their use in practice is still limited [60,134,135]; Becker et al. [134] found almost 70% of veterinarians carried out painful foot treatment

interventions without any form of pain relief. Commonly reported reasons for not administering analgesia to farm animals include the cost to the farmer, withdrawal periods for drug residues, few licensed analgesics or anesthetics approved for use in production animals, and particular difficulty in recognizing, assessing and evaluating pain [10,60,135]. Becker et al. [134], however, found fewer farmers thought it was acceptable to do certain procedures without pain relief when compared to practitioners. It is thus imperative that practitioners and farmers discuss clearly their thoughts on pain relief when developing pain management strategies.

One of the important roles that practitioners play is educating their clients about the use of pain relief; in Brazil, Cardoso et al., [136] found that many cattle farmers were unaware of the possibility of using pain relief when dehorning. Education is important also in bringing about changes in attitudes towards pain. In the same study, Cardoso et al. [136] found that farmers were willing to trade off animal welfare issues with production, with some farmers stating that although the cattle would feel pain when dehorning, because it would only be for a while, this would be acceptable. Educating clients about the benefits of managing pain effectively, including how and when to administer anesthesia and analgesia is imperative to ensuring pain management is well practiced and the benefits seen first-hand. It is more likely that attitudes towards pain in animals will change if the benefits are clear to see, such as through the changes in facial expression of the animals. Consideration must however be given to the need for repeat handling and constraint in order to administer repeat treatments and whether the benefits of continued treatment outweigh the distress potentially caused by re-handling.

For pain relief to be effective, the correct dose and length of administration is required. Long-term monitoring of the effectiveness of analgesia after a procedure is often lacking, yet research demonstrates that several days after procedures such as castration, pain relief is still required [137]. Additionally, effective management of the pain may not just mean providing

analgesia; diseases such as footrot respond positively to antibiotic treatment, and there is currently a lack of evidence that the use of non-steroidal anti-inflammatory drugs (NSAIDs) improves the healing process [138]; however, there is some evidence to suggest that NSAIDs may reduce the long-term negative effect of chronic pain [32]. In contrast, providing lame chickens with carprofen showed positive effects with birds increasing their walking speed [25]. It is clear that more research needs to be carried out in this area.

When managing pain, a multimodal approach is required [91,139]. Thought needs to be given as to the cause of the pain; if it is caused by a disease then treatment to eliminate the causative agent may be the best course of action. If the pain is caused by a routine procedure such as castration or tail docking, then anesthesia and analgesia should be considered, as well as for how long the treatment should be given. It may be beneficial to give both an analgesic as well as an NSAID. It should be remembered that there are a number of factors including previous experience, personality as well as genetic modification at neuronal level, that can impact in the effectiveness of pain relief and so the animal should be monitored regularly and re-adjustments made in its pain management as appropriate.

7. Future research

In order to continue to improve our understanding of, and thus prevention and/or better management of pain, research into its recognition, cause, effects on welfare, as well as on the pharmacological aspects needs to continue. There is a considerable lack of research on effectiveness of pain relief in a number of farm animal species, in particular small ruminants. Research needs to continue into how we can prevent pain through refinement or replacement of routine husbandry practices that are painful, whether this be through a change in procedure, the addition of pain relief, or a change in genetics that would not require the procedure to be carried out. The research into changes in housing and management of piglets [124–126] is a great example of what can be done, as is the recent research into changing the genetics of sheep to

reduce the need to perform mulesing [140,141], or even changing the genetics of the fly that causes flystrike as a prevention measure to reduce pain incidence [142,143].

Continuation of research into indicators of pain and disease in all farm species is required. Part of this research should also focus on measuring the intensity of pain and what the long-term payoffs are by providing treatment. In addition, the provision of pain relief, how much and how often, is much needed, especially in cases where there is limited or no licensed pain relief, or where there is concern surrounding the effect of analgesia, such as parturition. If the effectiveness of any drug can be demonstrated, this will go a long way into changing attitudes towards animal pain, but should also increase the chances of pain relief being provided to animals where they require it.

8. Conclusions

Farm animals experience pain for many reasons. Most causes are preventable by eliminating poor handling and refining current management practices; however, there will still be the need to carefully manage pain that is present. In farm animals, who tend not to overtly express their pain, this can be difficult. The ability to recognize and effectively assess pain in these animals is one of the major limiting factors in pain prevention and management. New techniques such as facial expression have shown to be a viable and reliable tool to assess pain in a number of species including farm animals. By increasing our ability to recognize pain, we can refine pain alleviation techniques and reduce the negative effect of pain on welfare. The use of such tools needs improvement through continued development and feasibility testing, but the possibility of automating such a tool should encourage its uptake and use amongst both farmers and veterinarians.

There needs to be a continued effort to demonstrate that farm animals experience pain and that this has a negative effect on their welfare as well as being counterproductive to the reasons to farm. By providing such evidence there will be a push to develop and license effective drugs

that can be used for farm animals without being overly costly, and that are safe to be used for food producing animals. The continued education of both veterinarians and farmers is also required in order to continue engagement in pain research, and to encourage a change in attitudes towards pain in these animals through recognition of the negative effect this has on their quality of life.

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