The impact of production system on animal welfare of cattle prior to slaughter

From loading on-farm to stunning at the slaughterhouse

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Påverkan av produktionssystem på djurvälfärden hos nötkreatur innan slakt. Från lastning på gården till bedövning på slakteriet

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Abstract

The slaughter process, from loading the animals on the transport on-farm until stunning at the slaughterhouse, makes our production animals exposed to stressful situations and unknown environments. Animal welfare prior to slaughter has been questioned for several years and science behind how animal welfare is affected is lacking. The aims of this master thesis were to develop and evaluate protocols for animal welfare assessment of cattle prior to slaughter and map variation in animal welfare indicators within and between different production systems, namely KRAV-certified and conventional production systems for cattle. Animal based indicators were observed at loading on-farm, unloading at the slaughterhouse, during lairage at the slaughterhouse and at driving to the stunning box. Both behaviour of the animal and the interaction between the stock person and the animal were observed. Loading time, transport time, unloading time, lairage time and time for driving animals to the stunning box were recorded as well as animal welfare indicators. The farms included in the study were one KRAV-certified beef farm, one conventional beef farm, and one KRAV-certified dairy farm. Semi structure interviews with farmers, transporters and slaughter personnel were performed during the study to assess their opinion of animal welfare prior to slaughter. After performed observation and evaluation of this animal welfare protocols it is suggested to include fewer categories of animal behaviours and human-animal interactions for the protocols to be easier to use with direct observations. The human-animal interactions like e.g., slapping and beating should be defined in different ways to assess the impact on the animal welfare. Observations at individual level could make the results more valuable. The observation position and the identification of the individual observed should be determined before the observation starts. Based on the results from this study, there are indications of variations in animal behaviours and human-animal interactions between animal categories and production systems of cattle. In the current study, KRAV-certified beef production had the lowest stress-related behaviours at loading and shortest loading time when compared with conventional beef production and KRAV-certified dairy production. The highest count of stress-related behaviours per animal in all production systems was during driving to stunning. The observations in lairage at the slaughterhouse indicated that the animals could not rest and recover during the time at the slaughterhouse.

Keywords: Animal behaviour, Human-animal interaction, Protocol, Direct observations, Loading, Transport, Unloading, Driving race, Conventional, KRAV-certified

Sammanfattning

Slaktprocessen, från lastning av djuren på slakttransporten på gården till bedövning på slakteriet, gör att våra produktionsdjur utsätts för stressiga situationer och en okänd miljö. Djurvälfärden i samband med slakt har ifrågasatts i flera år och forskning bakom hur djurvälfärden påverkas är begränsad. Syftet med detta examensarbete var att utveckla och utvärdera protokoll för djurvälfärd av nötkreatur i samband med slakt och kartlägga variation i djurvälfärdsindikatorer inom och mellan olika produktionssystem, med fokus på KRAV-certifierade och konventionella produktionssystem för nötkreatur. Djurbaserade indikatorer utfördes med direkta observationer vid lastning på gården, avlastning på slakteriet, under inhysningen på slakteriet och vid drivning till bedövningsboxen. Både djurets beteende och interaktionen mellan människa och djur registrerades. Lastningstid, transporttid, avlastningstid, inhysningstid och tid för drivning av djur till bedövningsboxen registrerades som djurvälfärdsindikatorer. De gårdar som ingick i studien var en KRAV-certifierad nötköttsgård, en konventionell nötköttsgård och en KRAV-certifierad mjölkgård. Semistrukturintervjuer med lantbrukare, transportörer och slaktpersonal gjordes under studien för att bedöma deras uppfattning av djurvälfärd innan slakt. Efter utförd observation och utvärdering av dessa djurvälfärdsprotokoll dras slutsatsen att om direkta observationer ska vara praktiskt användbara krävs färre kategorier av beteenden och interaktioner, det ska vara lätt att använda och inte ta för mycket tid. Interaktioner mellan människa och djur som att ”slå” och ”slå med redskap” bör definieras på olika sätt för att bedöma effekten på djurvälfärden. Observationspositionen och identifieringen av den observerade individen bör fastställas före observationstillfället, för att det ska vara möjligt att utföra observationer på individnivå. Det kan finnas variationer i djurbeteenden och interaktioner mellan människa och djur inom djurkategorier och produktionssystem för nötkreatur. Denna studie visar att KRAV-certifierad nötköttsproduktion hade lägst antal stressrelaterade beteenden vid lastning och kortast lastningstid vid jämförelse med konventionell nötköttsproduktion och KRAV-certifierad mjölkproduktion. Det högsta antalet stressrelaterade beteenden per djur i alla produktionssystem var under drivning till bedövningsbox. Observationerna under inhysningen på slakteriet tydde på att djuren inte hade möjlighet att vila och återhämta sig under tiden på slakteriet.

Nyckelord: Djurbeteende, Människa-djurinteraktioner, Protokoll, Direkta observationer, Lastning, Transport, Avlastning, Drivgång, Konventionell, KRAV-certifierad

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Abbreviations

DFD	Dark, firm and dry
SRB	Swedish Red-and-White

1. Introduction

The slaughter process, from loading the animals on the transport on-farm until stunning at the slaughterhouse, makes our production animals exposed to stressful situations and an unknown environment (Wigham et al. 2018). The animal welfare prior to slaughter has been questioned for several years and science behind how the animal welfare is affected is lacking (Wigham et al. 2018). According to Brennecke et al. (2020) there is not sufficient research on the subject of improving animal welfare with measurements of behaviour and physiological factors which can define the animal's affective state. A risk analysies protocol could be a tool to identify harmful effects, occurring pre-slaughter, on animal welfare and carcass quality. Since there is a lack of existence of this type of protocol, evaluating the behaviours of the animals can be difficult. If there were a tool or a protocol to assess animal welfare, it could be possible to advice possible improvements in handling routines in the pre-slaughter process and improve meat quality (Brennecke et al. 2020). The animal welfare before slaughter can have an economic effect as the carcass and meat quality can be affected if the animal is stressed, which leads to deductions both for the slaughter company and the farmer (Wigham et al. 2018). If the animal welfare implications are supported by science, it could be possible to improve animal welfare, and in addition, could lead to economic benefits for the farmer and the slaughterhouse.

1.1 Aim and research questions

The overall aim was to evaluate the animal welfare of cattle through the slaughter process, from loading on-farm until the animals enter the stunning box at the slaughterhouse.

The specific aims were to 1) develop and evaluate protocols for animal welfare assessment of cattle prior to slaughter and 2) map variation in animal welfare indicators within and between different production systems. The specific research questions to be addressed were:

- Which animal welfare indicators in the animal welfare protocol are practically feasible to record in different production systems for cattle, namely conventional and KRAV-certified production?

- Is there variation in animal welfare indicators relevant to describe variation between animal categories and between production systems?
- What is the opinion of the farmers, transporters, and slaughter personnel regarding animal welfare prior to slaughter and their motivation to use a protocol to assess animal welfare?
- Based on the protocols, can we identify relevant animal welfare issues during the process from loading on-farm to stunning at the slaughterhouse?

2. Literature review

2.1 Slaughter industry in Sweden

During 2021 approximately 411,000 cattle were slaughtered in Sweden (Swedish board of agriculture 2022). It is common in beef production to use mixed breeds of Hereford, Simmental, Charolais, Limousine, Highland cattle, Angus and Blonde d'Aquitane. The most common dairy breeds are Swedish Holstein and Swedish Red, and about half of the cattle slaughtered are of beef or mixed dairy-beef cattle (Hultgren et al. 2020).

2.1.1 Regulation

Animals should be handled calm and gentle during loading on-farm, transport and unloading at the slaughterhouse. Furthermore, the animals should not be exposed to stress caused by reflected surfaces, noise and loud sounds, air current, bright lightning, odours, sharp bends or end points, pain, rough handling with hits, nor stress from other animals (Animal welfare act 2018:1192; Council regulation (EC) No 1099/2009; Swedish Board of Agriculture's regulations and General Advice [SJVFS 2020:22] on slaughter and other euthanasian of animals, L22). Further, the Swedish welfare act (2018:1192) says the animals should be handled, driven, and housed in such a way which provide them to express their natural behaviours. In addition, stunning before exsanguination is required and regulated in the EU regulations (EC 1099/2009), as well as in the Swedish animal welfare act (SFS 2018:1192). The most common stunning method in Sweden for cattle is with a penetrating captive bolt gun (Hultgren et al. 2014). The animals should not be exposed to continuous loud sounds, however temporary mechanical noise exceeding 75 dBA can occur. The unloading area at the slaughterhouse should have proper design for unloading animals in a safe way, e.g., slippery free surface (SJVFS 2020:22).

When driving cattle, it is allowed to use electric tool, but it should be avoided as far as possible. Electric prod can only be used on adult cattle which refuse to be move and if the animal can move freely forward. The chocks from the electric tool shall

not last longer than one second, with long enough intervals, and only be used on the cattle's rear musculature. The chocks shall not be repeated if the animal does not react to them (EC 1099/2009). Tail twisting is not allowed when driving animals (EC 1099/2009; SJVFS 2020:22). It is allowed to regroup the animals, but it is recommended to avoid this, and especially during night-time if the animals need to stay over at the slaughterhouse (SJVFS 2020:22). Further, worth noting is that animals is only allowed to stay one night at the slaughterhouse. The space requirements during lairage at the slaughterhouse is higher for overnight animals (table 1).

Table 1. Minimum space requirements for cattle in group pens in Swedish slaughterhouse (SJVFS 2020:22)

Weight (kg)	During day (m^2)	During night (m^2)	KRAV-certified
< 100	0.5	1.0	1.0
100-250	1.0	1.5	1.5
250-400	1.5	1.9	1.9
400-600	2.0	2.3	2.3
> 600	2.5	2.7	2.7

In the Swedish Animal welfare act (SFS 2018:1192), it says animals shall be transported in vehicles appropriate for the purpose and provide every animal with protection against heat and cold or shocks and chafing. Animals should be held separate if needed. The transporter shall have supervision of the animals and take actions needed for not causing pain or suffering to the animals during loading, transport and unloading (SFS 2018:1192). There are minimum space requirements for cattle in the transport vehicle, which is found in table 2.

Table 2. Minimum space requirements per animal for cattle during roads transport ((Swedish Board of Agriculture's regulations and General Advice [SJVFS 2019:7] on transport of live animals))

Category	Weight in kg	Surface in m^2 per animal
Small calves	50	0.40
Middle sized calves	110	0.70
Heavy calves	200	0.95
Middle sized cattle	325	1.30
Heavy cattle	550	1.60
Very heavy cattle	700	2.20
	900	2.70

In EU all carcasses must be classified according to the provisions of EU-regulation, Swedish law, and the Swedish board of agriculture constitution. The Swedish board of agriculture monitor the estimation of carcass classification to make sure the estimation is performed similarly in the whole of Sweden (Swedish board of agriculture 1998). The purpose with the classification is to thoroughly describe the

carcasses content of meat, fat, and bone. All countries in EU are using the same system, the EUROP-system. It is built on five main classes for muscle confirmation, E, U, R, O and P, where E is has the best muscle development and P has poor muscle development. The main classes are further divided in – or +, which gives in total 15 classes. The fat is classified in 15 classes from 1- for the skinny animals to 5+ for the extremely fat animals. Moreover, the previous source states that the classification system facilitates the communication between consumers and producers. The system contributes to increased ability for the farmers to improve the meat quality and meet the demand of the market. The classification impacts the price of the meat, which in turn is estimated by the situation of the market (Swedish board of agriculture 1998).

2.1.2 KRAV-certified production and EU-organic production

The purpose with organic production is to produce good quality products rather than maximum performance (Regulation (EU) 2018/848 of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007). In EU there is a legislation which constitutes the basic level all organic production must meet to be able to sell their products as organic (Council Regulation (EU) No 834/2007). KRAV is a Swedish label of organic production and applies more rules concerning animal welfare than the usual EU-organic legislation (KRAV 2022). It was founded in 1985 and is an organisation with delegates from the farmers' organisations, processing industry, distributors, retailers, consumers co-operation, and the environmental movement (Hansson et al. 2000; KRAV 2022). Animals indicating poor welfare in the pre-slaughter process cannot be certified as KRAV (Hansson et al. 2000; KRAV2022). Welfare implications can be severe contaminated animals, or extremely thin or weak animals (Hansson et al. 200). In addition, the regulations of KRAV are describing poor animal welfare as driving and handling the animals with rough driving methods e.g., use of electric prod (KRAV 2022). The regulation of using electric tool when driving cattle differ between KRAV-certified, EU-organic, and conventional production and a comparison of the regulations at time for slaughter is found in table 3. For KRAV-certified animals the waiting time in the driving race to stunning should be minimized, the animals should not be in the driving race for more than 15 minutes.

At the time of slaughter, the KRAV-certified animals should be kept in established groups and cannot be mixed with other animals (KRAV 2022). It is allowed to split up groups of animals but not mix them with new, unfamiliar animals. The animal keeper must certify that the animals arrive to the slaughterhouse in established groups. Only 30% of the animals are allowed to overnight at a KRAV-certified

slaughterhouse. During the stay at the slaughterhouse the KRAV-certified cattle must have access to roughage (KRAV 2022).

Table 3. Overview of regulation at slaughter of KRAV-certified, EU-organic, and conventional animals in Sweden (KRAV 2022)

	KRAV	EU-organic	Conventional
Free access to roughage	Yes	No	No[a]
Maximum transport time 8 h	Yes	Yes	Yes
Electric tool when driving allowed	No	Yes[b]	Yes
Stay overnight at the slaughterhouse	Yes[c]	Yes	Yes
Stunning prior to exsanguination	Yes	Yes	Yes

a. Required only during night

b. Not allowed when loading or unloading

c. Not more than 30 % of the animals

2.2 Assessing animal welfare

The welfare of an animal comprises both physical and mental state (Mellor 2016). The animal's attempt to cope with its environment can be an indicator of good or bad welfare (Farm animal welfare council 1993). The animal welfare is determined of how well or bad the animal can cope with its environment (Farm animal welfare council 1993). Stress can be an indicator of poor animal welfare due to stress being a result of the animal's failure to cope with its environment. Stress can be defined as "an environmental effect on an individual, which overtaxes its control systems and reduces its fitness or appearance likely to do so" (Warren et al. 2010). However, it is important for animals to have a "life worth living", which is defined as minimizing negative experiences as well as provide the animals with positive experience (Mellor 2016).

Animal welfare can be assessed with reference to The Five Freedoms, which are a framework for analysing animal welfare. This concept was formed in 1965 by Farm Animal Welfare council (Wigham et al. 2018) and have influenced the animal welfare legalisation and the animal protection of farm animals. The Five Freedoms includes:

- Freedom from thirst, hunger, and malnutrition
- Freedom from discomfort
- Freedom from pain, injury, or disease
- Freedom to express normal behaviour

- Freedom from fear and distress

This framework of The Five Freedoms does not include absolute values, in other words it is not optimal to assess animal welfare (Wigham et al. 2018). These five freedoms have been explained as ideal states and not actual standards for animal welfare (Velarde & Dalmau 2012). The main principles of the Welfare Quality Project, which was developed to include measurements of animal welfare into the food chain, are based on The Five Freedoms. These main principles are: (Velarde & Dalmau 2012; Wigham et al. 2018)

- Good feeding
- Good housing
- Good health
- Appropriate behaviour

The criteria of the principle good feeding are absence of prolonged hunger and thirst, which can be measured through food provision and water supply. Good housing includes comfort around resting, which can be measured with type of floor and bedding. This principle further includes thermal comfort and ease of movement. The ease of movement can be measured with animal-based indicators such as the behaviours slipping and falling, or resource-based indicators such as stocking density on transport and at lairage. Good health includes absence of injuries, absence of disease and absence of pain induced by management procedures. Appropriate behaviour is defined by expression of social behaviours and other behaviours, good human-animal relationship, and the animals' positive emotional state (Welfare Quality® 2009).

2.2.1 Animal-based indicators

Animal-based indicators can be used as a measurement to assess the welfare state of the animals. These measurements include animal behaviour, fearfulness, health, or physical condition (Welfare Quality® 2009).

Behaviour

The behaviour of cattle has been showed to be a reliable animal welfare indicator before slaughter (Mendonca et al. 2018). When moving animals, behaviours like backing, turning around, and struggling are often related to stress (Hultgren et al. 2020). These behaviours can lead to more difficult handling and in turn increase risk of rough handling (Hultgren et al. 2020).

Vocalization is a way for cattle to communicate with other cattle, for example when the mother interacts with her calf, or when cattle communicate reproduction status, gender, and age to other cattle (Swedish board of agriculture 2012). For cattle it is important to warn each other for possible danger through vocalization. Vocalization in combination with fear or stress could be an indicator of negative animal welfare

(Swedish board of agriculture 2012). Hultgren et al. (2014) suggested when driving cattle, if more than 3 % of the animals vocalize under the pre-slaughter processes, it indicates the animal welfare is not acceptable. If it is more than 20 % of the animals showing this behaviour, there is a serious problem (Hultgren et al. 2014). The precent of animals vocalizing and falling during handling could be an indicator of poor handling and poor animal welfare (Grandin et al. 2013). Previous studies on animal behaviour and human-animal interaction when driving animals to stunning at the slaughterhouse included behaviours like move backwards, turning, running, slipping, falling, kicking, struggling, freezing and vocalization (Hultgren et al. 2014; Özdemir et al. 2022). The human-animal interactions that been studied were speaking, shouting, slamming, slapping, beating, gate hitting, tail twisting and prodding (Hultgren et al. 2014; Özdemir et al. 2022). The animal behaviour and the interactions between human and animal could be a measurement of animal welfare (Hultgren et al. 2014; Özdemir et al. 2022). When performing these measurements, the behaviours or interactions could be scored after their effect on animal welfare. The scoring in the study of Hultgren et al. (2014) were 1 (mild), 2 (moderate) and 3 (severe), where moving backwards had animal welfare score 2 and falling had score 3. According to Hultgren et al. (2014), the behaviour move backwards could be indicating that the animal is being disturbed in some way of e.g., shadows in driving race or human entering the flight zone, which can make the animal stressed (Hultgren et al. 2014). Falling is stated as a sign of fearfulness and pain-reaction (Welfare Quality® 2009).

Physical factors

Carcass bruises are easy to detect and can be seen as a common sign of poor animal welfare pre-slaughter (Stappini et al. 2009; Romero et al. 2013). Bruises can occur when there are improper handling and during transport to the slaughterhouse (Romero et al. 2013). In addition, bruises on the carcass could have an impact of the economic outcome of the beef chain, were both producers and slaughterhouses are affected (Mendonca et al. 2019). The bruises can occur at the slaughterhouse as well as while loading at the farm or during transport (Welfare Quality® 2009). Most bruises on cattle carcasses could be caused by the handling and transport to the slaughterhouse (Mendonca et al. 2018). However, it can be difficult to identify the age of the bruises.

Physiological factors

Urine catecholamines can be used as a pre-slaughter stress indicator, but it is unclear if it affects meat quality (Wigham et al. 2018). In a review of Wigham et al. (2018), blood cortisol measurements of animals after arrival at the slaughterhouse was mentioned as a method that has been used to assess cattle welfare prior to slaughter. However, this method cannot be reliable as an indicator

of stress pre-slaughter, due to the fact when taking the sample, the animal could be affected by the procedure itself (Wigham et al. 2018). Taking blood samples during bleeding has been suggested as a better alternative (Romero et al. 2017). Other than cortisol, glucose and lactate could be measured in blood as an indicator of stress according to Romero et al. (2017). Reduction of muscle glycogen, as a result of stress pre-slaughter, leads to high final pH of the carcass and reduced production of lactate (Romero et al. 2017). This could lead to dark firm and dry (DFD) meat (Romero et al. 2013), and when this occurs, the meat has poor processing quality, a dark colour, higher capacity of holding water, and higher risk to be contaminated of bacteria and microbial growth. The limit for which is considered a high ultimate pH can be as high as 6.0 (Franco et al. 2015). In a study of Romero et al. (2017), they measured pH 24 hours post-slaughter and had a limit for dark meat at a pH over 5.8. When comparing two different types of slaughterhouses, they saw a higher prevalence of DFD, because of higher ultimate pH for young bulls, which had been exposed to stressful handling during unloading and in lairage at the slaughterhouse (Romero et al. 2017). Other studies have found that increased heart rate, as an indicator of stress, led to faster decline in muscle pH, which could lead to impaired meat quality (Wigham et al. 2018). Furthermore, fast muscle pH decline without stunning has been found, which can indicate the importance of stunning prior euthanasia, to lower the risk of poor animal welfare and bad meat quality (Wigham et al. 2018).

2.2.2 Resource-based indicators

Resource-based measurements can be used to address risks and causes of poor animal welfare. These measurements include access to food and water, floor and bedding material, lairage and facility design. To identify animal welfare implications with resource-based indicators they should be closely correlated to animal-based indicators (Welfare Quality® 2009).

Space, light, floor and driving race design could influence animal welfare (Hultgren et al. 2014). If the driving race is not design in a way that makes the animal willing to enter the stunning pen, it could lead to driving the animals with enforcement. It is important to minimize distractions when driving animals, to avoid need of rough handling. Light is one important factor when driving cattle. There should be no shadows or reflections from misplaced light sources, neither bright dazzling light. Cattle do prefer to move from dark areas to light areas, proper light sources are important, and they must be placed correctly (Grandin 2013)

When driving cattle, it is important to consider the sight of the animal (Swedish board of agriculture 2012). Cattle have a wide field of sight over 300 degrees. They have a horizontal pupil, and the placement of the eyes make it possible for the cattle

to see the environment around them without turning its head. However, they have a blind spot from right behind (Swedish board of agriculture 2012). This contributes to the flight zone of cattle (Grandin 2022). This zone determines how close a human can approach the animal without inducing the flight instinct. The flight distance between human and animal can be different depending on how used the animal is to human handling. The more the animals have been handled, the smaller the flight distance is. The flight zone has a point of balance approximate in line with the animal's shoulder. The human driving the animal should be positioned between the point of balance and the blind spot (Grandin 2022). Small space in the unloading area and driving races could make it hard for the human to use the animal's flight zone. Hultgren et al. (2014) saw in their study that there were a lot of crowding in the driving race which resulted in many animals moving backwards or refused to move forward. Further, the walls in the driving race can affect the animal's behaviour due to its sight field (Swedish board of agriculture 2012). Therefore, the driving race walls should be designed in a way preventing the animal to be exposed to unpleasant visual impression (Swedish board of agriculture 2012). Open side walls have been shown to make cattle more nervous than solid walls (Hultgren et al. 2014). Furthermore, Mendonca et al. (2019) evaluated the risk factors of facilities condition and their impact on carcass bruises and discussed the use of a vertical guillotine gate. The authors concluded when driving the animals with a vertical guillotine gate, the risk of loin bruises could increase.

2.2.3 Human-animal interaction

Factors that can lead to stress and negative experience for cattle are the human's action and behaviour (Grandin 2013; Swedish board of agriculture 2012). The time of the handling procedure has an impact on animal welfare as well. Shorter handling procedures are often a sign of good animal welfare, provided that the human-animal interactions are positive (Hultgren et al. 2014). Long handling procedures can contribute to poorer animal welfare because of the need of using improper handling methods. Severe handling methods could be beating the animal with a tool, booting the animal, tail twisting or using an electric prod (Hultgren et al. 2014). Further, the loading- and unloading area, and driving race design can contribute to longer handling times and in turn lead to higher risk of negative human-animal interactions (Hultgren et al. 2014). Hultgren et al. (2020) studied animal behaviour and human-animal interactions when driving animals to stunning. They found higher prevalence of stress-related behaviours when the human actions increased. Hence, the personnel at the slaughterhouse should be trained and educated for proper handling of animals and proper use of equipment. The design of the lairage and facilities at the slaughterhouse should be adapted with purpose to optimize the handling of the animals (Hultgren et al. 2014; Mendonca et al. 2019).

Electric prods use when driving cattle has been shown to increase cortisol levels, which can be an indicator of stress (Grandin 2013). High number of repeated electric prod shocks before slaughter can increase meat toughness in cattle (Grandin 2013). But there could be a risk of poor animal welfare if banning the electric prod use as it can increase the frequency of using other improper handling methods like beating or hard tail twisting when there is an animal that refuse to move forward (Grandin 2013). The use of electric prod should be minimized when moving cattle, and Grandin (2013) recommend a numerical scoring of precents of animals being moved with an electric prod to evaluate animal welfare at slaughterhouses.

Shouting increases the cattle's flight instinct and fear, which can lead to negative experience for the animal if the human is shouting when handling the animal. This leads to more stress for the cattle and longer driving times (Swedish board of agriculture 2012).

2.3 Pre-slaughter process

2.3.1 Loading on-farm

Loading cattle on a transport to the slaughterhouse can in some cases be more stressful than the journey itself (Maria et al. 2004). An important factor that can have an impact on cattle when loading and unloading is the ramp of the transport, which should be as flat as possible (KRAV 2022). The ramp on the transport should not exceed a tilt over 15 degrees (SJVFS 2019:7). The loading area should be free from unnecessary disturbing objects like manure chutes, unregular surface or light shifts (Swedish board of agriculture 2012). If the animals have been moved through the loading area before and are used to the environment, it will lower the risk for stress (Swedish board of agriculture 2012). Cattle which are used to be handled might feel less fear during loading and unloading (Grandin 2003). Differences between intensive or extensive production systems due to the experience of human contact could influence the animal's behaviour during loading and unloading (Nilsen et al. 2011).

2.3.2 Transport

The duration of the transport to the slaughterhouse can have an impact on the animal welfare. Although there are mainly factors like access to food, water, and rest that are the most important for a good animal welfare (Nielsen et al. 2011). The duration of the transport can impair the welfare if mentioned factors are lacking or if the animal is being exposed to extreme temperatures. The animal's state after loading and handling before being transported, can affect their ability to cope with the

potentially stressful situation during transport (Nielsen et al. 2011). After the animals have adapted to the environment, the duration is a minor concern compared to other factors like loading densities, vehicle design, road conditions or the driver's behaviour (Strappini et al. 2009). The vehicle design includes floor conditions and shock absorbers (Nielsen et al. 2011). In previous studies, it has been shown that stops during transport can increase the number of bruises on carcases, while the transport time did not influence the occurrence of bruises (Romero et al. 2013). Loading densities has a major influence on the animal welfare during transport (Mendonca et al. 2019). High stocking densities in the transport can lead to higher risk of falling when the animals do not have space to change positions (Nielsen et al. 2010; Swedish board of agriculture 2012). If an animal falls during transport the risk for bruises increase (Mendonca et al. 2019). Cattle should be transported with enough space to provide them with the ability to avoid other animals in the transport (Swedish board of agriculture 2012). In a study by Mendonca et al. (2018) they investigated factors which could affect the occurrence of carcass bruises on beef cattle. They included factors like handling, transportation, and unloading. They saw moderate animal densities on transport vehicle resulting in higher numbers of bruises than high or low densities, where the low density was <370 kg/m^2 and high was >431 kg/m^2. In another study of Mendonca et al. (2019) they concluded that a transport load density above 400 kg/ m^2 resulted in a higher number of bruises compared to a load density under 400 kg/ m^2. The result indicates that high load densities could lead to lack of mobility and impair the animals balance in the transport, which leads to bigger risks of falling during transport (Mendonca et al. 2019).

2.3.3 Unloading, lairage and driving to stunning at the slaughterhouse

In Europe the animals are usually slaughtered the same day as they arrive to the slaughterhouse (del Campo et al. 2010). There are studies showing that >3 hours in lairage at the slaughterhouse could allow the animals to recover from the potential stress situation from the transport to the slaughterhouse (del Campo et al. 2010). If the animals have an opportunity to recover, it could potentially replenish glycogen concentrations in the muscles, reduce dehydration of body tissue and weight loss of the carcass (del Campo et al. 2010). The pre-slaughter process could lead to consumption of energy due to physical exercise or psychological stress, which could lead to reduced muscle glycogen levels in vivo and increase ultimate pH of muscles (del Campo et al. 2010). A study by del Campo et al. (2010) found a higher pH value at 1,3, 6, and 24 hours *post-mortem* after a shorter lairage time of 3 h compared to a lairage time of 15 h. The authors therefore recommended a resting period of at least 3 hours in lairage if the animals had been exposed to stress in the pre-slaughter process. Romero et al. (2013) compared a long lairage time of 18-24

h and short lairage time between 12-18 h and the results showed the occurrence of bruises increased with 2.1 times when the animals was in lairage 18-24 h compared to the short time (Romero et al. 2013). The time in lairage can contribute to rest and recover for the animal after transport, if food and water is present (del Campo et al. 2010). Welfare indicators in lairage can be food and water supply, type of floor and bedding (Welfare quality® 2009). Increased space allowances have been shown to improve of animal welfare in form of higher cleanness, reduced social stress and increased lying behaviour (Gygax et al. 2007). It is suggested that space requirements should be dependent on lairage time (Weeks 2008). The animal density should be lower if the animals must spend longer time in lairage. For cattle of 700 kg, Weeks (2008) suggested a space requirement of 1.7 m^2 per animal if the lairage time is shorter than 3 hours, and 3.6 m^2 per animal if the lairage time is longer than 3 hours.

An animal welfare measurement at unloading and driving to stunning could be handling times (Hultgren et al. 2014). Unloading time has been showed to affect numbers of bruises on carcass. Animals with longer unloading time had more carcass bruises (Mendonca et al. 2018). The time in driveway could be related to stressful behaviour which cattle display when being driven to stunning at the slaughterhouse (Hultgren et al. 2020). At unloading, the angle of the ramp could have an impact of the animal's behaviour (Romero et al. 2017). Romero et al. (2017) found a higher frequency of slips for young bulls during unloading with a ramp with 45° angle compared to a ramp with 20° angle.

3. Material and methods

There were three protocols used in this study. During loading, unloading, and in driving race to stunning, one animal behaviour protocol and one human-animal interaction protocol was used (Appendix 1 and 2). A third protocol was used for recording the behaviour of the animals during lairage time at the slaughterhouse (Appendix 3). The behaviours and interactions used in the protocols during loading, unloading, and driving to stunning are presented in ethograms, which can be found in Appendix 4 and 5. The ethogram for animal behaviour in lairage can be found in Appendix 6. Animal behaviours and human-animal interactions in all protocols are based on previous studies by Hultgren et al. (2014); Hultgren et al. (2020); Özdemir (2022) and from Welfare Quality® (2009). Interviews with farmers, transporters and personnel at the slaughterhouse were performed, and the questionaries can be found in Appendix 7. There were three farms including in this study, one KRAV-certified beef farm, one conventional beef farm, and one KRAV-certified dairy farm. Prior to the farm visits, a pilot study was performed at a conventional dairy farm with the purpose of testing the animal behaviour and human-animal interaction protocols.

3.1 Pilot study

The farm had about 300 dairy cows with both Holstein and Swedish Red-and-White (SRB). The animals included in the pilot study were three cows of the breed SRB and three heifers of the breed SRB. The observation was performed in February 2022 and the loading of the animals on-farm was in the morning. Two observers were conducting the observations, one observed the behaviour of the animals, and one observed the human-animal interactions.

Two different types of protocol for animal behaviour were used, one for loading on-farm and one for the slaughterhouse observations (unloading and driving). This was done to test which one was the best to use when register behaviours of the animals. The protocol at loading was based on if the behaviour were performed or not (1/0), and the other one used when driving animals at the slaughterhouse was counting how many times the behaviour performed per animal. To be able to see the frequency of the behaviours, the protocol with counts per performed behaviour

was chosen. The protocol for human-animal interactions at loading, unloading and driving to stunning were counting the frequency of interactions performed, and were not changed after the pilot study. In the human-animal interactions protocol the interaction "Pushing gate" was added (Appendix 2). All the protocols were at individual level, but were changed to group level after the pilot study. It was concluded that identify the individuals from the observation position and distinguish characteristics of the animals were too difficult and not applicable at all farms.

In lairage at the slaughterhouse, there were two observers performing the observations, and the observations were instantaneous with an interval of ten minutes during the first 50 minutes of lairage and the last 20 minutes of lairage with an interval of five minutes. These observation methods were changed to performing the observation during the whole lairage time and only by one observer to be more reliable. The interval was changed to ten minutes during the whole lairage time.

The results from the observations at the pilot farm were not included in the study, as the protocols were modified after the observations on the pilot farm. The interview of the farmer on the conventional dairy farm was chosen to be included as it contributed to valuable data and the questionary was the same for all farmers.

3.2 Loading on-farm

3.2.1 Farms and animals

The farms included in the study were one KRAV-certified beef farm, one conventional beef farm, and one KRAV-certified dairy farm. The first KRAV-certified farm was a beef cattle farm with approximately 260 animals including suckler cows, bulls, heifers, and young bulls. The animals included in the study was 14 suckler cows of the breed Charolais. The cows were loaded from their group pen in a three-wall stall. There was no bedding material on the surface of the loading area or on the ramp to the transport. The conventional beef farm had about 250 animals, both young bulls and heifers. The animals included in the study was eight young bulls of milk breed and four heifers of mixed meat- and milk breeds. The heifers were loaded from a pick-up pen in a stall with a loose housing system and the bulls were loaded from a group pen in a three-wall stall. Both loading areas had bedding material on the floor and on the ramp of the transport. The second KRAV-certified farm was a dairy farm with 125 dairy cows and the animals included in the study were three SRB cows. The cows were housed in a free stall and were loaded directly from the stall to the transport. The loading area had concrete floor with no bedding material on the surface of the loading area or on the ramp. There was a

threshold before entering the ramp. The observations were made once per farm from the end of March to the beginning of April 2022 and the loading of the animals were done in the morning. The result in this study is representing the animals that were send to slaughter at the observation occasion and is not representing the whole farm.

Table 4. Number of animals and animal category in the different production systems

		Cow	Young bull	Heifer	**Total**
Conventional	Beef	0	8	4	**12**
KRAV-certified	Dairy	3	0	0	**3**
	Beef	14	0	0	**14**

3.2.2 Behavioural observations and human-animal interactions

During loading on-farm both behaviour of the animal and the interaction between the human and the animal were recorded as continuous variables represented counts per behaviour or interaction performed. The observations were performed at group level with three to four animals in one group. The total amount of behaviour performed in one group was summed up and divided by numbers of animals in respective group.

Two students conducted the observations, one observed the animal's behaviour, and one observed the human-animal interactions at the same time at loading, unloading, and at driving to stunning.

Loading time was registered, the observations and time started when the gate from the pen on-farm was opened and ended when the gate closed on the transport. The loading time was calculated to seconds per animal due to the different number of animals in every group. The calculation was seconds for the whole group divided by number of animals in the group.

3.2.3 Interviews with farmers

There were semi-structured interviews with the farmers. Semi-structured interviews imply that the person who is interviewed has opportunity to a great variation in the answers and is not guided by the design of the questions. In these types of interviews, the researchers can adapt their questions more based on the answers received from the respondents, which are of interest to the study (Bryman & Bell 2017). Four farmers were interviewed, which were all the farmers visited, including the pilot farm. The first interview with the conventional dairy farmer was conducted

on-farm, and the other interviews were performed over telephone. All interviews were in Swedish, and the questionary had purpose of pointing out the opinions of the farmers regarding animal welfare of cattle prior to slaughter. Questions about animal behaviour, facilities design, and their motivation of implementing a protocol for assessment of animal welfare were included in the questionary (Appendix 7).

3.3 Transport and unloading at slaughterhouse

3.3.1 Behavioural observations and human animal interactions

Transport time was measured from the gate on the transport was closed until it was opened at the slaughterhouse. The transport length was registered and if there were stops when picking up animals at other farms, that was registered as well. At unloading, animal behaviour and human-animal interactions were observed. Unloading time started when the gate on the transport opened and stopped when all the animals entered the lairage pen. This method of measuring unloading time was used in a previous study (Romero et al. 2017). The animal behaviour and the human-animal observations were observed at group level during unloading and the group size was based on number of animals in each lairage pen and not on the number of animals in transport pens.

3.3.2 Interviews with transporters

Two transporters were interviewed with semi-structured interviews. Both interviews were in Swedish and performed during the visits to the slaughterhouse. The questionary had the purpose of pointing out the opinions of the transporters on the animal welfare of cattle prior to slaughter. The questions asked to the transporters were about animal behaviour during unloading and their motivation for using a protocol for assessing animal welfare (Appendix 7). The two transporters were chosen to be interviewed because they were the ones who drove the animals at the observation occasion. The result will present a summary from the two interviews and the answers are not correlated to the farms.

3.4 Slaughterhouse observations

All farms included in this study were sending their animals to slaughter to the same slaughterhouse, which were KRAV-certified and slaughtered both cattle and pigs. The line speed was approximately 20-40 cattle per day.

The slaughterhouse had six pens in total and every pen was 11 m^2 each, with a small pen of 3.5 m^2 which was used if it was necessary to isolate an animal. The pens

could be divided into two smaller pens or to one bigger pen. The floor in the pens had rubber mats and there were two to three water cups in every pen. The walls were open with metal bars on the short sides and the long sides facing the driving race. The other long sides had solid walls. The animal density in lairage is shown in table 5 and the measurements were quite higher than the Swedish and KRAV-certified regulations.

Table 5. Animal density in lairage at the slaughterhouse

Weight (kg)	Daytime (m^2/animal)	Night/KRAV (m^2/animal)
250-400	1.57	2.20
400-600	2.20	2.75
>600	2.75	2.75

The driving race at the slaughterhouse had concrete floor and it was designed to avoid two or more animals to be driven next to each other. The way was straight most of the driving race, with a small curve in the middle. The walls were open in the beginning of the driving race and had solid walls on the right side the last part of the driving race. There were two none-return gates and one guillotine gate in the end of the driving race.

3.4.1 Behavioural observations and human-animal interactions

Lairage

In lairage, the observations were performed instantaneously of the animal's behaviour with scan sampling. When doing scan sampling, the whole group of animals in one pen were observed every 10 minutes during the whole lairage time. The time when observing the one group of animals lasted for a few seconds, which is recommended by Martin and Bateson (2007). The protocol for scan sampling in lairage can be found in Appendix 3. The total lairage time of each group was recorded from when all animals were in the lairage pens after unloading. Lairage time ended when the first animal was driven to stunning in respective group. Description of lairage conditions was recorded and included current access to food, water, type of floor and bedding material, and animal density. The animal behaviours recorded in lairage can be found in Appendix 6.

Driving to stunning

During driving to stunning the animal behaviour and human-animal interaction were observed. Driving time was recorded as an animal welfare indicator (Hultgren et al. 2014; Hultgren et al. 2020; Sandström 2009). The time for driving to the stun box was counted per group and started when one pen was opened until all animals in that pen entered the stun box. The time in driving race were counted from the

first animal stepping out of the pen until the last animal that was driven at the same occasion were in the stunning box. The behaviours in the stunning box were not registered.

3.4.2 Interviews with personnel at the slaughterhouse

There were semi-structured interviews with three of the personnel at the slaughterhouse. They were interviewed during the visits of the slaughterhouse and the persons being interviewed are not representing a specific farm. The interviews were in Swedish, and the questionary had the purpose of pointing out the opinions of the personnel on animal welfare of cattle prior to slaughter. The questions to the slaughter personnel were about animal behaviour at the slaughterhouse, implementations to improve animal welfare prior to slaughter, how to assess animal welfare at the slaughterhouse and their motivation to using a protocol for assessment of animal welfare (Appendix 7). In the result there will be a summary from all three interviews.

3.5 Data compilation and analysis

This were a descriptive study, and the results from the protocols were presented descriptively quantitatively. The program used was Minitab (Minitab® 19.2020.1 (64-bit)). The result from the questionnaire was described qualitatively.

4. Results

4.1 Loading on-farm

4.1.1 Behavioural observations

On the KRAV-certified beef farm the mean loading time per animal was 22.0 seconds. There were four groups, and the groups had almost the same loading time with a standard deviation of 6.4 (figure 1). The animal behaviours performed during loading on the KRAV-certified beef farm were move backwards, turn around, try to turn around, freeze and run. The most common behaviour performed with the highest count per animal was try to turn around, which was performed 1.3 times per animal. The other behaviours had a low frequency compared to the other production systems (figure 3). The conventional beef farm had a mean loading time of 90.0 seconds and there were differences between the groups with a standard deviation of 30.0 (figure 1). The most performed behaviour was turn around. Other behaviours performed during loading were move backwards, try to turn around, slip, freeze and run. The mean loading time on the KRAV-certified dairy farm was 360.0 seconds per animal (figure 1), and the most performed animal behaviour was turn around which was performed 4.7 times per animal, and the other performed behaviours were try to turn around, freeze, move backwards, slip and fall. The KRAV-certified dairy farm had the highest number of performed behaviour per animal in all categories registered during loading on-farm (figure 2).

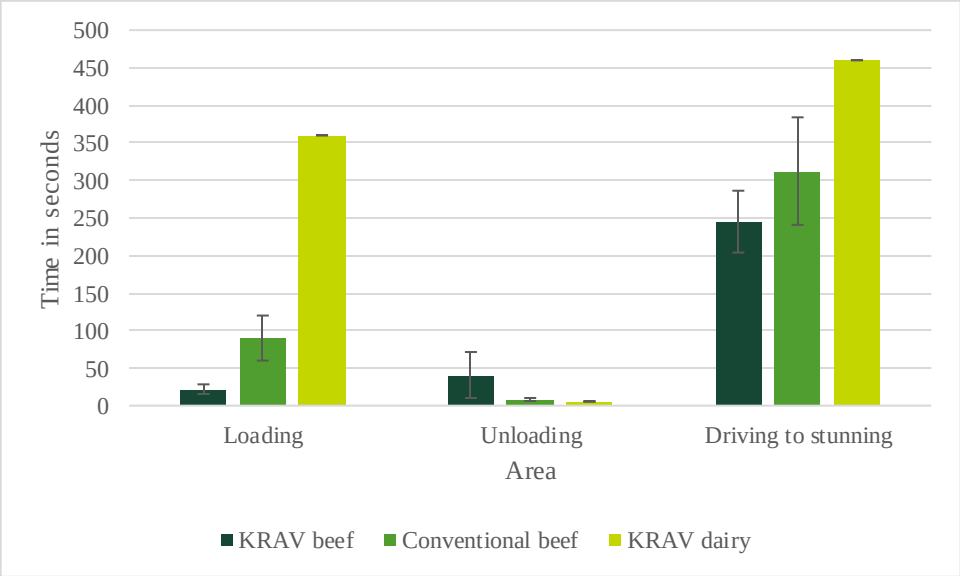

Figure 1. Time for loading, unloading, and driving to stunning for different production systems. Mean value and standard deviation per animal.

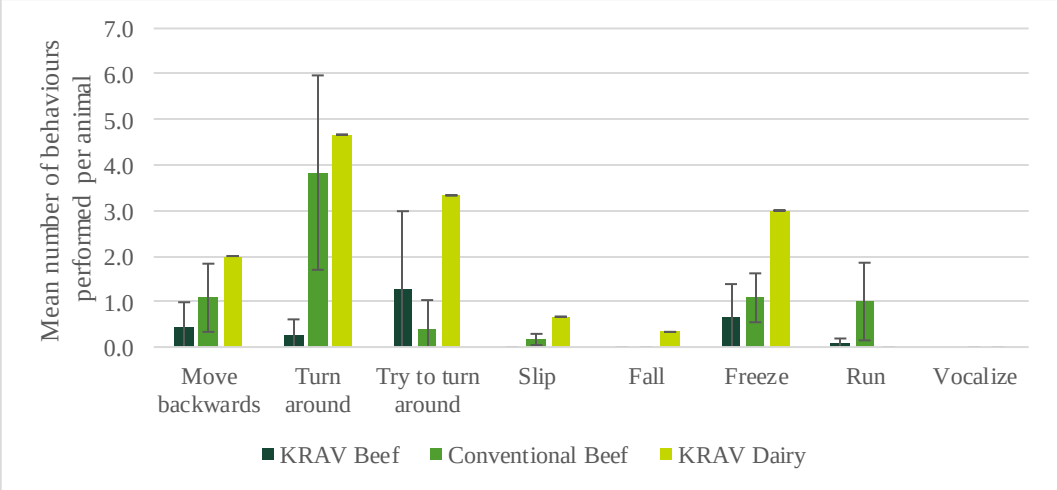

Figure 2. Animal behaviour during loading on-farm, mean value, and standard deviation per animal. Number of animals per group; KRAV-certified beef farm 4, 4, 3, 3; Conventional beef farm 4, 4, 4; KRAV-certified dairy farm 3.

4.1.2 Human-animal interactions

The most performed human-animal interaction on the KRAV-certified beef farm was speaking which included both speaking calm and whisper. Other interactions were shouting, beating rear, and pushing gate (figure 3). The human-animal interactions performed during loading on the conventional beef farm were speaking, beating rear, beating front, and pushing gate, where speaking was the most performed human-animal interaction. The human animal interactions during loading on the KRAV-certified dairy farm were speaking, shouting, slapping rear, slapping front, beating rear, beating front, tail twisting and pushing gate. Speaking

was the most performed human-animal interaction per animal. Since there were only one group of animals from the KRAV-certified dairy farm, there were no deviation from the mean value of performed animal behaviour or human-animal interactions. The mean values per animal shown in the tables is not counted on individual level, but on group level. The variation in mean value is possible to see between groups but not between individuals.

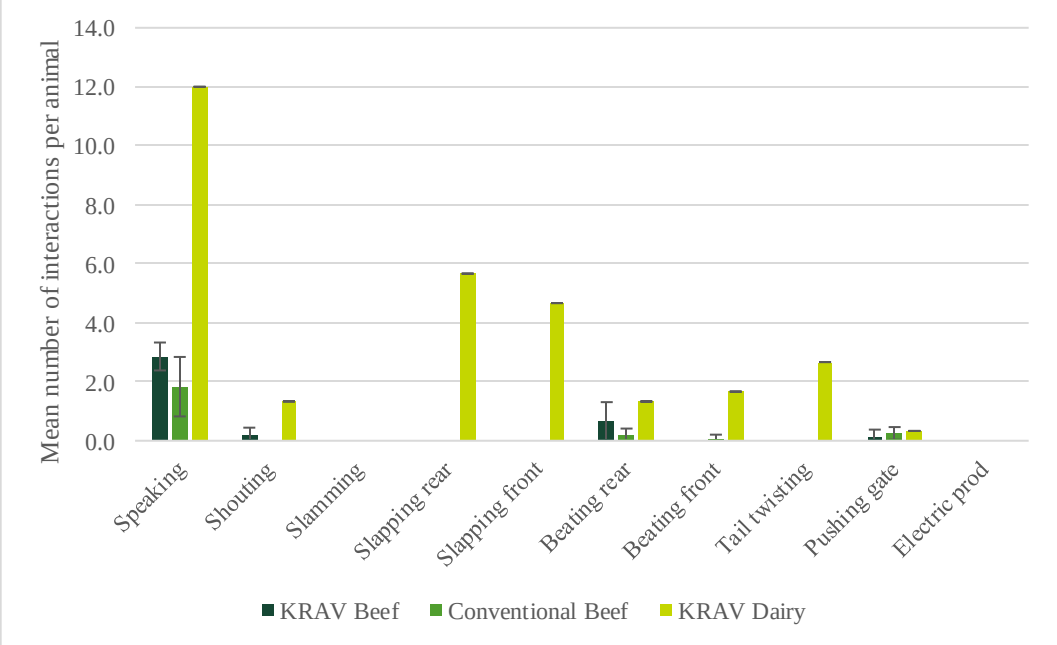

Figure 3. Human-animal interaction during loading on-farm, mean value and standard deviation per animal. Number of animals per group; KRAV-certified beef farm 4, 4, 3, 3; Conventional beef farm 4, 4, 4; KRAV-certified dairy farm 3.

4.1.3 Interviews with farmers

The conventional beef farm and the two dairy farms had loaded their animals one to two times before they were loaded on the transport to the slaughterhouse. The KRAV-certified beef farm had loaded their animals more than two times since they were driving them to summer pasture two times per season.

The factors which could affect animal welfare at loading were, according to the conventional dairy farmer, the odour in the transport (of other cattle or if it had been pigs in the transport before), if the engine was running during loading, the light, if the transporter is stressed, or if the transporter using tools unfamiliar to the animals. The number of persons loading the animals was considered an important factor and how experienced they are. The farmer though it would be less stressful for the animals if there were not too many persons loading the animals. It is better for the animals if the loading area is a familiar place where the animals have been moved before and if there is some type of bedding material on the floor and the ramp to

make the animals less fearful to enter the transport. The KRAV-certified beef farmer said it is better for the animals if they have been handled a lot, which would lower the stressful behaviours at loading. With unhandled animals, it could be higher risks for injuries at loading. The conventional beef farmer said the floor is important to make the animals more willing to enter the transport. The floor and the ramp should have bedding material like litter or straw to make the animals less fearful. The KRAV-certified dairy farmer also considered the floor to be important in the loading area. The floor should be slippery free and flat, without any thresholds or similar obstacles. According to the farmer, the gates should be easy to use when moving the animals and the driving race to the ramp should be narrow so only one animal can walk in it at the same time and not be able to turn around. This was the opposite of what the conventional dairy farmer said about the loading area, where it was preferred to have a wide area, which makes it possible for the bravest animal to walk first and lead the others.

The conventional dairy farmer mentioned freeze, turn, and move backwards as common behaviours during loading. The KRAV-certified beef farmer had not noticed any stressful behaviour during loading other than a few exceptions with young bulls. The conventional beef farmer said the behaviours varied from time to time and could not say any specific behaviours performed during loading. It depends on the animal's mood, and if one animal is entering the transport, all the animals enter. The farmer also mentioned breed influence on the behaviour of the animals. The KRAV-certified dairy farmer said it is common to see animals freeze and hesitate to walk up on the ramp of the transport.

The conventional dairy farmer did not have any opinion about which stages of the pre-slaughter process that affected animal welfare the most. What happened after loading the farmer could not influence. Adjustments suggested by the farmer to improve the animal welfare when loading the animals could be proper equipment, e.g., using gates to drive the animals up on the transport, as well as putting bedding material on the ramp to make it less fearful for the animals. Time is important, the farmer or animal keeper should not be in a hurry when loading the animals according to the conventional dairy farmer. The KRAV-certified beef farmer said changes in form of new environments are usually stressful for the animals, it is hard to avoid at the time of slaughter. This makes it is hard to answer the question of which the pre-slaughter procedures impact animal welfare the most. It is important for the transporter to be calm and gentle and handle the animals well at loading. The conventional beef farmer considered the transport and the lairage at the slaughterhouse as the most critical situations for the animals because of the unfamiliar environment. In addition, the farmer highlighted the value of having a nice and calm transporter, who does not stress the animals. The loading area should have proper gates which can be used effectively when driving the animals. The

transport vehicle could be improved with submerged floors to make the tilt of the ramp lower. In lairage at the slaughterhouse, the conventional beef farmer suggested improvements in the pens, for example, equipment to prevent mounting. This improvement was implemented recently by the slaughterhouse. The KRAV-certified dairy farmer thought that loading and transport are the most stressful situations for cattle pre-slaughter. If the animals were used to enter a transport the situation would not be as stressful and would not impact the animal welfare as much.

Three of the farmers had any experience from remarks on the carcass of the animals, other than liver abscess which according to the farmers, did not influence the meat quality. The KRAV-certified dairy farmer did once experience a remark from the carcass inspection where it was found an abscess. But it was not noticed any defects on the inspection of the live animal. However, it resulted in a lot of waste on the carcass of that animal.

The communication between the farmer and the slaughterhouse and transporter could be important from an animal welfare perspective according to the farmers. The conventional dairy farmer preferred to know which transporter that is going to pick up the animals. It would facilitate if the farmer would be informed in case delayed arrival of the transporter, to avoid the farmer being stressed due to lack of time for other routines. Lack of time at loading would affect the animal's welfare. The communication with the slaughterhouse could be improved with more feedback regarding the animal's condition during the time at the slaughterhouse. The KRAV-certified beef farmer was happy with the communication with the transporter and the slaughterhouse. The conventional beef farmer would wish for more information from the slaughterhouse. If there would be remarks, the farmer would like to know what the reason could be and advice on how to improve the animal husbandry to avoid these types of problems. The KRAV-certified dairy farmer was happy with the communication and appreciated a small-scale slaughterhouse. Even though the farmer did wish to get more feedback when getting remarks, for example regarding the cow with the abscess.

To assess the animal welfare from loading on-farm to stunning at the slaughterhouse using a protocol, the conventional dairy farmer considered it be most important to use it at the slaughterhouse. According to the farmer the personnel at the slaughterhouse need to be motivated and engaged to their profession for the protocol to work well. The farmer thought that a protocol could be hard to interpret for the personnel and be time consuming. Depending on the animal category, the behaviours would differ, and it could be a reason for difficulties with using a protocol, the farmer also mentioned. Further, the conventional dairy farmer said the protocol should not be too long or complicated

to use. The KRAV-certified beef farmer said the whole picture needs to be included in a protocol. The loading is individual and can be different on every farm, which makes it hard to follow a pattern for a protocol. The transport and unloading are more similar for all farms, which would make it easier to use. The question is if the farmers would have the interest to read it. The cattle husbandry business is already pressed, and this would require a higher workload. However, to get economical profit from this, the consumers need to be willing to pay more for the meat and animal products. The conventional beef farmer wanted a protocol to be able to follow up the animal welfare at the slaughterhouse and get feedback and statistics on remarks and their significance on the animal welfare. A protocol on-farm could be useful if the farmers do not load their animals as often. If the farmers are loading their animals once a month, they have a routine already and do not need a protocol. The KRAV-certified dairy farmer considered a protocol be usable to register animal behaviour at the slaughterhouse. The farmer wanted to know how the animals is handled but do not want to be there when they are slaughtered. Time at arrival and time in lairage would be factors of interest. The animal behaviour at the slaughterhouse would be interesting to know, according to the KRAV-certified dairy farmer. But the economical aspect determines if a protocol should be implemented. Economical support for good animal welfare could motivate farmers and the slaughter industry to use an animal welfare protocol.

4.2 Transport and unloading at the slaughterhouse

The transport time were highest for the KRAV-certified dairy farm and the distance were similar as for the KRAV-certified beef farm (table 6). The dairy farm had one stop which explain the higher time difference. The conventional beef farm had lowest transport time and distance to the slaughterhouse (table 6).

Table 6. Distance from farm to the slaughterhouse, transport time for the loaded animals, and number of stops the transport did on the way to the slaughterhouse

Farm	**Distance to slaughterhouse (km)**	**Transport time (min)**	**Stops**
KRAV-certified beef	113.0	109	0
Conventional beef	28.5	51	0
KRAV-certified dairy	107.0	177	1

4.2.1 Behavioural observations

The most performed behaviours during unloading were move backwards and freeze (figure 5). The animals from the KRAV-certified beef farm performed most types of behaviours per animal at unloading of the three production systems and had the longest unloading time per animal. The unloading time of the animals from the KRAV-certified beef farm was in total 40.8 seconds per animal (figure1). The unloading time varied between the groups with a standard deviation of 30.6. The animals from the conventional beef farm had an unloading time of 8.3 seconds in total for all the animals (figure 1). The behaviours performed by the animals from the conventional beef farm during unloading ware move backwards, freeze, and vocalize (figure 5). For the animals from the KRAV-certified dairy farm the unloading time was 17 seconds (figure 1), and the animals did not show any behaviour other than walking, which was not registered in the protocols.

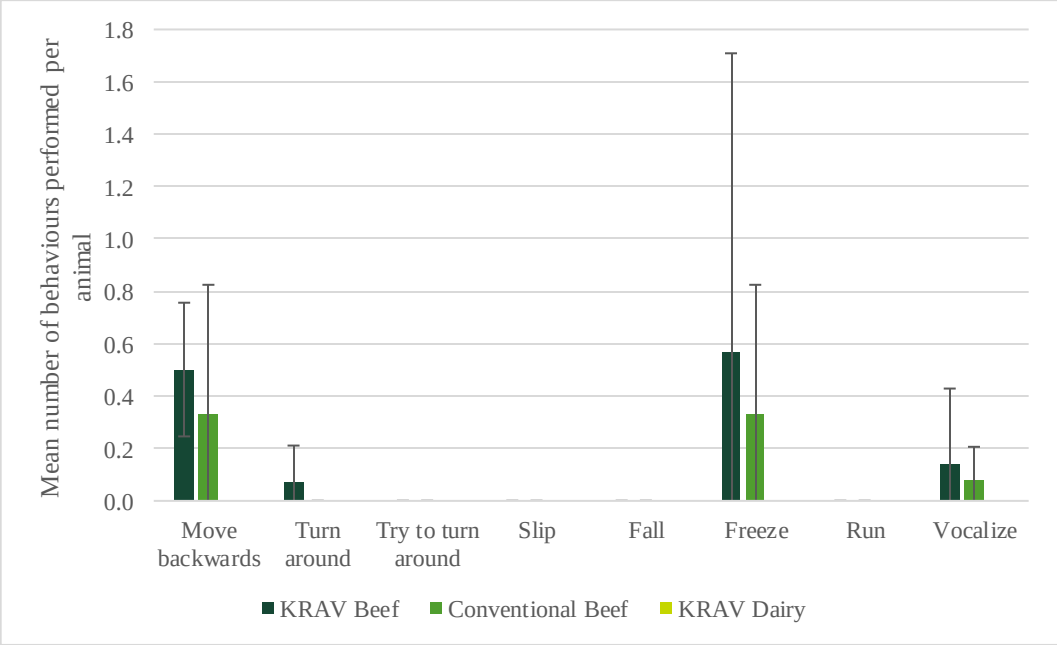

Figure 4. Animal behaviour during unloading at the slaughterhouse, mean values and standard deviation per animal. Number of animals per group; KRAV-certified beef farm 3, 6, 3, 2; Conventional beef farm 4, 4, 4; KRAV-certified dairy farm 3.

4.2.2 Human-animal interaction

Of the human-animal interactions during unloading of the KRAV-certified beef cows, speaking was the most performed interaction, which was performed 2.1 times per animal (figure 6). Pushing gate was performed 0.4 times per animal and shouting was performed 0.1 times per animal. During unloading the animals from the conventional beef farm, the human-animal interactions was speaking, and for

the animals from the KRAV-certified dairy farm the interactions were speaking and beating rear (figure 6).

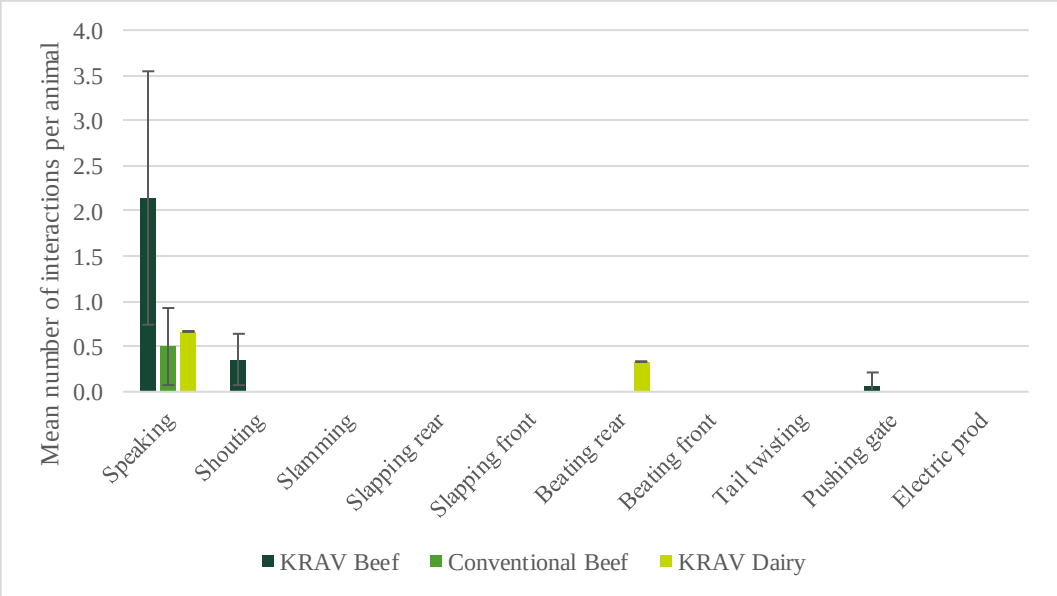

Figure 5. Human-animal interaction during unloading at the slaughterhouse, mean values and standard deviation per animal. Number of animals per group; KRAV-certified beef farm 3, 6, 3, 2; Conventional beef farm 4, 4, 4; KRAV-certified dairy farm 3.

4.2.3 Interviews with transporters

When unloading the animals, one of the transporters said that there is no specific behaviour that is common than the other, it varies between animal category and individuals. One states that bulls often run and walk faster. Cows are usually more familiar with human handling and do not react as heavy as the bulls when being driven by humans. The other transporter had experienced those animals that been handling a lot is harder to unload.

One of the transporters did not think any of the situations pre-slaughter were affecting the animal welfare. Overall, the transporter considered the welfare of the animals to be acceptable. The other transporter thought that the loading can be the most stressful situation for the animals in the pre-slaughter process. The first transporter had notice one issue at unloading and that is if there were other humans in the unloading area disturbing the animals when they are entering at the slaughterhouse.

The problems during transport could be the road conditions and when unloading the transporter think that the risk to be squeezed between animals is high. The other transporter had no comments concerning difficulties during transportation.

Neither one of the transporters had notice any difference in behaviour between KRAV-certified animals and conventional animals when handling them.

The transporters said that they have responsibility for checking on the animals and make sure they are well. No other documentation about the animals is done. They though that a protocol for assessing and improve animal welfare is unnecessary and would take too much time. They rather put that time on the animals.

4.3 Slaughterhouse observations

4.3.1 Behavioural observations

Lairage

The behaviours performed in lairage were standing, ruminate, drinking, vocalization, laying down and aggressive behaviour (figure 7,8 and 9). In all production systems, standing was performed by 100 % of the animals during their whole lairage time, except from one observation, when a cow from the KRAV-certified dairy farm was laying down. The lairage times is presented in table 7. Lairage time varied between animals within some of the groups. The maximum lairage time were on average 138 minutes ranging from 1 to 250 minutes in the groups from the KRAV beef farm, 60 minutes ranging from 1 to 100 minutes in the conventional beef farm and the animals from the KRAV-certified farm had a lairage time of 140 minutes. The KRAV-certified beef farm had the longest lairage time, which was 250 minutes for the last animals that were driven to stunning. The conventional beef farm ha the lowest lairage time, where the last animals were driven to stunning after 100 minutes.

Table 7. Lairage time in minutes for the different groups from each production system

	n	KRAV beef	n	Conventional beef	n	KRAV dairy
Group 1	3	100	4	30-80	3	140
Group 2	6	170-200	4	100		
Group 3	3	250	4	<1		
Group 4	2	<1				

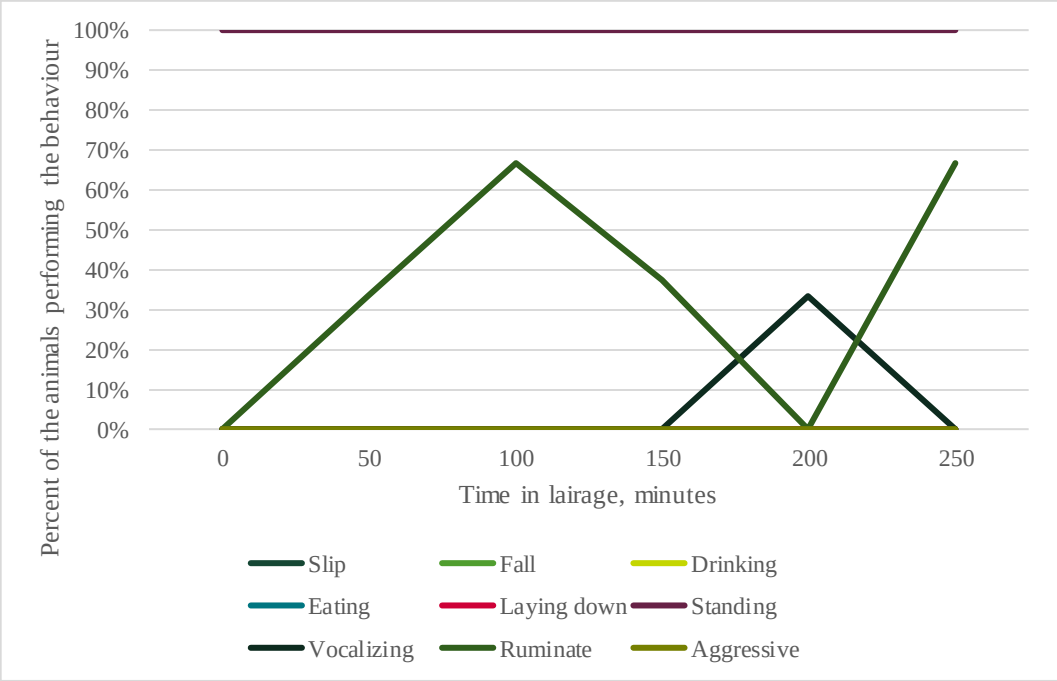

Figure 6. Animal behaviour in lairage at the slaughterhouse for the KRAV-certified beef farm, percent of total number of animals.

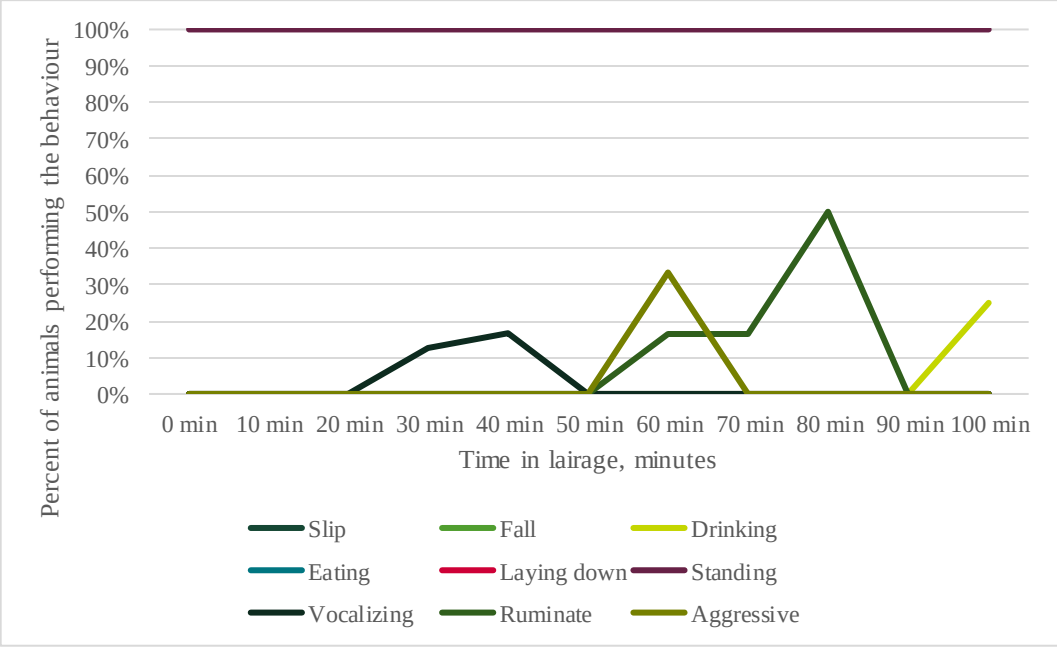

Figure 7. Animal behaviour in lairage at the slaughterhouse for the conventional beef farm, percent of total number of animals.

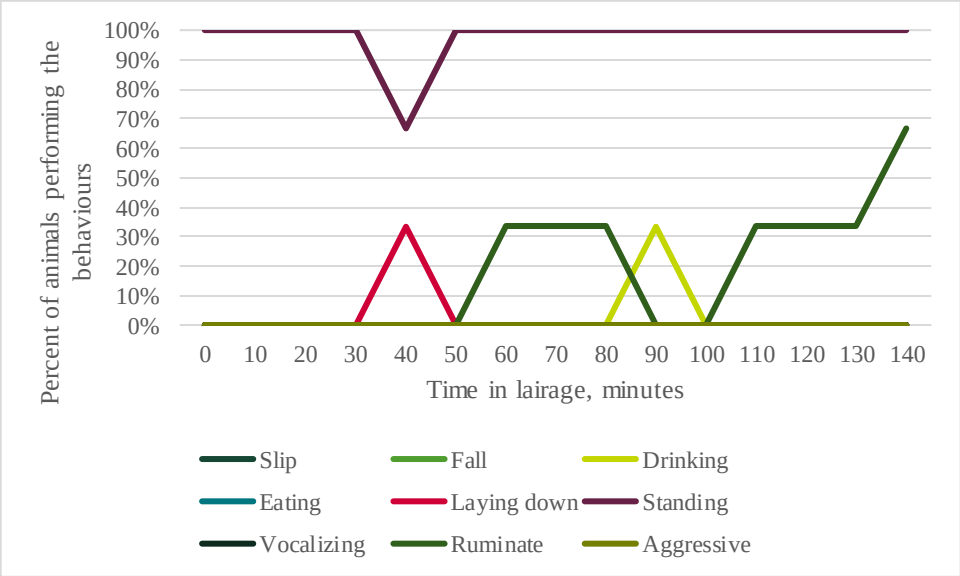

Figure 8. Animal behaviour in lairage at the slaughterhouse for the KRAV-certified dairy farm, percent of total number of animals.

Driving to stunning

The most performed behaviour per animal for all groups during driving to stunning at the slaughterhouse were move backwards (figure 10). The KRAV-certified beef farm had the lowest counts per animal of move backwards, but the highest count per animal of try to turn around, freeze, and vocalize comparing with the other production systems. Behaviours performed by the animals from the conventional beef farm were move backwards, try to turn around, slip, freeze and vocalize. The animals from the KRAV-certified dairy farm performed move backwards, turn around, and freeze.

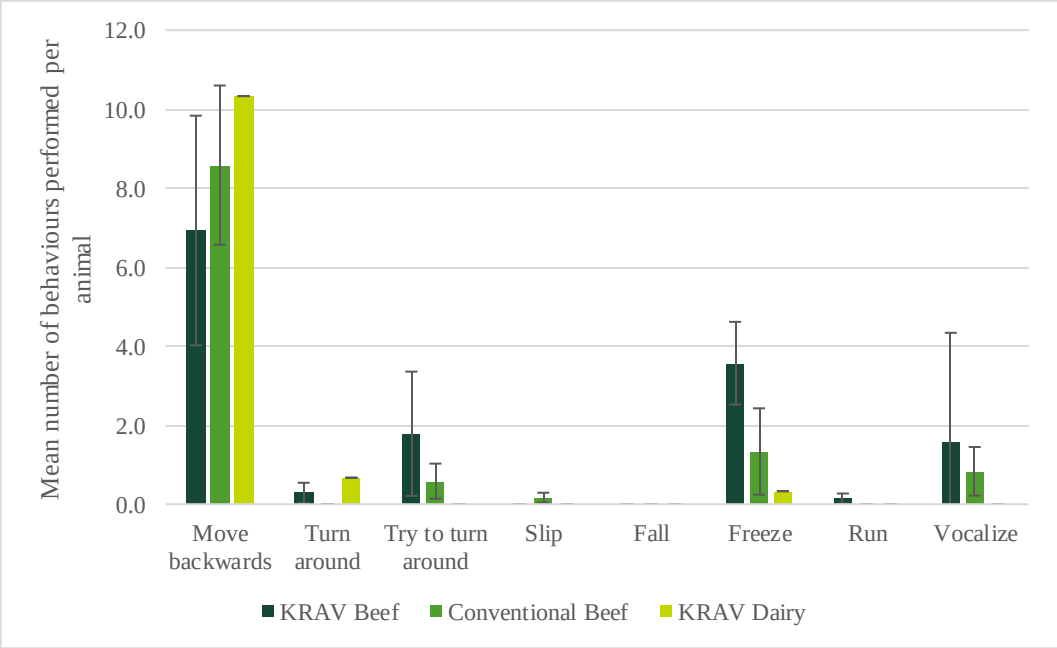

Figure 9. Animal behaviour during driving to stunning at the slaughterhouse, mean values and standard deviation per animal. Number of animals per group; KRAV-certified beef farm 2, 3, 6, 3; Conventional beef farm 4, 4, 4; KRAV-certified dairy farm 3.

4.3.2 Human-animal interactions

During driving to stunning, the most performed human-animal interactions per animal for the KRAV-certified beef farm was beating rear (figure 11). The other performed human-animal interactions during driving to stunning for the animals from the KRAV-certified beef farm were speaking, shouting, slamming, slapping rear, beating front, and electric prod. The most performed human-animal interaction per animal for the conventional beef farm were slamming. Other human-animal interactions for the conventional beef farm were speaking, shouting, slapping rear, slapping front, beating rear, beating front, and electric prod. For the KRAV-certified dairy farm the most performed human-animal interaction was beating rear, and slamming were performed almost as many times per animal as beating rear. Speaking, shouting, and electric prod were the other interactions performed during driving to stunning for the KRAV-certified dairy farm.

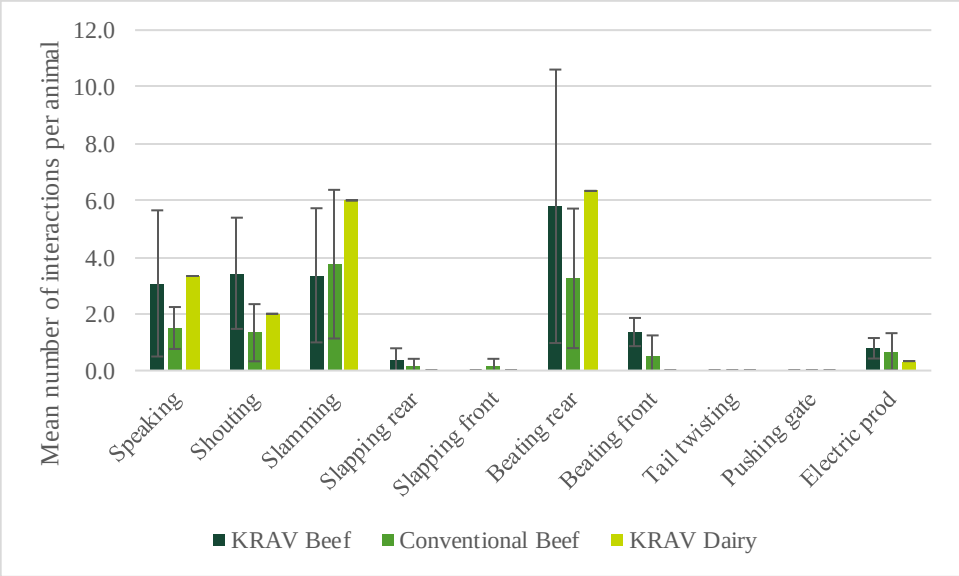

Figure 10. Human-animal interaction during driving to stunning at the slaughterhouse, mean values and standard deviation per animal. Number of animals per group; KRAV-certified beef farm 2, 3, 6, 3; Conventional beef farm 4, 4, 4; KRAV-certified dairy farm 3.

4.3.3 Interviews with the personnel at the slaughterhouse

The personnel that were interviewed at the slaughterhouse could not identify any specific behaviours at unloading, in lairage or at driving to stunning. The common answer to that question was that the behaviours depend on the animal category and type of individual. One example was brought up by the personnel was that young bulls often walk faster without any struggling compared to cows or heifers. The personnel considered that animals that have been handled before are much calmer at the slaughterhouse compared to animals that are not used to human contact. One of the personnel said that it was one farm that often weighed their animals which made them walk easier and be less nervous when driven at the slaughterhouse because they are used to be moved.

Of the three persons that was interviewed with the questionnaire, no one could say that they had seen differences in behaviour of animals from KRAV-certified farms and conventional farms. It was mentioned the differences in behaviours between animal categories, as stated above

The part of the pre-slaughter process that the personnel consider affect the animal welfare the most were lairage at the slaughterhouse. They had seen meat that was dark and sticky and with high pH value. They thought it was due to aggressive behaviour or stress in lairage, especially when the animals were staying overnight. One of the personnel said that it would have been better with the Uddevalla system, were the animals are kept in individual pens. Then it would be no risk that the animals will hurt each other during lairage. Another factor that affects the animals

according to one of the personnel was loading. If the farmer did not move the animals to the loading area the day before or in good time before loading, the animals could be stressed even before entering the transport.

If there were something that the personnel would like to change in the slaughterhouse to improve the animal welfare it would be solid walls to the pens were the cattle are kept. When the personnel are moving other animals in the driving race outside the pens it could disturb the animals in the pens. The animals driven to stunning can be stressed when they need to pass unfamiliar animals in the driving race. In addition, the personnel mentioned mechanical push gates in the driving race to stunning to avoid unnecessary human handling which could be stressful for the animals. Further, the lighting in the driving race was discussed as an important factor in driving race, which had been arranged by the slaughterhouse to improve the animal welfare. The gates in the driving race had been changed to avoid injuries on the animals because previous gates had harsh items. In the lairage pens they had problems with injuries earlier because of mounting, and now they have bars over the pens to prevent mounting.

There were different answers if the personnel feel a lack of time when handling the animals. One said no, one said yes, if there are people sick, and one said no but had experience that the transporter could be stressed.

The regular measurements on the carcass are temperature, faecal control, cleanness of the animal, and oil. There are no routine measurements on meat pH. The most common reason for disposal of carcass or part of the carcass could be abscess on the heart or veterinarian remarks, were the remarks normally had occurred on the farm.

Bruises on carcass are rare according to the personnel. The reason for bruises according to one person in the personnel is when the animals are mixed on-farm, which leads to aggressive behaviour and horn damage.

If a protocol for animal welfare should be implemented on-farm and on the slaughterhouse one of the personnel, considered it important to include on-farm variables, with focus on insurance of the farmers to bring together the animals in time before sending them to slaughter. Further, avoid mixing or moving the animals right before loading and avoid mixing animals between farms on the transport. The personnel also said it would be better for the animals and the slaughterhouse to have a more even flow throughout the year when sending the animals to slaughter. The most common today is that the farmers send their animals to slaughter in the autumn, which gives an uneven flow and workload and can lead to stressful situation for the personnel and poorer animal welfare due to higher animal density. The coding of damage on carcass should be improved according to one of the

personnel. There is a lot of damage that is not coded, and it should be different codes for old and new damages. The other person in the personnel did not have an opinion about what to include in an animal welfare protocol. There is already too much documentation, and it would be hard to use a protocol due to lack of personnel and time, and hard to interpret. One said that the younger generation would be more motivated to use a protocol. The main reason for using a protocol would be that it can lead to something, that the opinions of the personnel are raised. The other reason mentioned was better meat quality when improving animal welfare by using a protocol. If it was possible to show through a protocol or something similar that the animal welfare is high on slaughterhouse it would be great. Then it could be possible to show this result for consumers and in social media.

5. Discussion

The overall aim of this master thesis was to evaluate animal welfare of cattle through the slaughter process, from loading on-farm until the animals enter the stunning box at the slaughterhouse.
The specific aims were to 1) develop and evaluate protocols for animal welfare assessment of cattle prior to slaughter and 2) map variation in animal welfare indicators within and between different production systems. The specific research questions to be addressed were:

- Which animal welfare indicators in the animal welfare protocol are practically feasible to record in different production systems for cattle, namely conventional and KRAV-certified production?
- Is there variation in animal welfare indicators relevant to describe variation between animal categories and between production systems?
- What is the opinion of the farmers, transporters, and slaughter personnel regarding animal welfare prior to slaughter and their motivation to use a protocol to assess animal welfare?
- Based on the protocols, can we identify relevant animal welfare issues during the process from loading on-farm to stunning at the slaughterhouse?

Here, the main results will be discussed as well as how the pre-slaughter procedures could affect animal behaviour and welfare. Furthermore, the results from the questionaries will be discussed and related to the literature review.

The observations in this study do not include enough animals or farms to be able to draw general conclusions of the results regarding the production systems' impact on animal welfare prior to slaughter. The results do not represent the whole farm, but only the group of animals included in the observations. The observations in this study are not representative for the slaughterhouse but have been done to evaluate and identify measurable welfare indicators during the animals' time in the slaughterhouse.

5.1 Feasibility of the animal welfare protocol

5.1.1 Method for observations

The animals were observed at group level, and each group consisted of three to four animals. When observing this small size of group, it should be possible to make recordings of animal behaviour and human-animal interactions at individual level. The possibility to observe at individual level, were depending on the position of the observer. To be able to observe at individual level it also requires noting animal ID or characteristics of the animals before the observations starts to be able to distinguish the individuals. In this study, the bulls were more difficult to identify than the cows and heifers of milk breed. It could depend on the behaviour of the bulls, as they move faster than female animals. However, the Charolais cows from the KRAV-certified beef farm were even more difficult to identify because they had the same colour and were not marked in any way. The cows and heifers of milk breed had more clear features and therefore easier to distinguish.

Continuous observations require more labour than instantaneous observations, which is recorded at fixed intervals. However, continuous observations could make it possible to get important results like the frequency of a performed behaviour (Chen et al. 2016). When doing continuous sampling there is a risk for the measurements to not be reliable. To be able to record all performed behaviour there need to be only a few variables (Martin and Bateson 2007). In the protocols used in the current study there were eight behaviours in the animal behaviour protocol and ten interactions in the human-animal interaction protocol. The quantity of variables included in the protocols could be fewer. There could also be different protocols for loading, unloading, and driving to stunning. Moreover, in this study there were also behaviours, e.g., vocalization which did not occur at all during loading. On the other hand, vocalization could be an important indicator of poor welfare or poor handling of the animals (Hultgren et al. 2014; Grandin 2013; Swedish board of agriculture 2012). The risk with excluding this behaviour, is that the observer misses potential animal welfare indicators. Even though the behaviour did not occur during loading at the farms in this study, it does not implicate it never could occur during loading at other farms. Regarding the human-animal interaction protocol, the variables slamming, or electric prod did not occur during loading in any of the production systems. To make the protocol more useable these interactions could be left out during loading or replaced with other variables.

In the human-animal protocol there were behaviours which could have a better definition. The level of beating rear, which is defined as "beating animal with tool" could vary. In this protocol there were only one definition of using a tool when handling the animals (beating rear or beating front). During the observations tools

were used in different ways and it was sometimes spontaneously noted in the comment column in the protocol as an easy touch. For example, at the unloading of the KRAV-certified dairy cows the interaction "beating rear" were only touching the animal with the tool. In the study of Hultgren et al. (2014) they had two definitions of using hand that was either touching (rear or front) or slapping (rear or front) and when using a tool, it was either hitting (rear or front) or beating (rear or front), were hitting was defined as only touching the animal with a tool, and beating were beating animal with a tool. Hultgren et al. (2014) interpreted that the different interactions had different impact on animal welfare and thus beating had severe scoring point (3), and hitting rear had a mild scoring point (1). This scoring system is usable, but further research is needed to prove the effects on the animal welfare (Hultgren et al. 2014). Based on my findings there is a need for a protocol with different definitions for using tool or hand when driving cattle. On the other hand, the protocol should not have to many variables when doing direct observations. It should be easy to use and interpret, especially when it will be used by the industry.

5.1.2 Time measurements and observer's position

The time for loading was recorded on-farm and on the conventional beef farm one of the bulls jumped over a gate and into another pen of bulls. This resulted in a break of the loading and our observations because the observers could not count behaviours or interactions when it was not related to the loading. However, it could be considered as a part of the loading and loading time because it occurred during loading. When doing direct observations, unplanned situations can occur. We counted this event as the animals being out of sight. Nevertheless, this group with the bull that escaped did have the longest loading time of all groups on the conventional beef farm, even though we did not count the time when the bull escaped.

At the slaughterhouse unloading was observed, but from an angle that did not allow the observers to see the ramp of the transport. This made it difficult for the observers to record all the behaviours performed during the first seconds of unloading. With direct observations it was hard to find a position for the observers where the animals were not disturbed during unloading. If the animals could see the observers, they could get frightened. It would impact the result and if the animals get frightened of the observer and turn around quickly, it could be dangerous for the person who was unloading the animals. This was mentioned by one of the transporters during the interviews. The issue with visibility is pointed out in another study (Sandström 2009). A raised position is recommended to improve the observer's view.

When carrying out this study, the driving time was found complicated to measure. Questions were raised if the driving time should be measured from the first animal walks out of the pen in lairage until the last animal in that pen enter the stunning box. This was found difficult when the group was split up. One group from the KRAV-certified beef farm was divided into three groups of one, two and three cows in every group and the total driving time for that pen were 30 minutes. However, 30 minutes does not correspond to how long one cow was waiting in the driving race. The groups were in the driving race for 2 min, 11 min and 17 min respectively. It is hard to determine how to count the driving time per animal to get a valuable result. In one group the last cow driven was standing in the driving race for 17 minutes and the first cow for 3 minutes. In addition, the last cow in the 17 minutes-group was standing in the driving race for more than 15 minutes, which is the limit for KRAV-certified animals. Included in the driving time, was when the slaughter personnel performing de-bleeding of the stunned animal. The driving of the first animal was always faster as the next animal had to wait for the slaughter personnel finish stunning and debleeding the first animal before attending the next animal in the group. Part of the driving time there were no human present and no interactions registered. However, the animal behaviours were registered. It can be hard to measure correlation between animal behaviour and human-animal interactions during the observation time when there is no human present. The KRAV-certified beef farm had the shortest driving time, which could be explained by two of the four pens of that farm had two extra persons driving the animals. Previous studies included the driving race length when observing animal behaviour in driving race at the slaughterhouse (Hultgren et al. 2014). This could indicate a longer driving race could contribute to more behaviours and interactions, as well as longer driving times. When comparing different slaughterhouses, the driving race length could vary. It is important to consider the driving race length when doing behaviour observations. Driving race length were not included in this study.

5.2 Variation between production systems and animal categories

5.2.1 Animal's previous experience of human handling and loading

The behaviours of the animals at loading on-farm, which differed between production systems were move backwards, turn around and freeze (figure 2). These behaviours were lowest when loading the KRAV-certified cows compared to the heifers and young bulls from the conventional beef farm and the cows from the KRAV-certified dairy farm. The loading time per animal were lowest for the

KRAV-certified beef farm. This could depend on several reasons, e.g., the KRAV-certified beef cows were used to be moved and handled. They had been loaded before more than two times, which none of the animals from the other production systems had. The dairy cows were used to be handled, except from one of the cows from the dairy farm, which was a nervous cow and had always been, according to the producer. This could be the reason for the KRAV-certified dairy farm having longer loading time and more stressful behaviours per animal at loading on-farm.

According to the KRAV-certified beef farmer the cows that are used to be handled are less stressed during loading. The results from this study show that the KRAV-certified beef farm had the lowest loading time and showed lowest number of performed stress-related behaviours per animal. On the other hand, one of the transporters mentioned that animals who have been handled a lot are harder to unload. The unloading time were highest for the KRAV-certified beef farm and these animals had the highest count of animal behaviour and human-animal interactions during unloading.

The design of and the environment in the loading areas were different for the different production systems. Of the four farmers interviewed, three of them had ideas of how the loading area should be designed to facilitate loading and reduce stress for the animals. Floor, light, and ramp to the transport was mentioned by the farmers as important factors. This agrees with literature (Swedish board of agriculture 2012), and in the Swedish regulations (SJVFS 2020:22). The KRAV-certified beef farmer did not mention any of the environment factors but still had the lowest loading time per animal. Other factors could have affected the loading time, e.g., previous handling of the animals and driving technique. This agrees with Grandin (2003), that cattle which are used to be handled might feel less fear during loading and unloading. In the report of Swedish board of agriculture (2012) suggested training of the animals before transport could lower the stress during loading. According to the KRAV-certified beef farmer the cattle husbandry business is pressed and the time for training animals for transport might not be suitable in current cattle production. The methods for improving animal welfare must be practical feasible for the farmers. Economical aspects have great significance for the animal welfare and the possibility to implement improvements. Using a welfare protocol could be motivating according to the KRAV-certified dairy farmers if there were an economical support for good animal welfare. This could be a political issue due to the goal for improved animal welfare needs to be included in the rural development. Financial compensation to farmers that have higher demand on animal welfare should be implemented (Europeiska reviosionsrätten 2018).

5.2.2 Gender variation

Mendonca et al. (2019) found the gender of cattle had a big influence on the occurrence of bruises on cattle carcass. Cows had higher number of bruises compared to male animals. More studies on behaviour and handling techniques on different gender would be needed, since there was a difference in behaviour and human-animal interactions between the cows and the young bulls. This has been discussed in a study of Mounier et al. (2008) and in the interviews with farmers in the current study, there were mentioned a variation in animal behaviours between animal categories. The suckle cow from the KRAV-certified beef farm had a lower amount of human-animal interactions compared to the dairy cows. This indicates that there could be a difference between beef production and dairy production. From the interviews, the response of the farmers, slaughter personnel and transporters indicated a difference in animal behaviour between animal categories, rather than between animals from different production systems. The slaughter personnel did not consider it to be any variation in behaviours of KRAV-certified animal and conventional animals. Nevertheless, in this study there were no high variation between the two beef production systems. There were slightly more human-animal interactions for the KRAV-certified beef farm compared to the conventional beef farm when driving to stunning, e.g., speaking, shouting, beating rear and beating front. The conventional beef farm included four heifers which could have an influence on the result, and it could be even lower human-animal interactions if there were only bulls at the conventional beef farm.

5.3 Animal welfare implications

5.3.1 Lairage at the slaughterhouse

According to the Swedish regulation, the conventional animals do not need to have access to food or bedding material during lairage time in the slaughterhouse, except for animals that stay overnight. The access to food and bedding material is included in the KRAV-certified regulations, which could be an animal welfare implication in the regulations for slaughter of conventional cattle in Sweden since the lack of requirement of food and bedding material. In this study the observers did not observe differences in animal behaviour during lairage between conventional and KRAV-certified cattle, possibly due to the fact that none of the animals had food or bedding material. In the lairage pens there were no space for the animals to lay down at the same time, even when the animal density was meeting the requirement of space, for both conventional and KRAV. The most performed behaviour was standing, which indicate laying down is either not motivated or possible for the animals. Furthermore, the pens at this slaughterhouse had higher measurements per

animal than what the regulations minimum requirements for both KRAV-certified and conventional animals. For example, the pens for an animal of >600 kg should according to Swedish regulations be minimum 2.5 m^2 per animal and 2.7 m^2 per animal according to KRAV regulations (table 1). In the slaughterhouse minimum measurements in the pens were 2.75 m^2 per animal for both conventional and KRAV-certified animals (table 4). The time in lairage could enable the animals to rest and recover from transport (del Campo et al. 2010). However, there were no food or bedding material and even though one cow displayed "laying down" (figure 9) as a behaviour during lairage time, there were no opportunity for the whole group of animals to lay down and rest at the same time, as it was too crowded in the pens. This could indicate there was no possibility for the animals to recover in lairage. A comment from the slaughter personnel was that laying down indicated the cow suffered from pain in her legs, and it was probably the reason for laying down in lairage. Lower animal density has been shown to have positive effects on animal welfare of cattle (Gygax et al. 2007). The reason for the lack of food and bedding material for the KRAV-certified animals was according to the slaughter personnel the deficiency of time to prepare the pens before the animals arrived at the slaughterhouse, due to shortage of personnel. In the current study, the lairage time were up to 4 hours and it might not have affected the animal welfare as much as if the lairage time had been longer. The deficiency of time for the personnel could indicate too high workload and that in turn impact the animal welfare.

5.3.2 Handling when driving animals to stunning box

Of all the different procedures the animals are being exposed to during pre-slaughter, driving to stunning was in the current study when most stress-related behaviours and rough human-animal interactions were performed. Which could indicate when driving animals to stunning at the slaughterhouse being the procedure affecting the animal welfare the most. However, as mentioned above, the length of the driving race to stunning could have an impact on the time and the number of behaviours performed. The distance the animals had to walk in the unloading area were shorter than the driving race.

In this study the electric prod was used on both conventional and KRAV-certified animals. The personnel driving the animals considered using the electric prod necessary due to the long waiting time for the other animals in the driving race and lairage. In these human-animal observations it was concluded that with direct observations the possibility to perform observations at induvial was limited. If observations on individual level is recorded, it is easier to detect what behaviour the animal is performing when being exposed to electric prods. Behaviours noted spontaneously when the electric prod was used were move backwards, slip, run, and vocalize. The time when the electric prod is used could be interesting to

register, whether it is used early during handling in driving race or if the human waits and use it if the animal does not respond to any other driving methods. In the current study, the time when the electric prod was used was not registered during driving, but the observers took spontaneous notes of electric prod use during the observations. A conclusion after performed study was that the time of electric prod use could be included in the protocol. This parameter was identified during the observations and that is the reason for not including this when designing the protocol from the beginning. The personnel normally waited 5-7 minutes after driving to stunning started before using it and in most cases in the end of the driving race. On one occasion the personnel used the electric prod as soon as one animal stopped in the beginning of the driving race.

The slaughter personnel had opinions about the animal welfare at the slaughterhouse. They mentioned factors associated with lairage at the slaughterhouse and driving to stunning. For example, the importance of proper light in the driving race and in stun box to facilitate the handling of the animals when driving to stunning. The responses for using a protocol at the slaughterhouse varied. If the ideas and opinions of the personnel, e.g. changes of the facilities in driving race or lairage at the slaughterhouse could be prioritized through implementation of an animal welfare protocol, it might be motivating to use. One of the responders mentioned lack of time for using a protocol which could indicate a greater need of labour to avoid too high workload for the personnel, which would not be sustainable from a social perspective.

5.3.3 Future research of animal welfare of cattle pre-slaughter

Grandin (2013) discussed alternative methods to electric prod use when driving cattle at the slaughterhouse. An air-powered prod which creates a very intense vibration could be used instead of using an electric prod. To maintain or improve animal welfare at the slaughterhouse it is important that the manager of the slaughterhouse pay attention to the handling and stunning methods. Grandin (2013) suggested an objective numerical scoring which could make it possible to determine if the handling of the animals and stunning is performed in a successful way. The use of a protocol could tell if the animal welfare is acceptable, for example, when an electric prod is used it could be measured and show on which level the animal welfare is. For example, if the electric prod is used less than 25 %, it could be considered as acceptable and if it is used on less than 5 % it could be considered as excellent according to Grandin (2013). The animal welfare of every individual which is exposed to electric prod could be considered not acceptable, regardless of when it is used during driving. However, more research is needed to find alternative method for electric prod use that would be suitable for both big and small-scale slaughterhouses. According to Grandin (2013), a prohibition of electric prod could

lead to improper driving methods, and then there must be considered which driving methods impair the welfare of cattle the most. A realistic solution in the current conditions at slaughterhouses could be to reduce the number of animals being exposed to electric prod during driving to stunning, until alternative methods has been developed. Other variables like animal behaviour should be included in the objective numerical scoring (Grandin 2013).

Stunning quality and behaviour in the stun box are further important factors to include when evaluating animal welfare before slaughter. This was not included in this study due to difficulties of observing the events in stun box and at the same time observe the animal behaviour and human actions in driving race. Video recorded observations would make these behavioural studies more practical feasible. In addition, video auditing in slaughterhouses can contribute to maintain high standards and to be able to show when the conditions are good (Grandin 2013).

6. Conclusion

After performed observation and evaluation of these animal welfare protocols it is suggested to include fewer categories of behaviours and interactions for direct observations to be practical useable. The human-animal interactions like e.g., slapping and beating should be defined in different ways to assess the impact of the interactions on the animal welfare. The observation position and the identification of the individual animals observed should be determined before the observation. Based on the results from this study, there were indications of variations in animal behaviours and human-animal interactions between animal categories and production systems of cattle. In the current study, KRAV-certified beef production had the lowest stress-related behaviours at loading and shortest loading time when compared with conventional beef production and KRAV-certified dairy production. The highest count of stress-related behaviours per animal in all production systems was during driving to stunning. The observations in lairage at the slaughterhouse indicated that the animals could not rest and recover during the time at the slaughterhouse. Further research in this subject could focus on animal behaviour correlated to human-animal interactions and the reason for using electric prod when driving cattle to stunning box.

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Populärvetenskaplig sammanfattning

Slaktprocessen, från lastning av djuren på slakttransporten på gården till bedövning på slakteriet, gör att våra produktionsdjur utsätts för stressiga situationer och en okänd miljö. Djurvälfärden i samband med slakt har ifrågasatts i flera år och forskning bakom hur djurvälfärden påverkas är begränsad. Syftet med detta examensarbete var att utveckla och utvärdera protokoll för djurvälfärd av nötkreatur i samband med slakt och kartlägga variation i djurvälfärdsindikatorer inom och mellan olika produktionssystem, med fokus på KRAV-certifierade och konventionella produktionssystem för nötkreatur. Med djurvälfärdsindikatorer menas faktorer som kan påverka djurens välfärd. Tanken bakom detta projekt är att i framtiden kunna ta fram hjälpmedel för branschen, det vill säga lantbrukare, transportörer och slakteripersonal för att kunna förbättra djurvälfärden för nötkreatur innan slakt. Genom att identifiera stressrelaterade beteenden, hanteringsmetoder vid drivning av nötkreatur och miljön som nötkreaturen befinner sig i, är förhoppningen att hitta förbättringspotential gällande nötkreaturs välfärd igenom hela produktionskedjan. Tre gårdar ingick i studien, en KRAV-certifierad nötköttsgård, en konventionell nötköttsgård och en KRAV-certifierad mjölkgård. När gårdarna skulle skicka en omgång med djur till slakt utfördes beteendestudier på både djurens beteende och människa-djurinteraktioner vid lastning, avlastning, och vid drivning av djuren till bedövning, samt djurens beteenden under inhysningen på slakteriet. Lastningstid, transporttid, avlastningstid, inhysningstid på slakteriet och tid för drivning av djur till bedövningsboxen registrerades också som djurvälfärdsindikatorer. Intervjuer med lantbrukare, transportörer och slakteripersonal gjordes under studien för att bedöma deras uppfattning av djurvälfärd innan slakt och deras motivering till att använda sig av ett djurvälfärdsprotokoll. Intervjuerna var semistrukturerade vilket innebär att den person som intervjuar inte behöver hålla sig till frågeformuläret under intervjun, utan kan använda sig av spontana följdfrågor. Syftet med intervjuerna var att fånga upp viktiga synpunkter som bör inkluderas vid en utveckling av djurvälfärdsprotokoll. Branschens åsikter är viktiga för att kunna utforma detta hjälpmedel på bästa sätt.

Tidigare forskning har visat att tiden som det tar att driva djuren kan vara en djurvälfärdsindikator, då kortare drivningstid kan vara ett tecken på god djurvälfärd, förutsatt att människa-djurinteraktionerna är acceptabla. Det finns ett

visst intresse för lantbrukarna som intervjuades i denna studie att få ta del av djurens tillstånd på slakteriet. Lugn hantering av djuren vid lastning och drivning var något som värdesattes och som uppskattades av lantbrukarna. Återkoppling från slakteriet var ett förslag som kom upp under intervjuerna. Slakteripersonalen hade upplevt att det förekom att djur från vissa gårdar kunde vara stressade vid ankomst till slakteriet. Anledningen till detta kan vara svårt att avgöra, om det beror på transporten eller om det var en stressad situation vid lastning. Slakteripersonalen tyckte att det är viktigt att djuren inte blir blandade vid lastning eller på transporten då det leder till stress för djuren och det i sin tur kan påverka köttets kvalité. Försämrad köttkvalitet kan påverka ekonomin för både lantbrukare och slakteriföretagen. Förutom den etiska aspekten att upprätthålla en god djurvälfärd, så är den ekonomiska aspekten viktig. Ekonomin avgör även hur djurvälfärden kan förbättras. Resurser i form av förbättringar av utrustning vid drivning och design av drivgångar och lastningsutrymmen behövs. Även arbetskraft och tid för att undvika stressad personal vid hantering av djuren på slakteriet. Kunskap och utbildning kräver också ekonomiska resurser.

Efter utförd observation och utvärdering av dessa djurvälfärdsprotokoll dras slutsatsen att om direkta observationer ska vara praktiskt användbara krävs färre beteenden och interaktioner i protokollen. Det ska vara lätt att använda dem och inte ta för mycket tid. Interaktioner mellan människa och djur som att ”slå” och ”slå med redskap” bör definieras på olika sätt för att bedöma effekten på djurvälfärden. Vid behov av att använda redskap för att driva djuren kan redskap användas på olika sätt. Upprepade hårda slag med redskap bryter mot djurskyddslagen och försämrar djurvälfärden. Denna felhantering kan identifieras med ett protokoll och då skapas underlag för förbättringspotential. För att kunna upptäcka vilka beteenden som utförs vid olika hantering av djuren bör observationerna ske på individnivå. Vid användning av protokollen för att utföra studier vid lastning på gård och vid hantering på slakteri bör observationspositionen och identifieringen av den observerade individen fastställas före observationstillfället, för att det ska vara möjligt att utföra observationer på individnivå. Detta kan bli en svårighet för lantbrukare och slakteripersonal att utföra. Potentiell brist av hanteringen av djuren var användandet av elpåfösare vid drivning. För att identifiera hur användandet av elpåfösare påverkar djurvälfärden kan eventuella stressrelaterade beteenden observeras och registreras, samt följa upp frekvensen av användandet av elpåfösare. Även slaktkroppen kan undersökas för att se om den kan påverkas av användning av elpåfösare.

I den utförda studien ingick också en jämförelse mellan konventionell och KRAV-certifierad nötköttsproduktion. En generell slutsats går inte att dra då det inkluderades för få gårdar och djur i studien. Gårdarna hade även olika djurkategorier vilket skulle kunna påverka resultatet. Därför blev det även en del av

frågeställningen. Det som framgick var att det kan finnas variationer i djurbeteenden och interaktioner mellan människa och djur inom djurkategorier och produktionssystem för nötkreatur. Denna studie visar att KRAV-certifierad nötköttsproduktion hade lägst antal stressrelaterade beteenden vid lastning och kortast lastningstid vid jämförelse med konventionell nötköttsproduktion och KRAV-certifierad mjölkproduktion. Det högsta antalet stressrelaterade beteenden per djur i alla produktionssystem var under drivning till bedövningsbox. Observationerna under inhysningen på slakteriet tydde på att djuren inte hade möjlighet att vila och återhämta sig under tiden på slakteriet oavsett produktionssystem.

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Appendix 1

Protocol of animal behaviour during loading, unloading, and driving to stunning. Classification: Number of behaviours performed per group

Date: Area: Observer: Start/end time: Total time:

Production/Animal category: Number of animals:

Group	**Animal ID**	Move backwards	Turn around	Try to turn around	Slip	Fall	Freeze	Run	Vocalize	**Comments**

Appendix 2

Protocol of human-animal interactions during loading, unloading, and driving to stunning. Classification: Number of interactions per group

Date: Area: Observer: Start/end time: Total time:

Production/animal category: Number of animals: Number of humans:

Group	**Animal ID**	Speaking	Shouting	Slamming	Slapping rear	Slapping front	Beating rear	Beating front	Tail Twisting	Pushing gate	Electric goad	**Comments**

Appendix 3

Protocol of animal behaviour during lairage at the slaughterhouse

Date: Start time: Observer: Number of animals:

Production/animal category: Group: Classification: Behavior performed

Time interval	Animal ID	Animal ID	Animal ID	Animal ID	Animal ID	**Comments**
0 min						
10 min						
20 min						
30 min						
40 min						
50 min						
60 min						
70 min						
80 min						
90 min						
100 min						
110 min						
120 min						
130 min						
140 min						
150 min						
160 min						
170 min						
180 min						
190 min						
200 min						
210 min						
220 min						
230 min						
240 min						
250 min						
260 min						
270 min						
280 min						
290 min						
300 min						
310 min						

Slip: Slip Drinking: D Laying down: L Vocalizing: V

Fall: F Eating: E Standing: S Ruminate: R Aggressive behavior: A

Appendix 4

Ethogram of animal behaviours during loading, unloading, and driving to stunning

Behaviour	Description	Reference
Move backwards	The animal takes at least 2 steps backwards by itself or as a reaction to the handling	Hultgren et al. (2014); Hultgren et al. (2020); Welfare Quality® (2009); Özdemir et al. (2022)
Turn around	The animal turns around by itself or as a reaction to the handling	Hultgren et al. (2014); Hultgren et al. (2020); Welfare Quality® (2009); Özdemir et al. (2022)
Try to turn around	The animal does an unsuccessful attempt to turn. Turning its head does not count as try to turn around	Welfare Quality® (2009)
Slip	Loss of balance in which the animal is loses its foothold or the hooves slide on the surface	Hultgren et al. (2014); Hultgren et al. (2020); Welfare Quality® (2009); Özdemir et al. (2022)
Fall	Loss of balance in which part of the body other than feet and legs are in contact with the floor	Hultgren et al. (2014); Hultgren et al. (2020); Welfare Quality® (2009); Özdemir et al. (2022)
Freeze	The animal does not want to move forward, even if human attempts to move it	Hultgren et al. (2014); Hultgren et al. (2020); Welfare Quality® (2009); Özdemir et al. (2022)
Run	The animal runs forward	Hultgren et al. (2014); Hultgren et al. (2020); Özdemir et al. (2022)
Vocalize	Makes vocal sound as a result of obvious signs of pain or stress	Hultgren et al. (2014); Hultgren et al. (2020); Welfare Quality® (2009); Özdemir et al. (2022)

Appendix 5

Ethogram of human-animal interactions during loading, unloading and driving to stunning

Animal-human interaction	**Description**	**Reference**
Speaking	Speaks or whistles softly and quietly	Hultgren et al. (2014)
Shouting	Speaks or shout harshly or loudly	Hultgren et al. (2014); Hultgren et al. (2020)
Slamming	Makes noise by hitting wall with a tool	Hultgren et al. (2014); Hultgren et al. (2020); Özdemir et al. (2022)
Slapping rear	Slaps the animal behind hip bone with hand	Hultgren et al. (2014); Hultgren et al. (2020)
Slapping front	Slaps the animal in front hip bone with hand	Hultgren et al. (2014); Hultgren et al. (2020)
Beating rear	Beats the animal behind the hip bone with tool	Hultgren et al. (2014); Welfare Quality® (2009); Özdemir et al. (2022)
Beating front	Beats the animal in front of the hip bone with tool	Hultgren et al. (2014); Welfare Quality® (2009); Özdemir et al. (2022)
Tail twisting	Bends or twists tail	Hultgren et al. (2014); Hultgren et al. (2020); Özdemir et al. (2022)
Pushing gate	When human pushes gate on the animal to make it move forward	Hultgren et al. (2014); Hultgren et al. (2020); Özdemir et al. (2022)
Electric prod	Using electric prod to make the animal move forward	Hultgren et al. (2014); Hultgren et al. (2020); Welfare Quality® (2009); Özdemir et al. (2022)

Appendix 6

Ethogram of animal behaviours during lairage at the slaughterhouse

Behaviour	Description	Reference
Slip	Loss of balance in which the animal is loses its foothold or the hooves slide on the surface	Hultgren et al. (2014); Hultgren et al. (2020); Welfare Quality® (2009); Özdemir et al. (2022)
Fall	Loss of balance in which part of the body other than feet and legs are in contact with the floor	Hultgren et al. (2014); Hultgren et al. (2020); Welfare Quality® (2009); Özdemir et al. (2022)
Drinking	Drinking from water cup	Welfare Quality® (2009)
Eating	Eating from available feed	Welfare Quality® (2009)
Laying down	The animal is laying down with the whole body on the floor	Welfare Quality® (2009)
Standing	All four hooves toughing the floor and the animal is not moving	Welfare Quality® (2009)
Vocalizing	Makes vocal sound as a result of obvious signs of pain or stress	Hultgren et al. (2014); Hultgren et al. (2020); Welfare Quality® (2009); Özdemir et al. (2022)
Ruminate	Makes chewing movements with mouth	

Appendix 7

Lantbrukare

- Hur många gånger har djuren blivit lastade förut?
    - 0
    - 1-2
    - >2

  Övrigt:

- Vilka faktorer i miljön och inredningen vid lastningsutrymmet tror du påverkar djurens beteende vid lastning? T.ex. Ljus, ljud, golv, gångar, redskap

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- Har du sett några vanligt förekommande beteenden hos djuren vid lastning?
    - Tvekar att gå fram – upp på rampen
    - Vänder
    - Backar
    - Halkar
    - Trillar
    - Haltar
    - Vokaliserar
    - Aggressivt beteende
    - Stannar upp

  Övrigt:

- Vilken del av slaktledet tror du påverka djurvälfärden mest?

- Lastning
- Transport
- Avlastning
- Inhysning
- Drivning till bedövning

Övrigt:

- Vad tror du skulle kunna förbättras?
  - Mer tid vid lastning, avlastning och drivning
  - Djurens tidigare upplevelse av lastning
  - Lastningsutrymmet
  - Rampen på transporten
  - Djurdensitet i transporten
  - Boxar på slakteriet
  - Tid på slakteriet (övernattning)
  - Drivgångar på slakteriet

Övrigt:

- Har du några erfarenheter av anmärkningar på avräkningen?
  - Ja, som har orsakats på gården
  - Ja, som har orsakats på slakteri
  - Nej

Om ja, stämmer det med eran bild av djurens tillstånd när de lämnar gården?

Övrigt:

- Är du nöjd med kommunikationen med slakteri och transportör?
  - Ja
  - Nej

Om nej, vad skulle kunna förbättras?

Övrigt:

- Om det skulle utformas ett verktyg som skulle kunna användas av er djurägare för att få en översikt av djurvälfärden från gård till slakteri, vad hade du tyckt varit viktigt att inkludera?
    - Protokoll där man kan registrera djurens beteenden vid lastning, för att se om det finns något beteende som är återkommande och därmed kunna sätta in åtgärder
    - En checklista med olika åtgärder för att minimera stress hos djuren vid lastning
    - Ett protokoll som ska fyllas i på slakteriet där beteenden registreras

Övrigt:

- Vad skulle motivera dig/er till att använda ett protokoll på gården?
    - Ekonomisk ersättning för bra djurvälfärd
    - Bidrar till att lastningen blir smidigare
    - Lättförståeligt och tydligt protokoll

Övrigt:

Transportör:

- Vilka beteenden hos djuren upplever du vara vanligt förekommande vid lastning eller avlastning?
    - Tvekar att gå fram
    - Vänder
    - Backar
    - Halkar
    - Trillar
    - Haltar

- Vokaliserar
- Aggressivt beteende

Övrigt:

- Vilken del av slaktledet anser du vara mest påfrestande för djuren?
  - Lastning
  - Transport
  - Avlastning
  - Inhysning
  - Drivning till bedövning

Övrigt:

- Vad tror du skulle kunna förbättras?
  - Mer tid vid lastning, avlastning och drivning
  - Djurens tidigare upplevelse av lastning
  - Lastningsutrymme
  - Ramp på transporten
  - Djurdensitet i transporten
  - Boxar och inhysning på slakteriet
  - Drivgångar på slakteriet

Övrigt:

- Vilka svårigheter upplever ni under transport?
  - Tillsyn av djuren
  - Ventilationen i transporten
  - Tidspress
  - Vägförhållanden
  - Väderförhållanden

Övrigt:

- Om du har transporterat djur inom både konventionell och ekologisk produktion, har du upplevt skillnad i djurens beteende?
    - Ja

    Om ja, vilka?

    - Nej

    Övrigt:

- Ni har en tillsynsjournal som måste fyllas i, är den utformad på ett bra sätt eller tycker du att något saknas?
    - Ja, den fungerar bra och det är inget som saknas
    - Ja, men djurens beteende borde ingå
    - Ja, men det borde finnas mer tid för journaldokumentation

    Övrigt:

- Om det skulle utformas ett protokoll om djurvälfärd från gård till slakteri, vad hade du tyckt varit viktigt att inkludera?

- Tror du att det skulle finnas några svårigheter med att praktiskt använda ett protokoll?
    - Tidskrävande
    - Resurser
    - Svårt att tolka
    - Bedömningen kan skilja sig beroende på vem som utför den

    Övrigt:

- Vad tror du skulle krävas för att implementera ett protokoll?
    - Ekonomisk ersättning för bra djurvälfärd

- Kunskap och information
- Lättförståeligt och tydligt protokoll
- Att det kan leda till förändring

Övrigt:

Personal slakteri:

- Vilka av dessa beteenden hos djuren anser du vara vanligt förekommande vid avlastning? Samt vilken djurkategori utför de olika beteendena?
  - Tvekar att gå fram
  - Vänder
  - Backar
  - Halkar
  - Trillar
  - Haltar
  - Vokaliserar
  - Aggressivt beteende

Övrigt:

- Har du sett något av dessa beteende hos djuren vid inhysning? Samt vilken djurkategori utför de olika beteendena?
  - Halkar
  - Trillar
  - Hälta
  - Vokalisering
  - Aggressivt beteende
  - Ligger
  - Idisslar
  - Står

Övrigt:

- Har du sett några beteenden hos djuren vid drivning till bedövning? Samt vilken djurkategori utför dessa beteenden?

- Tvekar att gå fram
- Vänder
- Backar
- Halkar
- Trillar
- Haltar
- Vokaliserar
- Aggressivt beteende

Övrigt:

- Har ni upplevt skillnad i djurens beteende för konventionell respektive KRAV-certifierad produktion?
  - Ja

Om ja, vilka?

  - Nej

Övrigt:

- Skiljer inhysningen sig åt för konventionella respektive KRAV-certifierade djur?
  - Ja

Om ja, hur?

  - Nej

Övrigt:

- Vilken del av slaktledet tror du påverkar djuren mest ur ett djurvälfärdsperspektiv?
  - Lastning på gård
  - Transport till slakteri

- Avlastning på slakteri
- Inhysningen på slakteri
- Drivning till bedövning

Övrigt:

- Vad skulle kunna förbättras på slakteriet utifrån ett djurvälfärdsperspektiv?

- Upplevs tidspress vid hantering av djuren, vid avlastning och drivning?
  - Ja
  - Nej

Övrigt:

- Vilka rutinmässiga mätningar görs på slaktkroppen?

- Vilka är den vanligaste orsakerna till kassering av slaktkropp eller delar av slaktkropp?

- Hur vanligt är det med blåmärken på slaktkroppen?

- Vad kan vara den främsta orsaken till blåmärken?

- Om det skulle utformas ett protokoll om djurvälfärd från gård till slakteri, vad hade du tyckt varit viktigt att inkludera?

- Tror du att det skulle finnas några svårigheter med att praktiskt använda ett protokoll?
    - Tidskrävande
    - Resurser
    - Svårt att tolka
    - Bedömningen kan skilja sig beroende på vem som utför den

  Övrigt:

- Vad tror du skulle krävas för att implementera ett protokoll?
    - Ekonomisk ersättning för bra djurvälfärd
    - Kunskap och information
    - Lättförståeligt och tydligt protokoll
    - Att protokollet skulle fungera som underlag för förbättringsförslag

  Övrigt:

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