Utrecht University

The cow and her horns

A literature review on the implications of current practices of cow dehorning in Europe

Picture 1: © De Hondspol, biodynamic care farm Driebergen-Rijsenburg, The Netherlands.

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Abstract

Dehorning is common practice in Europe. 81% of the dairy, 47% of the beef and 68% of the suckler cows are disbudded or dehorned. Disbudding is the removal of the horn bud of calves at an age of up to two to three months. Dehorning describes the removal of the horns which is carried out in older animals, after the age of two months. The reason for the dehorning of cows is to reduce the risk of injury to handlers and herd mates. Regardless of the method, disbudding and dehorning are painful and stressful procedures. Less than 30% of farms in Europe performing disbudding uses some form of medication before or after the procedure, and less than 44% uses any form of pain-medication at dehorning.

The aim of this study was to answer the following question: What are the implications of the current practice of dehorning in cattle farms in Europe? In order to answer this question a literature review has been conducted. Additionally, two farmers have been interviewed. These interviews are of an exploratory nature.

In the study it was found that the original functions of the horns for the cow include defence of themselves and their offspring, determining of dominance relationships within the herd and for self-grooming. There is furthermore a hypothesis that the cow horn plays a role in thermoregulation, by nasal heat exchange. Moreover, biodynamic farmers express the conviction of a role for the horn in digestion. This has been, however, poorly investigated. In current dairy systems the function of determining dominance relationships, self-grooming and the possible functions of thermoregulation and digestion are still relevant functions. The others are less relevant. The results of the interviews indicate pathways for future research.

An alternative for dehorning cattle is, among others, adjusting the stable to a horned herd. EU requirements on animal welfare state that unnecessary pain should be prevented. There can be stated that this minimum European requirement is generally not met when it comes to dehorning. Dehorning is often considered as an act which contributes to the welfare of the animal, however, there are indications that dehorning might be disadvantageous for the cow. In order to answer the question, whether the benefits of the mutilation procedure of dehorning outweighs the drawbacks of it, more research is needed on the injuries caused by the horns, the emotional and physical pain the cow experiences during and after dehorning, as the possibilities to adjust the farm system to the animal instead of the animal to the farm system.

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Content:

1. Introduction

Animal welfare increasingly occupies public attention (Cornish, Raubenheumer & McGreevy, 2016). In cattle one aspect of this is the removal of horns. Originally, both females and males of cattle possess horns. Polled (hornless) cattle only developed because of breeding (Irrgang, 2012). The practice of dehorning and disbudding of cattle came about only recently. It started around the 1960/1970's when cows began to be kept in loose-housing systems as opposed to tie-stables (Windig, Cozzi & Vessier, 2015). The reason for the disbudding or dehorning of cows is to reduce the risk of injury to handlers and herd mates in the increased interaction in loose-housing systems (Gottardo, Nalon, Contiero, Normando, Dalvit, & Cozzi, 2011). Indeed in practice farmers in Europe report more injuries among herd mates when they keep horned cows in this type of housing compared to dehorned cows (Kling-Eveillard, Knierim, Irrgang, Gottardo, Ricci, Dockès, 2015).

Dehorning is common practice in Europe. In 2015 Cozzi et al., found that 81% of the dairy, 47% of the beef and 68% of the suckler cows are dehorned. Disbudding is the removal of the horn bud of calves at an age of up to two to three months, by damaging the tissues around the bud in order to stop the bud from growing (Windig et al., 2015). It is usually carried out using a hot iron or caustic paste. Hot iron disbudding is most frequently applied in Europe (Cozzi et al., 2015-a). Only 30% of the farmers in Europe report using a form of medication in order to relieve the pain for the animal before and/or after disbudding (Cozzi et al., 2015-a). Dehorning describes the removal of the horns, which is carried out in older animals, after the age of two months. The dehorning procedure is described to be more painful than disbudding, since at that age the horn is attached to the skull and the bottom part of the horn contains very sensitive live tissues (Winckler, 2014). The dehorning after the age of two months is most often carried out with a wire saw, sometimes a tube or a scoop is used (Cozzi et al., 2015-a). Pre and post-operative medication is more commonly applied while carrying out dehorning practices in comparison to disbudding practices: 44% of the farms in Europe use a form of medication during dehorning (Cozzi et al., 2015-a). In this review dehorning is the umbrella term for both disbudding and dehorning, if not stated otherwise.

Often the practice of dehorning is formulated as an act of animal welfare; since animals will hurt each other less without horns (Windig et al., 2015). One may, however question this statement. As dehorning produces a painful experience and, moreover, little is known about the long term effects dehorning has on the cow (Knierim, Irrgang & Roth,

2015). Research on the severity of injuries of horns is also scarce. Furthermore little research has been carried out on the questions which essentially precedes the practice of dehorning, namely: what is the function of the horn for the cow? Why did they evolve? The main question of this research is: What are the implications of the current practice of dehorning in cattle farms in Europe? In order to answer this question, first the anatomy of the cow horn will shortly be discussed, followed by an overview of the current state of knowledge on practice of dehorning in Europe and the pain involved for the cow. Next, the reasons for cows having developed horns during evolution will be discussed, and it will be questioned whether these functions are still relevant is current cattle systems. Then the alternative for dehorning cows; the adjustment of the stable and management practices and injuries caused by horns of cows will briefly be touched upon. Because of the short scope of this thesis not more attention could be given these last mentioned topic. The last part of this review consists of an overview of regulations concerning animal welfare and dehorning in Europe and a reflection on whether the practice of dehorning in Europe adheres to these EU requirements.

The aim of this review is to open a discussion about the practice of dehorning as a general and necessary rule in modern cattle farming and to call for more research regarding this topic.

2. Methods

For this literature review searches were conducted in four different databases: Google Scholar, Pubmed, Scopus, and Ovid Veterinary sciences. Search terms included: “cow horn”, “function cow horn”, “dehorning”, “calf”, “cattle” “methods dehorning”, “EU regulation dehorning”, “animal welfare regulation”, “pain dehorning”, “disbudding”, “dehorning Europe” and other combinations of these words. Papers were selected on their relevance for this review, based on the abstract of the papers. Literature was considered relevant when it was about cow horns, regulation or dehorning practices in Europe.

Additionally to this literature review two interviews have been conducted with dairy farmers that keep horned cows. These interviews were considered of added value, since there is little literature on the function of the cow horns and in order to obtain a picture of the reasons why farmers keep horned cows, and what, according to the farmers, the importance of the cow horn is. The interviews with these two farmers are of an exploratory nature and no

conclusions can be drawn from them. The conclusions of these interviews are therefore only occasionally included in the main text, but are mainly presented in green boxes. When presented in the main text it is clearly stated what the source of the information is and whether or not scientific research has underpinned these statements. But, not all the green boxes contain information from the interviews, they sometimes also contain additional information to the main text from other sources. These interviews did provoke questions that show possible interesting pathways for future research.

The two farmers were chosen because they keep horned cattle and have a clear view on the importance of horned cattle. Another reason of why these two farmers have been chosen is that their farms are relatively small scale, which means that they can observe the behaviour of their cows well. The first farmer that has been interviewed runs a dairy farm with 90 Jersey cows in Lunteren, The Netherlands. The second interviewed farmer runs a mixed farm, with 35 blister head dairy cows in Doorwerth, The Netherlands.

3. Anatomy of the horn

Horns of cows consist of dense keratin (Irrgang et al., 2012). Keratin is a protein and is the key structuring element which also makes up hair, nails and hoofs (Menke, Waiblinger, Studnitz & Bestman, 2004). The horns of a cow are permanent, unlike antlers of cervids, which are shed annually. Horns continue to grow during a cow's entire life (Knierim et al., 2015). They mainly grow in length and not so much in width (Habel & Budras, 2011).

The horn bud of a calf starts to form during the first two months of its life. The horn is produced at the corium, the area located at the crossing of the horn and the skin (Irrgang, 2012). In young calves, up to about 2 months of age, the horn bud is not yet attached to the skull; it is free-floating in the skin above the skull. After two months of age the horn bud will attach to the skull and the horn starts to grow and becomes a bony extension of

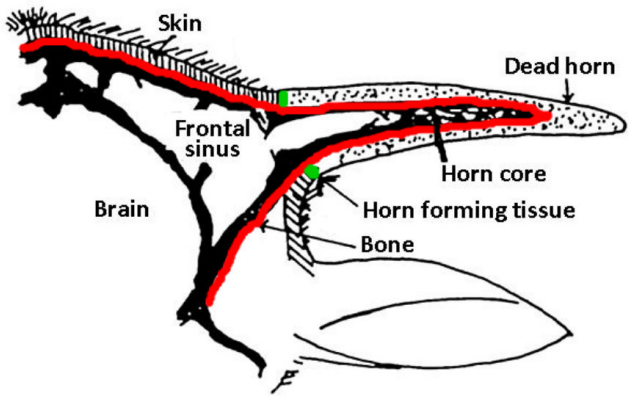

Figure 1: Anatomy of the horn (Animal Ethics RI, 2018).

the skull (Irrgang, 2012). The anatomy of the horn is depicted in Figure 1. Around the age of 7 - 8 months the hollow centre of the horn core opens into the frontal sinuses of the skull (Parsons and Jensen, 2006). This sinus has a direct opening to the nasal cavity (Habel & Budras, 2011), which is the reason why dehorning is more painful than disbudding; it involves damaging nasal tissue, which is very sensitive (Windig et al., 2015). The form of the horn differs between breeds and species, but also within the same breed the horn shows considerable individual variation (Habel & Budras, 2011).

4. Methods of disbudding and dehorning

Cozzi et al. published in 2015 a research on current practices of disbudding and dehorning in Europe. They found that 81% of the dairy, 47% of the beef and 68% of the suckler cows are disbudded or dehorned (Cozzi et al., 2015-a). Within Europe the dehorning percentages differ per region. The countries in the north of Europe had clearly the highest prevalence of total dehorned cows: 85,6%. This concerns Denmark, Estonia, Finland, Ireland, Latvia, Lithuania, Sweden and the UK. The centre has a somewhat lower number: 61.2%; these are Austria, Belgium, Luxemburg, Czech Republic, France, Germany, Netherlands and Slovakia. In the east the number is 46.4%, and in the south 36.6% (Cozzi et al., 2015-a). Dehorning was reported to be more frequent in conventional than in organic farms (Cozzi et al., 2015-a).

There are different ways to dehorn a cow. Before the age of two months, the tissue around the bud is damaged to prevent further growth; this is called `disbudding'. When dehorning is performed after that age the horn is cut off most commonly using a wire saw (Irrgang, 2012).

Cozzi et al. (2015-a) found that 75% percent of the farms that dehorn their cattle reported disbudding as the method. Hot-iron cauterization was the main disbudding method, which is performed by 71% of the farms that disbud their calves, followed by caustic paste (26%) and scoop or tube disbudding (3%) (Cozzi et al., 2015-a). Dehorning cattle, after two months of age, was reported to be carried out in 25 % of the farms. Wire saw was the most commonly applied tool (Cozzi et al., 2015-a). There may be more dehorning-methods possible, however, in this review attention is restricted to the methods described and found by Cozzi et al. (2015) which are reported to be carried out in Europe.

Hot-iron disbudding works by burning the skin around the horn bud, in such a way that it cannot grow further. For the hot-iron disbudding procedure the calf is normally separated in a box (Irrgang, 2012). The ending of the iron burning device is cup shaped and fits around the bud (see *Figure 2*). The iron is heated to 600°C and then pressed onto the area around the bud (Gottardo et al., 2011). The iron burns through the skin and the core of the bud turns brown (Irrgang, 2012). The heat of the burning device is supposed to close the damaged blood vessels so no bleeding should occur if it is properly done (Parsons & Jensen, 2006).

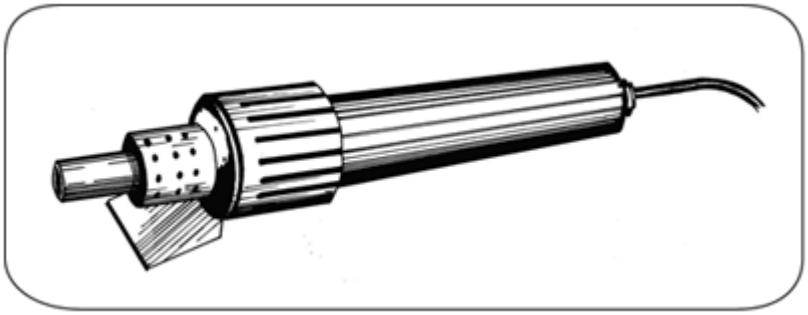

Figure 2: Hot-iron dehorner (Anderson, 2010)

Caustic paste (*See Figure 3*): is a means of disbudding which should be applied at a very young age of the calf. The advice is between 8 to 14 days after birth (Irrgang, 2012). If applied on calves over 14 days the effect of the caustics might be insufficient, and horn may continue to grow (Rosenberger, 1970 as cited in Irrgang, 2012). The caustic paste contains chemicals; normally calcium hydroxide and sodium hydroxide. When applied to the horn bud, the paste causes a chemical burn that destroys horn-producing cells (Stafford & Mellor, 2005-b). The caustic paste is applied on the buds and the areas around them. The caustic paste remains on the bud until the tissue is rejected, which takes 4 to 6 weeks (Irrgang, 2012). The chemical is very intrusive, which means that care must be taken in order to avoid further damage to other body parts, handlers or herd mates (Irrgang, 2012).

Figure 3: Caustic paste for disbudding. (Anderson, 2010)

A tube or scoop (See figure 4 and figure 5) can be used both for disbudding and early dehorning (Irrgang, 2012). They are used to remove the horns or buds and to inhibit their

further growth by cutting off a ring of skin of at least 1 cm around the base of the horns (Cozzi et al., 2015-a). The horns are amputated, bordering skin and some underlying bone (Irrgang, 2012). Sometimes hot-iron disbudding is carried out after the tube or scoop dehorning to be sure that the horn will not grow back (Staněk et al., 2018).

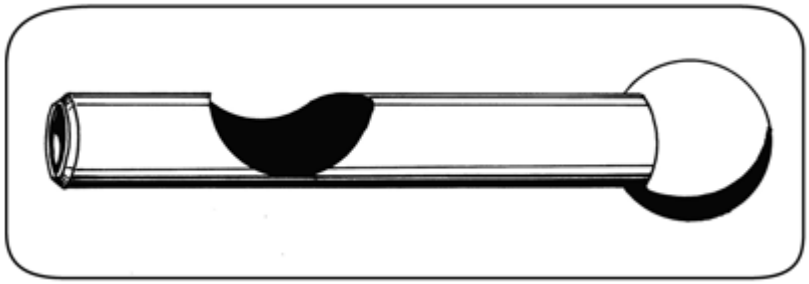

Figure 4: Tube dehorner. (N. Anderson, 2010)

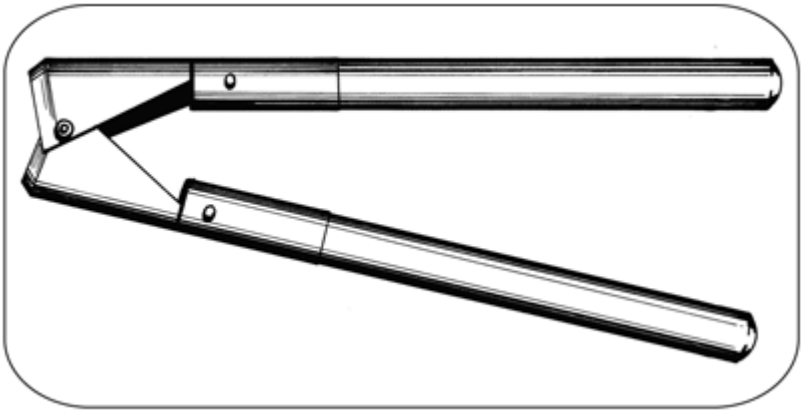

Figure 5: Scoop dehorner. (Anderson, 2010)

Wire saw dehorning is carried out when the horns are attached to the skull. It is done by sawing of the horn, while leaving the skin intact. The device used is a metal wire with saw teeth (See figure 6).

Figure 6: Wire saw dehorner. (GlobalNasco, 2018)

5. The pain caused by dehorning and medication against it

Regardless of the method, disbudding and dehorning are painful and stressful procedures (Stafford & Mellor, 2011-a). According to Stafford and Mellor (2011-a) the pain caused by dehorning cattle can be assessed by behaviour, physiological, and production responses. They reported that dehorning is accompanied with physical stress responses: all of the three dehorning methods mentioned above cause an increase in cortisol in the calf (Stafford & Mellor, 2011-a). The response to scoop or tube disbudding is significantly greater than the other methods (Stafford & Mellor, 2011-a). Disbudding and dehorning also increases heart and respiratory rates (Irrgang, 2012) and can negatively affect growth of the cow (Stafford & Mellor, 2011-a). In particular calves disbudded without medication have a slower growth rate than calves that are disbudded using local anaesthesia and sedation ((Huebner, Kunkel, McConnel, Callan, Dinsmore & Caixeta, 2017). Dehorning furthermore causes behavioural responses, like decrease in play behaviour, restless behaviour such as head jerks, rubbing and changing posture can be observed after disbudding, which indicate, according to Vickers et al., impaired welfare of the calves (Vickers et al., 2005 as cited in Stafford & Mellor, 2005-b). Stafford and Mellor advise to use medication, a combination of local anaesthesia and non-steroidal anti-inflammatory drug (hereafter: NSAID). They hypothesize that this combination can possibly eliminate the pain during disbudding (Stafford & Mellor, 2011). However, the pain relief of anaesthesia is expected to last for approximately 2-3 hours, but the pain may last longer (Irrgang, 2012).

As mentioned before, according to Cozzi et al. (2015) less than 30% of farms in Europe performing disbudding used some form of medication before or after the procedure. In a later research (2018) carried out by Staněk et al. on disbudding practices on Czech dairy farms this percentage was even lower; less than 10%. This low percentage in the Czech Republic may also be caused by the loose regulations on dehorning (Stafford & Mellor, 2005-b). The percentage of medication use in European farms during dehorning practices after the age of two months was higher: 44% (Cozzi et al., 2015-a)

One possible reason for this limited use of medication within Europe can be the lack of regulation: there are no EU rules on medication use at dehorning (EU, 2007 as cited in Cozzi et al., 2009-b). In chapter 8 regulation in Europe concerning dehorning will be

discussed in further detail. Another reason for the low amount of medication application is probably the costs involved (Staněk et al., 2018).

Apart from the direct physical pain of dehorning for the cow, little is known about the long-term pain, after 24 hours (Stafford & Mellor, 2011). Furthermore, there has been little research conducted on the emotional, as opposed to the physical, reaction of the cow on dehorning, although pain is both an emotional and sensory experience (Neave, Daros, Costas,

Von Keyserlingk & Weary, 2013). However, one study, conducted by Neave and et al. (2013) assessed the emotional state of cows before and after disbudding. They reasoned that humans judge ambiguous events negatively when they feel depressed; in their study they gave the first evidence of a similar response to pain in calves (Neave et al., 2013). They found a way to see if calves react positively or negatively to neutral events. The conclusion of Neave et al. was that calves became more 'pessimistic' after being disbudded; they undergo a negative change in emotional state during the procedure (Neave et al., 2013). All disbudding surgeries were performed with a sedative and local anaesthetic to minimize, and possibly even eliminate the pain calves experienced during disbudding (Stafford & Mellor, 2011). This research was conducted just after disbudding; it would be interesting to see whether this 'negative bias' is something that lasts.

It is, nonetheless, difficult to assess the long-term effects of dehorning on cows; as there are a lot of variables present that can influence the calves and cows. However, in 1996 Waiblinger found in 35 herds, with partly horned and partly dehorned cows, that the number of dehorned cows correlated with the avoidance distance of the herd towards humans (Knierim et al., 2015). While the *presence* of horns, normally causes the cows to keep more distance between them (Knierim et al., 2015), in his study the absence of horns correlates with cows keeping more distance from humans. One of the possible explanations is that dehorned cattle become more fearful of humans due to the possibly traumatic experience of dehorning (Irrgang, 2012). This is, however an hypothesis which deserves further investigation in the future.

Little research has been conducted on the healing of the wound after dehorning, and the possible inflammation involved. Stafford and Mellor (2011-a) presume that cows are likely to experience ongoing pain up to about 15 weeks after dehorning, depending on the method applied. Taschke (1995, as cited in Irrgang, 2012) observed that one week after disbudding with hot iron that 46% of the wounds suppurated, after 3 weeks this was 5%. For complete healing it took 4-6 weeks (Taschke, 1995 as cited in Irrgang, 2012).

In 1989 Kihurani, Mbiuki & Ngati found that after amputation dehorning with a wire saw the wound may take three months or more to heal.

Despite the general scientific agreement on that dehorning causes pain, more than 48% of the farmers in Europe think that the pain only lasts a few minutes (Gottardo et al., 2011).

6. Functions of cow horns in evolution

Research on the function of the cow horn is scarce (Knierim et al., 2015). There are, however, a couple of hypotheses of why nature developed horns on the ancestor of the cow, the now extinct aurochs (Ajmone-Marsan, Garcia & Lenstra, 2010). The general agreement for the main evolutionary benefit of horns for bulls relates to intrasexual competition for mates (Irrgang, 2012). For cows the hypotheses are less straightforward but include the function of defence of themselves and their offspring, the function of determining dominance relationships within the herd and for self-grooming (Knierim, 2015).

The rapidity of the horn growth changes during the lifespan of a cow; in stressful periods the horn growth decreases, for instance pregnancy or lack of food. This results in rings on the horns (Habel & Budras, 2011). Thus rings can be seen as effects of stress (Irrgang, 2012). However in the interview with one of the farmers he expressed the conviction that cows use minerals in their horns during stressful situation. According to him this was the cause of these rings. There is, however no scientific evidence nor studies conducted that underpin this supposition. There is furthermore a hypothesis that the cow horn plays a role in thermoregulation, by nasal heat exchange. This has also been, however, poorly investigated (Irrgang, 2012).

Moreover, some farmers, all of them working according to the biodynamic (hereafter BD) principles[1], expressed their conviction that the cow horn has a major role in digestion. This view will

How relevant are these opinions?
Worldwide around 190,000 hectares are farmed under BD (Demeter) standards, with a total amount of 5387 farms. These also include vegetable and fruit farms. However, Demeter strives for mixed farms, so often livestock is included (Demeter, 2018).

[1] These principles are anchored in the Demeter certification standards. These standards apply to production, processing and labeling. Here the guidelines of the the production standards of Demeter are documented and explained: http://bdcertification.org.uk/wp/wp-content/uploads/2017/02/Demeter-Production-Stds-February-2017.pdf

also be discussed in this review, although quite little scientific research has been conducted on this topic.

6.1. Defence

The benefit for female ungulates does not lie in fighting with each other for mates. Horns may have brought advantages regarding defence against predators for both themselves and their offspring. They furthermore may have provided advantages for competition for resources (Robinson & Kruuk, 2007). Estes (1991 as cited in Irrgang, 2012) developed the hypothesis that horns on cows could have protected male calves against the aggression of dominant bulls. This protection would cause bull calves to longer stay in the natal herd. This, in turn, may have enhanced survival and thus reproductive success of male offspring, which causes the mother's genes to be better passed on (Estes, 1991, as cited in Irrgang, 2012).

6.2. Ranking

Ranked battles are ritualized battles, so that injuries are avoided. In head-to-head battles, the horns do not serve as a direct weapon, but rather as a fixation of the opponent (Brands & Baars, 2000).

Since the horns of cows keep on growing during their lives, horns are also a sign of age. The older the animal is, the higher it normally is in the social ranking (Irrgang, 2012). This means horns also have a function in determining dominance relationships within the herd. Bouissou studied in 1972 twenty-five groups of heifers in the period that social ranking was established. He found that both body weight and horns are important in the determination of ranks, however horns are most important (Bouissou, 1972). Another factor in determining dominance relationships among cows is the shape of the horns; according to Baars & Brands (2000) cows with pointed curved horns have normally a higher rank than cows with less favourable curved horns (Baars & Brands, 2000).

Sambraus et al. (1979 as cited in Knierim, 2015) hypothesised that in hornless herds body mass is the decisive factor of determining dominance relationships, while in horned herds it is age. This would mean, as Menke, Waiblinger, Fölsch & Wiepkema (1999) also hypothesized, that horns have positive effects on the stability of the social structure of the

herd, since older horned cows might be able to stay high in rank despite losing weight and physical strength. Furthermore Graf (1974, as cited in Knierim, 2015) found that horned herds show less agonistic behaviour compared to hornless herds.

One investigation that has been done on this topic has been conducted by Reinhardt (1986 as cited in Irrgang, 2012) he reported from a semi-wild herd of Zebu cattle that, although older cows had lower body weight, they still kept their higher rank because of their longer horns. When dominance relationships are established within a herd, butting and injuries are rare. Thus, horns can have an influence on the stability of a herd. Indeed, according to Baars and Brandt (2000) who conducted a research on several organic dairy farms with different cow breeds in the Netherlands, horned cows bump less into each other than dehorned cows. However, there is no doubt that the effect of a push with a horn on skin, udder and vulva causes more severe injuries than a push of a dehorned cow (Irrgang, 2012).

One of the interviewed farmer switched from hornless cows to horned cows, so he had a period in which he had both dehorned and horned cows in his herd. The farmer observed that the horned cows were higher in rank than the hornless cows, while the hornless cows were older. He noticed the rank most clearly when he brought the herd from one pasture to another. All the horned cows went first, followed by the hornless.

Stability in the herd is not only positive because of less agonistic behaviour among the cows, but a stable herd includes a clearer dominance relationship structure within the herd and may therefore cause cows to be less stressed. Here it must be noted that in current breeding a number of behavioural characteristics is selected for, among which calmness is an important one (Wiener, 2015). This may cause cows to be less stressed, regardless of herd stability.

6.3. Self-Grooming

Horns, when present, are also used during self-grooming and scratching of body parts that cows cannot reach without their horns. Taschke (1995) observed six adult cows kept in tie-stalls for 24 hours and found that about 28% of all self-scratching acts were carried out with the help of the horns (Tascke, 1995 as cited in Irrgang, 2012).

Horned cows, furthermore, use their horns consciously. Menke (1996) noted that horned cows do not bump into narrow feeding racks, but instead, tilt their heads so they can access the feeding rack. According to Irrgang (2012) some farmers reported cows opening feeding racks using the tip of their horns (Irrgang et al., 2012).

6.4. Thermoregulation

Another possible function of the horn is thermoregulation. There is, again, little literature on this possible function, however Irrgang (2012) noted that, since the horn is connected to the nasal sinus, horns may contribute to nasal heat exchange. This nasal heat exchange to cool the body is found in a range of large mammals, such as giraffes, waterbucks, goats and cows (Langman, Maloiy, Schmidt-Nielsen, Schroter, 1979). It reduces water loss through cooling of the air during exhalation (Langman et al., 1979). It makes the exhaled air leaving the body at a lower temperature than that of the body. Nasal heat exchange works as follows: in inhalation the nasal surfaces are cooled by the incoming air, augmented by evaporation of water, and during exhalation warm air passes over these cool surfaces where it gives up heat, and water vapor condenses. In the giraffe and waterbuck as well as the goat and cow the mean exhaled air temperatures lie around 9°C below body core temperature (Langman et al., 1979).

Cain, Krausman, Rosenstock and Turner wrote in 2006 an article on how desert ungulates cope with hot weather. They mentioned that horns of bovids may have a thermoregulatory function. They also noted that bovid species from arid areas have larger horn cores and thinner keratin sheats compared to species from temperate areas (Cain et al., 2006). These two characteristics of horns provide cooling (Cain et al., 2006). Picard et al., conducted a research in 1998 on the different morphology of horns from cows from temperate and arid regions, they concluded that these differences have evolved in accordance with the climate; horns from cows from temperate climates limit heat loss, while the horns from cows that originated from tropical areas facilitate heat loss (Picard et al., 1998).

6.5. Rings on horns

Variations in level of nutrition of the animal are reflected in variations in rapidity of horn growth, resulting in a series of rings on the horn, which may reflect seasonal stress, notably the stress of calving in cows. In the last weeks of a cow's pregnancy and at the beginning of the lactation the production of the horn reduces (Baars & Brandt, 2000). The age of the animal may be estimated by counting the rings of the horns (Gottschalk et al., 1992 as cited in Irrgang, 2012).

One of the interviewed farmers reported that he noticed that his horned cows had less hoof problems than his dehorned cows. His reasoning was that a pregnant cow without horns 'uses it's hoofs' for her pregnancy as calcium storage, thus has more irregularities in her hoof growth during pregnancies due to the lack of horns. No scientific research underpins this statement, however it is an interesting conducting more interviews with farmers to found out whether it is worth conducting further research on this topic.

6.6 Digestion

The main reason for farmers that are farming according to BD principles to keep the horns on the cow is that, according to them, horns play a role in the digestive system. BD agriculture assumes there is a link between the ability to deliver high metabolic performance and the presence of the horns (Baars en Brandt, 2000). Arguments that these farmers commonly put forward in favour of the link between horns and cow's digestive system are based on observations of these farmers. For instance, they claim that horns get warm while the cow is ruminating (Irrgang, 2012). Furthermore, it is claimed that dehorned and polled cows tend to have more digestive problems (Knierim et al., 2015). However, there is no scientific literature to be found on the link between horns and their digestion. This is an interesting area, more research is needed.

One of the interviewed farmers stated that the bottom part of the horn gets warmer during rumination. He noticed that he can feel the difference in temperature of a horn of a cow not ruminating and a cow ruminating.

7. The relevance of horn functions in current dairy systems

Some of the previously discussed potential functions of the cow horn are not anymore relevant in current dairy and beef systems, since the environment of the cow in a dairy system does not resemble its original environment (Knierim et al., 2015). Features of current dairy systems, such as cows living in a stable, insemination, the production of milk during all months of the year differ from the natural conditions of the ancestors of the cow. However, important to note here is that the current cow breeds are domesticated, and may have different needs than their ancestors, which are the extinct aurochs (Ajmone-Marsan et al., 2010). The question may be raised if the conditions aurochs favoured, are still the best conditions for current cow breeds.

The aim of this chapter is to evaluate what original functions of the cow horn are relevant in these current cattle systems. Although dairy systems and practices vary within Europe, there are many common practices that are carried out in the majority of the dairy systems (European Commission, 2017).

The function of horns as a **defence** against predators and male aggressors is not relevant in current dairy systems, since increasingly cows are kept solely indoors (Charlton & Rutter, 2017). Besides that, cows on pasture are also not likely to encounter predators. Male aggressors will not attack offspring, since most of the cows do not interact with bulls, but get inseminated (Charlton & Rutter, 2017). On top of that; separating newborn calves from their mothers is common practice in the dairy sector in Europe (Johnson et al., 2018). Calves are normally placed in a box away from the mother (Irrgang, 2012). Thus, there is no role for the mother in defending her calves. The sexual attraction of the horn for bulls is not relevant in the current system anymore, because of the same reason that bulls often not mate with the females (Charlton & Rutter, 2017).

The function of **ranking** seems a relevant one since cows do still live in a herd with dominance relationships (Knierim et al, 2015). If it is the case that the presence of horns makes the herd more stable, this can be seen as an important function. It must, however, be noted that European dairy farms are increasing in size and number of cows, furthermore the replacement rates of cows are also augmenting (Johnson et al, 2018). These two factors make the dominance relationships within the herd less stable (Baars & Brands, 2000). As noted before, cows also become more calm due to selection. More research is needed on the

question whether, and if so how, the presence or absence of horns plays a major role in the stability of the herd and how this influences the cow.

Self-grooming is a function that stays relevant, although there are also other means to facilitate self-scratching and grooming for the cow, as for instance cow brush machines.

The role the horn may play in **thermoregulation** seems an interesting and still accurate function; since cows still have to cool themselves down, however as there is few research on this topic, the exact role of the horn in this mechanism requires more research.

Rings that appear on horns during stressful life-periods are now assessed as a reaction on stress rather than a function of the horn, however, the conviction of one of the interviewed farmers is that cows use minerals from their horns during stressful events. This, however, needs further research.

Whether the horns have a role in **digestion** is not clear; however, is would be interesting to investigate this topic, and if horns play a role in this, to see what the role is, since digestion is, off course, important for the cow.

8. Alternatives for dehorning and injuries caused by horns

Alternatives for dehorning cattle are, among others, investigated by Irrgang (2012). She listed requirements for keeping horned cattle that farmers reported. In a study conducted by Schneider (2010), 84 % of 62 farmers keeping horned cows had adjusted the stable to the horns of their cows with at least one - mostly even two or more- structural changes (Schneider, 2010 as cited in Irrgang, 2012). Necessities according to the farmers for keeping horned cattle were in sum: a stable with more space per cow than average and no corners, so that cows can flee easily. The most important requirement was however, a good herd manager. It was furthermore advised to have an outdoor space and a low replacement rate; which means of new cows within the herd (Irrgang, 2012).

Both the interviewed farmers reported that more space per cow is needed when cows have horns compared to dehorned cows. They also reported that outdoor space is important and they both focus on the stability of the herd, by replacing old cows after on average 7 years.

Another interesting area for future research is the question whether horned cows indeed cause more injuries to both herd mates and handlers than dehorned cows. There is little research done on this topic, the current conclusions are based on farmers' experiences. These experiences are of course valuable indicators. However, a systematic research on the amount and the severity of these injuries and the factors contributing to these injuries is paramount. One study in 1998 has been conducted on this topic. Menke et al., carried out a study on 35 dairy farms with horned cows and assessed among others the amount of injuries caused to other cows and farmers by the horns. On these farms the farmers told they themselves were never harmed by the horns. Here it must be noted that the above group was small, which makes general conclusions on horned cows and injuries difficult.

One of the interviewed farmers said they had chosen to have blister-head cows in their farm because, among other reasons, the horns are curved towards the inside. This makes the horns causing injuries less probable.

9. Regulations in Europe on animal welfare

The European Union (hereafter: EU) and the Council of Europe (hereafter: CE) are responsible for minimum requirements to which all member states must adhere concerning, among others, animal welfare (Veissier Butterworth, Bock & Roe, 2008). The member states are responsible for the implementation and refinement of these requirements, and to formulate laws based on them. The EU has 28 member states. The CE has 47 member states, including the 28 EU member states. The CE cannot make binding laws, but it does have the power to enforce international agreements reached by European states. The conventions on animal welfare of the CE have been the basis of EU legislation on animal welfare (FAO, 2013).

The CE has been creating international agreements related to animal welfare since the 1960s. The EU adopted a series of directives to protect farm animals since the 1980s (Veissier et al., 2008). The international agreements of the CE are developed using both practical and scientific insights, by agreement of a wide range of partners, such as welfare scientist, veterinarians and farmers (FAO, 2013). The three conventions that protect farm animals were approved by 24 European countries. Compliance with the regulations on farm animals is checked by the Treaty Animal Protection (TAP) (FAO, 2013).

On the website of the European Commission can be found that concerning cattle handling, there is no specific EU legislation, except for organic farming. For organic farming the EU states the following on cattle dehorning:

> *"Operations such as […] dehorning shall not be carried out routinely in organic farming. However, some of these operations may be authorised by the competent authority for reasons of safety or if they are intended to improve the health, welfare or hygiene of the livestock on a case-by-case basis. Any suffering to the animals shall be reduced to a minimum by applying adequate anaesthesia and/or analgesia and by carrying out the operation only at the most appropriate age by qualified personnel (EU, 2007 as cited in Cozzi et al., 2009-b)."*

For conventional (non-organic) cattle farming the EU has no specific rule, but the general rules laid down in the council directive 98/58/EC concerning animal welfare do apply (European Commission, 2018). This directive consists of 5 pages, some of the articles in this directive can be interpreted as concerning cattle dehorning, one of them is Article 3:

> *"Member States shall make provision to ensure that the owners or keepers take all reasonable steps to ensure the welfare of animals under their care and to ensure that those animals are not caused any unnecessary pain, suffering or injury (Council Directive, 98/59/EC, 1998)"*

What is meant with *the welfare of animals* is off course not specific and can be interpreted in multiple ways, nor is it clear what *all reasonable steps* means. As Fraser (2008) stated: our understanding of animal welfare is both value-based and science-based. Which means that science alone cannot answer all the questions on animal welfare (Fraser, 2008). The EU did make a choice in the values concerning animal welfare; the minimum requirements of the EU are guided by the five freedoms which animals should have. These five freedoms are:

1. *Freedom from hunger and thirst;*
2. *Freedom from discomfort;*
3. *Freedom from pain, injury or disease;*

4. *Freedom to express normal behaviour;*
5. *Freedom from fear and distress (Farm Animal Welfare Council, 2012)*

Freedom 3 can be found in the last part of Article 3 of Council directive 98/58/EC : *to ensure that those animals are not caused any unnecessary pain, suffering or injury*. Since there is scientific consensus that any form of dehorning causes pain, suffering and injury for the calf and that only 30% of the farms in Europe use any form of medication (Cozzi et al., 2015-a), there can be stated that this minimum European requirement is generally not met when it comes to dehorning.

If medications are used, the question remains whether this pain is necessary or *unnecessary*. What unnecessary pain means is again open to multiple interpretations. A possibility of *necessary pain* is that the pain caused, outweighs the benefits for the cow or the herd. Nordquist et al., (2017) wrote an opinionated article on this topic: whether or not the pain of mutilating practice outweighs future pain. They write the following about beak trimming in chickens: *"The general question thus is whether the harm inflicted on the individual outweighs the benefits for the individual and/or the group. (Nordquist et al., 2017)"* This could also be a relevant question concerning dehorning.

Moreover, Directive 98/58/EC includes the following on mutilation in cattle:

> *"Pending the adoption of specific provisions concerning mutilations in accordance with the procedure laid down in Article 5, and without prejudice to Directive 91/630/EEC, relevant national provisions shall apply in accordance with the general rules of the Treaty."*

The Directive which Directive 98/58/EC refers to is a directive on pig rearing, which is no longer in force (EUR-Lex 2018), but was repealed by Council Directive 2008/120/EC. In this directive the following is said about mutilating procedures:

> *Tail-docking, tooth-clipping and tooth-grinding are likely to cause immediate pain and some prolonged pain to pigs. Castration is likely to cause prolonged pain which is worse if there is tearing of the tissues. Those practices are therefore detrimental to the welfare of pigs, especially when carried out by incompetent and inexperienced*

persons. As consequence, rules should be laid down to ensure better practices. (Council directive. 2008/120/EC)

Since this directive applies to pigs, it is not clear how this directive should be interpreted concerning cow dehorning. As we already have seen, the case is that dehorning very likely causes immediate pain and possibly prolonged pain to cows (Stafford & Mellor, 2011-a). Should it be concluded that rules should be laid down to ensure better practices? And what are these better practices? The conclusion can be drawn that the EU does not demand clear requirements on dehorning practices.

Member states within Europe make their own laws, which must at least conform to the requirements of the EU, but may also be more strict. This means that the laws on animal welfare differ between countries in the EU. The countries in the north of Europe are in general stricter concerning their animal welfare regulations (Cozzi et al., 2009-b). In the following the rules concerning dehorning of the Netherlands, Poland and Italy are demonstrated. These three countries have been chosen in order to show the differences there are within Europe, since they differ a lot in their strictness of their regulations on cattle dehorning (Cozzi et al., 2009-b).

Legislation in the Netherlands:

The procedure should be carried out by instructions of a local veterinarian, who should also apply local anaesthetic before dehorning. Furthermore, the calf should be younger than two months when hot-iron disbudding is applied or on cattle older than six months by means of a wire saw (Cozzi et al., 2009-b).

Legislation in Poland:

Poland has no legislation concerning cattle dehorning (Cozzi et al., 2009-b)

Legislation in Italy:

For hot iron disbudding the cows should be younger than three weeks. After three weeks dehorning is allowed, however it is not specified which method should be applied. No medication is mentioned (Cozzi et al., 2009-b).

In short, there is a great variety in regulation on cattle dehorning within the member states of the EU, due to the unspecific requirements set by the EU.

10. Discussion & Conclusion

The present review aimed to provide a picture of what the implications are of the current practice of dehorning in cattle farms in Europe. Dehorning is often considered as an act which contributes to the welfare of the animal, however, there are indications that dehorning might be disadvantageous for the cow, i.e. it is likely that dehorning causes pain during the procedure and pain can continue at least up to 15 weeks afterwards. Furthermore, Neave et al., found first indications that calves undergo a negative change in emotional state during the procedure. This is an interesting area for further research, since dehorning might induce long-lasting effects both physically and emotionally. Reactions of cows on dehorning, such as stress and anxiety play an important role in animal welfare

Dehorning furthermore takes the benefits of the functions of horns away from the cow. Original functions of the horn include defence, the use for ranking, and self-grooming. Horns have moreover possibly a function in thermoregulation and digestion. These topics need more investigation as well. When a cow has a stressful period, as for instance a pregnancy, rings on the horn occur. This may be a stress reaction of the cow. One farmer reported that his cows had less hoof problems since he stopped dehorning his cows. This is just a one-case report and more interviews with farmers should be conducted to find out if more farmers report this link. If so, investigation on whether the absence of hoof problems relate to the presence of horns might be an interesting area of investigation. There is overall little research on the actual function of the cow horn. Scientific research on this topic is urgently needed, to find out to what extent the health and welfare of the cow is restricted by dehorning.

In the discussion on usefulness of dehorning of cows the question which Nordquist et al. (2017) raised should be considered: “The general question thus is whether the harm inflicted on the individual outweighs the benefits for the individual and/or the group“. To be able to answer this question more research is needed to chart how much pain and disadvantages a cow experiences due to dehorning.

The potential benefits of dehorning cows also deserve more attention. As for instance research on the possible economic benefits of keeping dehorned cows. These possible economic benefits could be due to for instance less injuries.

Several aspects concerning dehorning were beyond the scope of this thesis. Both the costs of dehorning, and the cost of adjusting a stable to a horned herd. Another topic that has not been mentioned due to the short scope of this thesis is the relation between horns and milk quality. Furthermore, the amount of injuries and their severity caused by horns and under what circumstances these injuries have a higher prevalence were only briefly touched upon.

Only 30% of the farmers in Europe use any form of pain-medication during or after disbudding, and 44% at dehorning, which are low percentages. This may be caused by the unclear requirements concerning dehorning from the EU for conventional farming. The member states of the EU vary in strictness of their laws concerning dehorning. It can be stated, however, that the directive on the prevention of unnecessary pain is generally not met. Since it is very likely that dehorning causes pain to the calf, the advice would be that during dehorning anaesthesia should at least be applied. Best would be if the use of medication could be laid down in legislation all over Europe.

In conclusion, in order to answer the question whether the benefits of the mutilation procedure of dehorning outweighs the drawbacks of it, more research is needed on the injuries caused by the horns, the emotional and physical pain the cow experiences during and after dehorning, as the possibilities to adjust the farm system to the animal instead of the animal to the farm system.

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