Transportation of beef cattle to the slaughterhouse: Relation between methods of loading and unloading, carcass bruising and animal welfare.

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Abstract

In Uruguay, the extensive production of beef is a substantial part of the economy and culture. In this extensive production system the transport of beef cattle to the slaughterhouse compromises animal welfare. The objective of this study is to evaluate animal welfare by assessing transport conditions and relate these to carcass bruising. In this study, 243 trucks with in total 8.132 animals were assessed on loading, transport, unloading conditions and carcass bruising. The average time loading took was 0:24:53 minutes and the perception of the truck driver was correlated with the time loading took and the use of devices. The average time unloading took was 0:05:54 (± 0:03:54) minutes with a significant difference in mean time for the use of devices; only flag 0:03:51 (±0:01:46), cattle prod 0:06:43 (±0:04:22) and sticks 0:08:09 (±0:05:55). Of the carcasses observed, 772 (9,5%) had no bruises, 873 (10,7%) had one bruise, 1.312 (16,1%) had two bruises, 1.231 (15,1%) had three bruises and 3.944 (48,5%) had four or more bruises. The prevalence of the bruises was highest on the tuber coxea (29,3%) following the forequarter (22,4%), the tuber ischiadicum (17,3%), ribs/flank (14,1%), Rump/round (10,1%) and the loin (6,8%). A poisson prediction model was fitted to the data to predict the number of bruises on transports with the following parameters taken into account: Number of animals on transport, year of construction of the truck, category of animals, body condition score, animals with injuries, loading time, course of loading, journey length, parking at unloading, behaviour on and of the truck, number of people unloading, shouts used when unloading and the use of flags. Reducing physical and emotional stress during transport will both improve animal welfare en decrease economic losses due to carcass bruising.

1. Introduction

In Uruguay, beef production is an important part of the economy. In 2010 beef was the second largest export product of Uruguay, presenting $753.364.690, 13,5% of the total national export and 5,12,% of worldwide frozen beef export comes from Uruguay[1]. Product quality is crucial for the export position of Uruguay and animal welfare is part of product quality. In the extensive production system one of the most important stressors for cattle is the transport to the slaughterhouse. Reducing the physical and emotional stress during transport and associated events can both improve carcass quality and improve animal welfare[2].

1.1 Animal welfare

'Animal welfare is a wide term that embraces both the physical and mental well-being of the animal' as stated by the Brambell Committee in 1965. To assess animal welfare, all scientific evidence that concerns the feelings of animals including structure, function and behaviour should be considered. Animal welfare has been an issue of increasing importance since the introduction of the five freedoms of the Brambell Committee in 1965 [3].

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

These freedoms form the basis of all current definitions of animal welfare. In 1986 welfare was defined by Broom again as follows: "The welfare of an individual is its state as regards its attempts to cope with its environment. This includes both the extent of failure to cope and the ease or difficulty in coping". Although both the five freedoms and Broom's definition seem complete and accurate there is no room for positive experiences. In 2009 a Dutch platform named: 'Veterinary Medicine and Society' formed by F. Ohl et. al made a new definition: "An individual is in a state of welfare when it is able to adapt to its living conditions and can achieve a state that it experiences as positive"[4]. This definition is also adopted by the faculty Veterinary Medicine of the University of Utrecht.

Untill the moment of transportation, most beef cattle in Uruguay is reared extensively. In this situation an animal has the ability to adapt to situations. The deprivation of food and water, fear, arousal, mixing of groups, physical exertion and bruising are all factors that contribute to stress during transport. The inability to adapt to living conditions during transport makes transport a severe degradation in welfare. Which event contributes most to the welfare degradation and what measures are most effective to limit the degradation in welfare is not determined yet.

1.2 Economic implications

There are two ways carcass bruising influences the value of marketed beef. First, severe bruises are removed from the carcass, resulting in a loss in kilograms per carcass. Second, the public acceptation of beef production influences the market and a degradation of welfare documented by bruises can influence the total demand for beef. A study in North America, by Smith et. al in 1997 to assess the marketing of dairy beef cattle, estimated the losses to bruises $3,91 in non-fed cattle and $4.03 per carcass in fed dairy cattle. In comparison, the losses due to injection sites were respectively $0,66 and $7,03. Non-fed cattle usually comes from cow-calf operations and fed cattle comes from feedlots or extensive fattening sites. A study from New-Zealand from 1977 determined the weight of tissue that was removed due to bruising. This was 5,58 kg/ bruised carcass[5].

Huertas (2010) has developed a mathematical model to determine the economic loss due to bruises. This model (figure 1) is based on the average loss in grams per bruise in a certain area. In this specific study the average loss per carcass was 1,085 kg. Considering the average price of $1,85/kg, this corresponded with a total loss during the two years the study was performed of $3.060.000 in Uruguay[6].

$$x = \sum_{i=1}^{z} \sum_{j=1}^{Gr} p_j \, p_i \, gram_{pj}$$

- X= Total loss due to bruises in grams/animal
- Z= Numer of zones that should be included in the formula
- i= index of the different zones
- Gr= Grade of bruise
- j= index of the different grades
- p_j= frequency of the different grades
- p_i= frequency of the different zones
- $gram_{pi}$= contributing weight of a bruise in a zone.

Region of bruise	$gram_{pi}$ (weight/bruise)	
	Grade 1	**Grade 2**
Back	800	1700
Rib	625	2100
Round/rump	780	1100
Forequarter	0	1700

Figure 1
Mathematical model by S.M. Huertas (2010) to determine the devaluation of carcasss due to bruising

1.3 Comparable studies

Numerous studies have been conducted to assess the welfare of cattle during transport[2,7-14]. Physiological parameters, carcass quality and behavioural measures are used for the assessment. Most studies use carcass quality, since this is the least invasive method. Knowles and Warriss (2000) described the physiological responses to transport of different livestock production animals in T. Grandins Livestock Handling and Transport[11]. These responses are shown in
Table **1**.

Table 1 Common physiological responses to transport

Stressor	**Physiological variable**
Food deprivation	↑FFA, ↓Glucose, ↓ Urea
Dehydration	↑Osmolarity, ↑Total protein, ↑Albumin, ↑PCV, ↑CK, ↑LDH5 Lactate
Physical exertion, bruising	↑Cortisol, ↑PCV, ↑LDH5, ↑Heart rate
Fear/arousal	↑Heart beat variability, ↑Breathing rate
Motion sickness	↑Vasopressin
Hyperthermia/Hypothermia	Body temperature, skin temperature

from Knowles and Warriss (2000) FFA, Free fatty acids; PCV, Packed cell volume; CK, Creatine kinase; LDH5, lactate dehydrogenase isoenzyme 5

Bruising, as an event during transport, increases cortisol, packed cell volume, lactate dehydrogenase isoenzyme and hearth rate. Increased hearth rate and cortisol are known physiological responses to stressful situations and part of the fright, fight and flight coping system in mammals[15].
In 2013, Strappini et al. studied the primary bruising event by direct observations and video analysis of 52 culled cows. The goal of their study was to determine specific bruising events. 46,1% of the bruises were inflicted during animal-facility interactions,26.9% from human-animal interactions, and 26,9% from animal-animal interactions. The potential bruising events occurred mostly during the lairage time (91,2%). Only Bruises on the back were inflicted in the stunning box and most bruises on the pin area during loading at the farm.

Muscle pH is a factor that is associated with stress during transport and used as an indicator. Romero et. al investigated risk factors that increased both bruises and high muscle pH during transport in 2013. In 86 journeys referring to 1179 animals, risk factors for bruises were load density, stops during transportation of the cattle and the lairage time at the plant. No significant risk factor was found for high muscle pH but there was less risk of presenting high muscle pH in steers[12].

Gonzalez et. al studied events during transport and related these to lameness, non-ambulatory and dead cows during transport. The transport of 290.866 cows in 6.152 trucks was assessed. There were significant more non-ambulatory cows in extreme temperatures, under -15 °C or above 20 °C. The experience of the truck driver was related to the lameness and non-ambulatory rate of the cattle[8].

In 2009, Huertas et al. reported the effect on animal welfare of conditions during transport by scoring bruises. In total 15.168 cows were assessed in 12 abattoirs during 2 years. Factors that were associated with a high number of bruises were bad maintenance of the truck, presence of guillotine doors, journey duration longer than 5 hours, bad quality of roads, devices to move animals and the presence of horned animals. This data was mostly collected using surveys filled in by truck drivers.

1.4 Bruising assessment

Different results in table 2 indicate that there is diversity in the assessment methods used worldwide. Both Strappini and Romero used the Chile INN (Instituto Nacional de Normalización) method. Nearly twice as much bruises were found in the study by Strappini. Although the observation methods in all these studies are comparable the results are very different. Whether the results are really different or the inter user reliability for scoring bruises is to low is debatable.

Table 2
An overview of different carcass assessment studies and their basic outcomes.

	Number of animals	**Animals with bruises**	**Predilection places of bruises**
Strappini et al. (2013)	52	71,2 %	Back 29,4%, Pin 24,4%
Romero et al. (2013)	1.179	37,5%	T. ischiadicus 32,8%, t. coxae 25,1% and loin 21,3%
NBQA* (2011)	18.159	33%	Loin 50,1%, rib 21,3% and chuck 13,8%
Huertas et al. (2009)	15.168	60%	Round/rump 86,1%
Costa et al. (2006)	± 150	66,9%	-
NBQA (2005)	49.330	35,2%	Loin 32,6%, rib 19,5% and chuck 27,0%

*National Beef Quality Audit

Apart from to the prevalence of bruises that is not corresponding in most studies also the place on the carcass where they occur is different. Most studies describe several degrees of bruises regarding depth of the lesion, size of the bruise and involvement of different tissues.

1.5 Objective

The objective of the present study is to evaluate whether certain events during loading, transporting and unloading cattle have influence on the amount, location and degree of bruises on the carcass. An evaluation of current animal welfare standards can improve and evaluate measures that have been taken. It can identify critical control points that will both improve animal welfare and carcass quality.

2. Materials and Methods

Over a period of 5 weeks all trucks arriving at a slaughterhouse have been assessed on various parameters in three main subjects: loading, the journey and unloading. The following day all animals were assessed on the number, location and severity of bruises on the carcass.

2.1 Study design

In October and November of 2012 the study took place in a middle-sized town in the north of Uruguay. Over a period of three weeks trucks were assessed on three major subjects: the course of loading, the course of the journey and the course of the unloading. The state of the carcasses was assessed the following day in the slaughter house. All assessments were done by 4 students, which were trained for this.

The daily routine of the slaughterhouse was as follows. Most cattle transports arrived between 5 pm and 2 am. After arrival and administration, the truck driver would unload the cattle on a ramp. Animals were given a group number when leaving the truck. This number was related to the farm of origin. Some groups were on multiple trucks and on some trucks there was more than one group present. All groups of animals stayed together and there was no mixing between groups. From this point on the lairage period starts in which animals where moved to different pens closer to the stun box twice. Slaughter started at 6 am in the morning with an all-in-all-out system. Information about the loading and the journey was collected by a survey for the truck drivers (Attachment 1.3).

To standardize observations in the slaughterhouse, a two week trial period was performed in which all participating students observed the carcasses and assessed these on bruise location and gradation. After these two weeks the inter observatory reliability was optimized. To minimize the effect of difference in interpretation, the observations were split in two different groups. Two students would assess the transport, unloading and take the questionnaire. The other two students would only assess carcasses at the slaughter line.

2.4 Loading

The loading of the cattle was assessed from a survey filled in by the truck drivers, see attachment 1.3. This survey had the following aspects on the course of loading: Time the loading took in minutes; the course of loading specified between 'good' , 'regular' and 'bad'; the use the following devices: flags, electric cattle prods and/or sticks.

2.5 Truck driver

The truck driver is essential in the regulation of the loading and unloading of the cattle. The truck driver is responsible and will determine the use of devices during these events. The influence of the truck driver was assessed in the 'encuesta camioneros', see attachment 1.2. The number of years of experience transporting beef cattle and whether the driver followed a course on animal welfare was asked.

2.7 Trucks, journey and the influence of the animals are assessed byS.T. Aarnink

The following parameters were assessed: Length of journey, duration of journey, quality of the roads, weather during journey, type of truck, year of construction of the truck, points of protrusion on the truck, type of door, type of floor, number of animals, number of animals with horns, number of animals with injuries, breed of animals, gender of animals and body condition score.

2.8 Unloading

After arrival of the cattle at the slaughterhouse, the course of unloading was assessed by two observers. The unloading was scored on way of parking; unloading time in seconds; the behaviour of animals on the truck and the behaviour when animals were leaving the truck; the use of devices to force animals to move i.e. flags, electric cattle prods and sticks; the manner in which these devices are used i.e. gentle, intense or rough; the number of people that were involved unloading the cattle and the use of hard shouts and hard sounds.

Parking was considered correct if there was no more than 5 cm difference between the trucks and the ramps edge in distance and/or sideward deviation. Behaviour was scored and considered nervous if there were one or more animals vocalizing repeatedly, running and/or jumping. The use of devices was considered gentle if these were used less than 5 times, intense if they were used between 5 and 10 times and rough if the devices were used more than 10 times. The use of sticks usually meant handling a flag as a stick by turning it around. Shouts were considered used if a person handling the cattle used their voice loudly to urge on cattle. Sounds were assessed similarly and mostly created by hitting devices against the truck.

2.9 Carcass scoring

At the slaughter line the carcasses were assessed on location and degree of bruises, according to Huertas et al., (2009). The observations were made just before the lairage time of the carcass. The carcass is eviscerated and split in half at this point.

All bruises were categorized by grade and location. Only bruises and lesions with signs of live tissue damage were included. There were three types of lesions distinguished in this study. Grade 1 bruises are superficial, not deeper than 2 cm and with a diameter less than 10 cm. Grade 2 bruises involved damage to underlying muscle tissue and contained all lesions bigger than 10 cm in diameter. Grade 3 lesions involved severe carcass damage with fractured bones or perforation in abdominal of thoracic cavities. On some carcasses muscle damage was already removed by slaughterhouse employees because this is part of the normal routine. These lesions were included as grade 2 bruises because of their probable involvement of muscle tissue. Examples of bruises are shown in attachment 2. In Figure 3 of this attachment the locations of different bruises are shown. From a meat production perspective these regions could be defined as follows: Region 1 is the forequarter, region 2 the ribs and flank, region 3 rump and round, region 4 is the loin. A special category was made for the region of the tuber coxae and ischiadicum i.e. region 5 and 6. This category was introduced because of the frequent occurrence of lesions and the relative minor damage to the meat. If a bruise or lesion occurred in more than one area the bruise was only mentioned in the area where the majority of that bruise was located.

2.10 Data analysis

All results were analysed using IBM SPSS (version 20). For descriptive analyses different methods have been used. Most continuous variables are described by mean, maximum and minimum. For discrete values a portion is determined. To assess the influence of all events on the number of bruises a Poisson model was applied. For this model only 92 trucks could be used because the model is not compatible with missing values.

3. Results

3.1 Loading

Average time is 24,89 minutes with a minimal time of 6 minutes and a maximum time of 5 hours where cattle was loaded from different farms. Course of loading was assessed by the truck driver as being good in 81,9%, neutral in 15,7% en bad in 2,4% of cases. In 10,6% of the loading events no devices (electric cattle prods, sticks or flags) were used, one device in 73,5%, two devices in 14,7% and all three in 1,2% of the events. The devices that were used were flags (19,9%), sticks (6.8%) and electric cattle prods (3,8%). In 47% of the events hard shouts were used to load cattle on the truck.

To assess whether there is a connection between the perception of the truck driver and the time the loading took, a Spearman correlation was calculated. Results, shown in table 3 show a correlation of 0.233 on a significance level of 0.007.

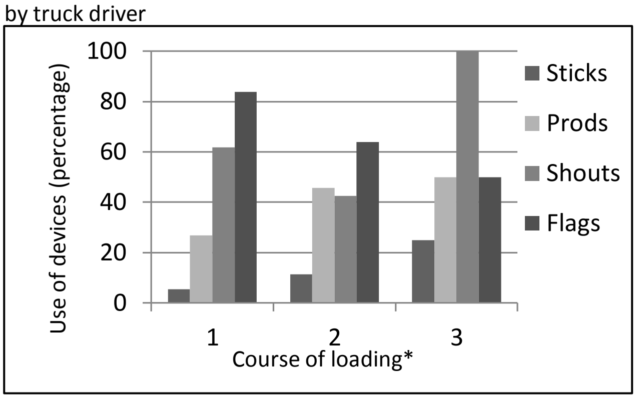
Figure 2 shows the trend from which can be concluded that the use of devices such as electric cattle prods and sticks or the use of hard shouts were associated with a neutral or bad course of loading. The use of flags is negatively correlated with the course of loading by the drivers ($r = -0{,}218$ $p = 0{,}007$) and the use of prods ($r=0{,}189$ $p =0{,}022$)and shouts ($r= 0{,}197$ $p = 0{,}022$) is positively correlated with the course of loading.

Table 3
Correlation between the course of loading according to the truck driver, use of devices and the time loading took in minutes

		Loading: Time(min)	Course of loading
Course of loading (Good = 1, Neutral = 2, Bad = 3)	Pearson Cor.	**.200***	1
	Sig.	**.021**	
	N	133	
Use of flags (Yes=1, No= 0)	Pearson Cor.	-.145	**-.218***
	Sig.	.099	**.007**
	N	130	153
Use of Sticks (Yes=1, No= 0)	Pearson Cor.	-.011	.140
	Sig.	.899	.078
	N	131	159
Use of prods (Yes=1, No= 0)	Pearson Cor.	.026	126
	Sig.	.776	**.189***
	N	126	**.022**
Use of Shouts (Yes=1, No= 0)	Pearson Cor.	**.192***	**.197***
	Sig.	**.030**	**.016**
	N	128	148

*. Correlation is significant at the 0.01 level (2-tailed).

Figure 2
The use of devices in different courses of loading as interpreted by truck driver



* Interpretation course of loading by truck driver (1 = good, 2 = neutral, 3 = bad)

3.1 Truck driver
Years of experience transporting cattle was on average 17,4 years with a maximum of 40 year experience. An animal welfare course was followed by 79,5% of the truck drivers.

3.2 Trucks
243 trucks were included in this study. For further details see report by: S.T. Aarnink

3.3 Journey and Animals are assessed by S.T. Aarnink

3.4 Unloading
Parking at the ramp for unloading was assessed as correctly in 93,7% of all cases. The behaviour of the animals on the truck was calm in 69,0% of all cases, when leaving the truck, 80,3% of all cases behaved calm. There is a correlation between the behaviour on the truck and when leaving the truck, Spearman's rho is 0.294 on a significance level <0,000.

Table 4
The use of devices when unloading cattle

Device	No	Gentle	Intense	Rough
Flag	44,7 %	15,6 %	29,1 %	7,8 %
Electric cattle prod	44,4 %	8,3 %	6,3 %	41,0%
Stick	75,7 %	8,6 %	3,3 %	12,5 %

The average unloading time was 05:54 (± 03:54) minutes with a maximum of 30:21 minutes and a minimum time of 1:09 minutes. The average unloading time per animal was 11.28 seconds with a minimum of 2,41 seconds and a maximum of 65.04 seconds The difference in mean time loading took and the use of devices between different unloading methods is shown in table 5. In 79.6% of unloading events sticks and/or electric cattle prods were used to force animals off the truck. Hard shouts were used in 63% of all cases and hard sounds in 17% of all cases. The average number of people interfering with the unloading of cattle was one in 70,7%, two in 26% and three or more in 3,3% of all unloading events.

Table 5

Different methods of unloading and the difference of means in time unloading took

				Independent t-test			
						95% Confidence Interval of the Difference	
Methods of unloading cattle	N	Mean	Std. Deviation	t	Sig.	Lower	Upper
Average	130	0:05:54.08	0:03:56.563	17.066	.000*	0:05:13.03	0:06:35.13
Only flags**	33	0:03:51.58	0:01:46.427	12.500	.000*	0:03:13.84	0:04:29.31
Cattle prods***	77	0:06:43.70	0:04:22.613	13.489	.000*	0:05:44.10	0:07:43.31
Sticks***	35	0:08:09.40	0:05:55.782	8.138	.000*	0:06:07.18	0:10:11.62
1 Person	90	0:04:47.02	0:02:11.177	20.758	.000*	0:04:19.55	0:05:14.50
>1 Persons	35	0:07:48.86	0:04:32.935	10.163	.000*	0:06:15.10	0:09:22.61

*On a significance level of p< 0,001 ** only flags were used, no sticks or cattle prods ***Device was used unloading cattle, no demands about other devices/methods.

3.5 Carcass scoring

Of the 8.132 carcasses observed 873 (10,7%) carcasses had one bruise, 1.312 (16,1%) had two bruises, 1.231 (15,1%) had three bruises and 3.944 (48,5%) had four or more bruises. 772 (9,5%) of the carcasses had no bruises. The average number of bruises per carcass was 3,57. The location and prevalence of bruising on a carcass is shown in Table 5. There were no grade 3 bruises in this study.

Table 5

Gradation of bruises and the prevalence on the carcass (bruises/location/carcass)

	Forequarter	Ribs/Flank	Rump/Round	Loin	T. Coxae	T.Ischiadicum	Total
Grade 1	12,2 %	7,9 %,	8,3 %	5,5 %	20,0 %	14,9 %,	68,7 %
Grade 2	10,2 %	6,3 %,	1,9 %	1,3 %	9,3 %	2,4 %	31,3 %
Total	22,4 %	14,1 %	10,1 %	6,8 %	29,3 %	17,3 %	

3.6 Poisson model

A poisson model was fitted to the total number of bruises per group (number of animals times average number of bruises). A specification of the procedure is shown in attachment 3. In this model the collected data of S.T. Aarnink has been used to create a model that takes all factors into account. The outcome of the model is defined as the total number of bruises per group because the factor $n_{animals}$ had a substantial influence on the total number of bruises. Estimate of $\log(n_{animals})$ was 1.315, and not 1. The following model was created using Akaiki's Information Criterion. This generalized linear model predicts the number of bruises in certain situations.

$$\begin{aligned} Log(nbruise) = {} & factor(tyoc) + dyoe + factor(catanimal) + factor(animalrace) \\ & + factor(animalbcs) + animalinj + loadtime + factor(loadcourse) \\ & + jlength. + factor(upark) + factor(ubehav) + factor(ubehavl) \\ & + factor(unpeople) + factor(ushout) + factor(uflag) + log(nanimals), \end{aligned}$$

For the interpretation of the model four situations are outlined.

Situation 1: Thirty Hereford steers are loaded on a truck constructed after 1995 by a driver that has five years of experience transporting cattle. The body condition score is 4 and 2 animals have physical injuries. The course of loading is good and it takes 30 minutes. After a journey of 100 kilometers the truck is parked correctly at the unloading ramp. One person unloads the steers using a flag without shouting. The animals remained calm during unloading. The model predicts 10.8 bruises, 0,36 bruises per animal, in this situation.

Situation 2: Twenty Holstein-Friesian cows are loaded on a truck constructed before 1995 by a driver that has 40 years of experience transporting cattle. The body condition score is 3 and 2 animals have physical injuries. The course of loading is neutral and it takes 30 minutes. After a journey of 50 kilometers the truck is not parked correctly at the unloading ramp. Three persons unload the cows using no flag and shouting ten times. The animals were nervous during unloading, both on the truck and off the truck. The model predicts 52,72 bruises, 2,64 bruises per animal, in this situation.

Situation 3: Thirty Angus cattle (mixed gender) are loaded on a truck constructed before 1995 by a driver that has 20 years experience transporting cattle. The body condition score is 3 and no animals have physical injuries. The course of loading is good and it takes 60 minutes. After a journey of 200 kilometers the truck is parked correctly at the unloading ramp. Two persons unload the cattle using no flags and shouting 15 times. The animals were nervous both on the truck and when leaving the truck. The model predicts 145,89 bruises, 4,86 bruises per animal, in this situation.
Situation 4: Identical to situation 3 but when unloading cattle a flag was used and only five shouts where used. The cattle behaved calm on the truck and when leaving truck. The model predicts 27,65 bruises, 0,92 bruises per animal, in this situation.

4. Discussion

This study was conducted to evaluate animal welfare during transport to the slaughterhouse. The goal was to create an insightful model that would show the influence of different transportation methods on animal welfare and a model that could be used as a financial incentive to improve animal welfare.
Two major concessions had to be made during the study. First, the observation methods were far from ideal because they were depending on a survey filled in by truck drivers who often felt at risk being criticized for their animal handling methods before. Because the information collected was less reliable, the number of trucks observed was increased to at least two hundred. This was, however, unavoidable and everything has been done to assure the survey was anonymous. Secondly, the identification at the slaughter line was not ideal. Trucks are the experimental unit in this study and, unfortunately, not all observations at the slaughter line could be brought back to the trucks because of groups on multiple trucks.

Another goal was to compare the results of this study to the results collected in 2008 by S.M. Huertas. Unfortunately, the assessment method was not totally comparable, so the results could not be compared. An attempt to compare different studies worldwide was also impossible A global comparable assessment method would make it easier to compare different countries/ regions. This could improve animal welfare and product quality by creating benchmarks.

During this study, an article was published by Strappini et al. that described potential bruising events from farm to desensitization in the slaughterhouse. Strappini associated most potential bruising events during lairage time, not during loading, transport and unloading.[13] This study only included the last three events.

When loading cattle, the interpretation of truck drivers about the course of loading was associated with the duration. A shorter loading time was considered as a good course of loading. The correlation between the time loading, unloading and the use of different devices is probably due to the fact that
people handling cattle tended to start using devices if loading and unloading halted. Of all the devices used during unloading, the use of flags only had a significantly lower time unloading cattle. There is, however, no causality in this correlation and it might be that prolonged unloading was the cause for the use of more devices.

Two noteable observations were done when the model was created. First an increasing number of animals with injuries decrease the number of bruises predicted by the model. Possibly the animal handling is gentler on injured animals or the expression of arousal and fear is less distinct in groups with a large number of injured animals. Secondly the number of animals in a group which had a negative effect on the number of bruises per carcass. This could be explained by the farms the animals were from, these possibly have better equipped housing and loading ramps.

The mathematical model of S.M. Huertas to determine the financial consequences of bruising would lead to a loss per carcass of 1.79 kilo as shown in table 6 Region 5 and 6, t. coxae and t. ischiadiucum are excluded from these calculations because of their high prevalence and low impact on carcass quality.

Table 6 – Financial model to determine the costs of bruises on carcasses.

Zone	**Gram/bruise**		**Prevalence of bruises**		
	Grade 1	Grade 2 and 3	Grade 1	Grade 2 and 3	Total(grams)
Back	800	1700	0.198	0.044	233.2
Ribs	625	2100	0.27	0.22	630.75
Hindquarter	780	1100	0.289	0.067	299.12
Frontquarter	0	1700	0.44	0.37	629
Total					**1792.07**

Although the description of grade 1 and 2 bruises was similar in both studies it is not sure if carcasses have been scored exactly the same. Also the differences in the number of bruises per carcass indicate that the average weight per bruise is different.

The objective of this study was to evaluate current transport conditions and the relationship to animal welfare. The intensive monitoring from farm to slaughterhouse was, however, not possible and the information on loading and the transport depended on questionnaires. Previous reports and results of this study indicate that the transport of beef cattle to the slaughterhouse is accompanied by degradation in animal welfare. A tool to measure animal welfare is to look at bruises on the carcass. These bruises are an incentive to improve the transport conditions and animal welfare by preventing economic losses. Strict guidelines on human-animal interactions and on the use of devices are important issues.

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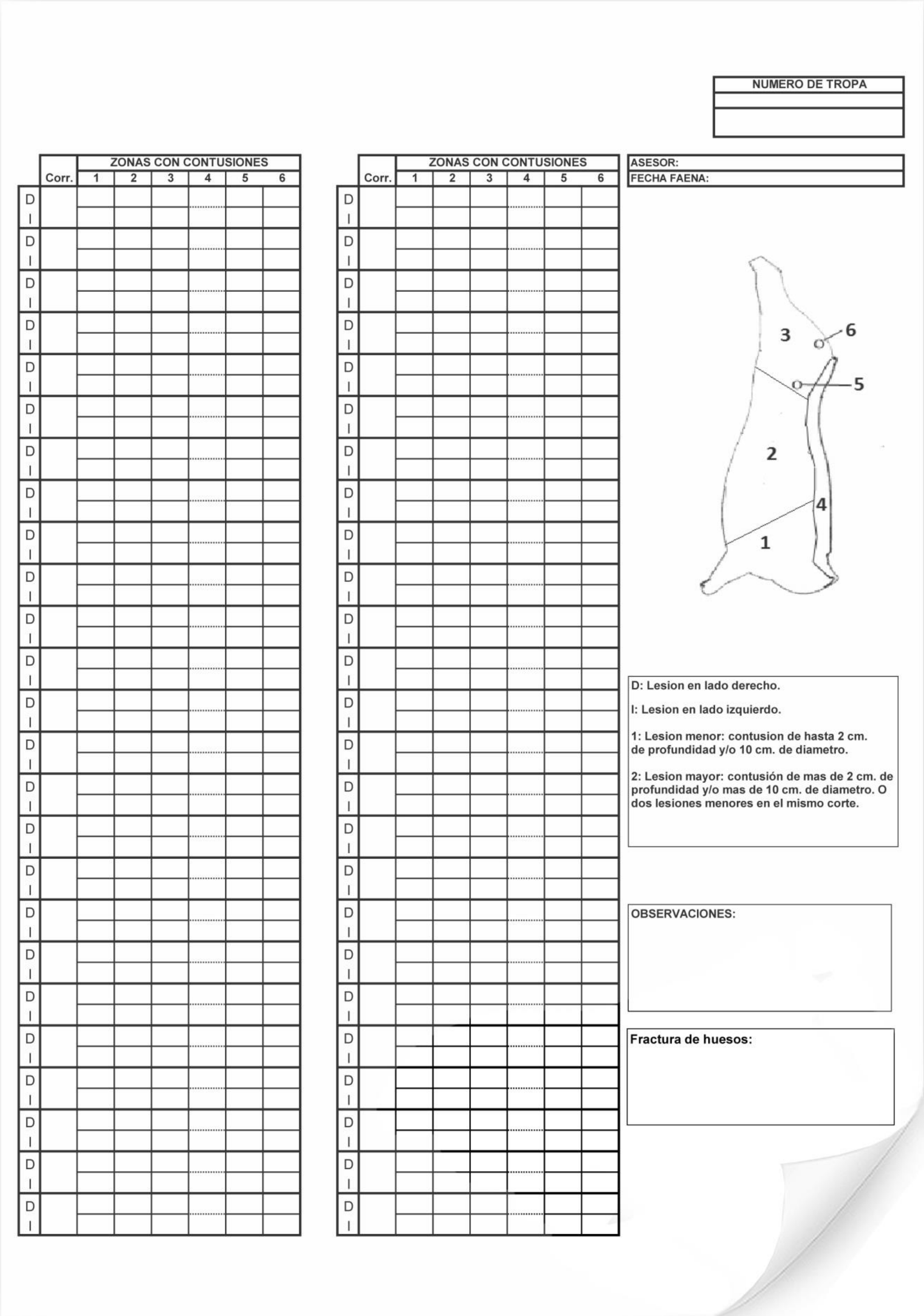
Attachment 1 – Survey and observation charts

1. 1 Carcass assessment chart



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ASESOR:

FECHA FAENA:

D: Lesion en lado derecho.

I: Lesion en lado izquierdo.

1: Lesion menor: contusion de hasta 2 cm. de profundidad y/o 10 cm. de diametro.

2: Lesion mayor: contusión de mas de 2 cm. de profundidad y/o mas de 10 cm. de diametro. O dos lesiones menores en el mismo corte.

OBSERVACIONES:

Fractura de huesos:

1.2 Cattle transport protocol

Cattle Transport Protocol

Assessment on farm to abattoir transport of cattle in the Uruguayan beef industry
Department of Farm Animal Health, Faculty of Veterinary Sciences, Utrecht University

Standard information

Group number: ....
....
Truck number plate: ....
Date: ....../...../.......
Number of animals ....

Truck characteristics

Dimensions of door:
Type of door: ○ Guillotine ○ Side doors
Roller bars at door: ○ No ○ Yes
Dimensions: ....x............
Roller bars: ○ No ○ Yes
Grated floor: ○ No ○ Yes
Points of protrusion: ○ No ○ Yes
Number ....
Separation: ○ No ○ Yes
Other:

Animals

Category: ○ Bulls ○ Steer ○ Cow ○Heifers ○ Calves
Race: ....
BCS: ○1 ○2 ○3 ○4 ○5
Horns ○No ○ Yes
Number ....
General health: ....
Behavior on the truck ○nervous ○quiet

Unloading

Correct parking: ○ No ○ Yes
Time first animal leaves truck ....
Time last animal leaves truck ....
Behavior when leaving the truck ○nervous ○quiet
Weight of animals in truck ....
Use of devices to force movement

- Sticks ○ No ○ Yes
  Manner in which devices are used*
  Gentle ○ Intense○ Rough○
- Electric cattle prods ○ No ○ Yes
  Manner in which devices are used*
  Gentle ○ Intense○ Rough○
- Flags ○ No ○ Yes
  Manner in which devices are used*
  Gentle ○ Intense○ Rough○

Handling the cattle
Number of people ....

- Hard shouts ○ No ○ Yes
- Hard sounds ○ No ○ Yes

1.3 Truck driver survey

Encuesta anónima para estudiantes de Tecnologo Cárnico y Veterinaria de Holanda sobre condiciones de transporte.

Información general

Fecha: ....../...../.......
Hora de arribo: ....
Años de experiencia transportando animales: ....
Entenamiento en Bienestar Animal: ○ Si ○ No

Del embarque:
Tiempo que llevó el embarque: ....
Estado del embarcadero: ○ bueno ○ regular ○ malo
dispositivos de ayuda para cargar:

- palos ○ Si ○ No
- picana eléctrica ○ Si ○ No
- voces ○ Si ○ No

Del viaje
Duración del viaje: ....
Rutas pavimentadas: ○ Si ○ No
Rutas no pavimentadas: ○ Si ○ No

- kilometros no pavimentados (aprox) ....

Estado del tiempo : ○ Lluvia ○ Viento ○ Tormenta eléctrica

İMUCHAS GRACIAS!

Attachment 21 - Example-chart bruises

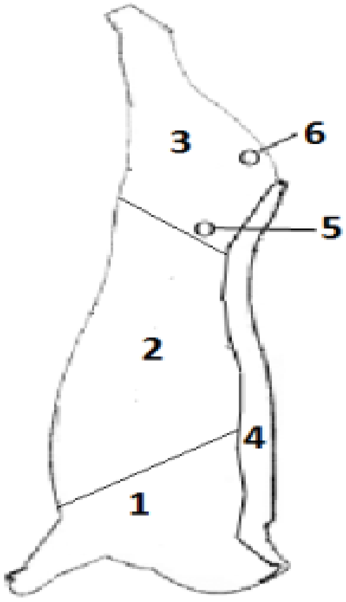

Figure 3 - Categorization of lesions by location. 1. forequarter, 2. ribs and flank, 3. rump and round, region 4. Loin. 5. Tuber coxae and 6. ischium

Figure 4 - Grade 1 bruise in the flank area with discoloration of the fat without muscle damage

Figure 5 - Grade 2 bruise on the tuber coxae (location 5) with muscle damage

Figure 6 - Lesion was removed before assessment, because of probable muscle damage scored as grade 2, location 1

Figure 8 - Superficial lesion > 10 cm in diameter, grade 2 lesion on location 2

Figure 7 - Clean carcass without lesions

Attachment 3 – Poisson model

A poisson moddel was fitted to the the total number of bruises per group (number of animals times average number of bruises). The following independent variables were taken in the model:

factor(tyoc<1995)+factor(tpop>0)+dyoe+factor(dwelfare)+factor(catanimal)+factor(animalrace)+factor(animalbcs)+nanimalhorn+animalinj+loadtime+factor(loadcourse)+factor(loaddev)+factor(loadflag)+factor(loadshout)+jlength.+jbad+factor(upark)+factor(ubehav)+factor(ubehavl)+factor(unpeople)+factor(ushout)+factor(usound)+factor(udev)+factor(uflag)+nanimals

See below for the meaning of the shorthands for the names of the variable.

Then a stepwise backward procedure using Akiake's information criterium (AIC) was performed. This showed that the variables were related to the number of bruises could be implemented in de following model:

nbruise ~ factor(tyoc < 1995) + dyoe + factor(catanimal) + factor(animalrace) + factor(animalbcs) + animalinj + loadtime + factor(loadcourse) + jlength. + factor(upark) + factor(ubehav) + fator(ubehavl) + factor(unpeople) + factor(ushout) + factor(uflag) + log(nanimals)

The estimates (log ratio's) and their standard errors are:

glm(formula = nbruise ~ factor(tyoc < 1995) + dyoe + factor(catanimal) + factor(animalrace) + factor(animalbcs) + animalinj + loadtime + factor(loadcourse) + jlength. + factor(upark) + factor(ubehav) + factor(ubehavl) + factor(unpeople) + factor(ushout) + factor(uflag) + log(nanimals), family = poisson)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-6.7991	-1.7538	-0.0095	1.4925	6.4294

Table 7
Variables included in the model selected by the AIC

	Df	Deviance	AIC
<none>		712.96	1366.2
factor(tyoc < 1995)	1	720.58	1371.8
dyoe	1	720.25	1371.5
factor(catanimal)	3	845.52	1492.7
factor(animalrace)	3	756.79	1404.0
factor(animalbcs)	3	736.17	1383.4
animalinj	1	829.76	1481.0
loadtime	1	743.38	1394.6
factor(loadcourse)	2	747.16	1396.4
jlength.	1	738.64	1389.8
factor(upark)	1	719.05	1370.3
factor(ubehav)	1	723.41	1374.6
factor(ubehavl)	1	733.08	1384.3
factor(unpeople)	3	798.86	1446.1
factor(ushout)	1	738.02	1389.2
factor(uflag)	1	754.96	1406.2
log(nanimals)	1	1935.24	2586.4

Table 8
The variables included in the model with the accompanying estimates

Coefficients:

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-0.5628108	0.1937533	-2.905	0.00368 **
factor(tyoc < 1995)TRUE	0.0880711	0.0317601	2.773	0.00555 **
dyoe	0.0026426	0.0009764	2.706	0.00680 **
factor(catanimal)1	0.9176725	0.1255995	7.306	2.75e-13 ***
factor(catanimal)2	0.9534245	0.1244262	7.663	1.82e-14 ***
factor(catanimal)4	0.7265386	0.1248931	5.817	5.98e-09 ***
factor(animalrace)1	0.2347920	0.0816866	2.874	0.00405 **
factor(animalrace)3	0.1743792	0.1121675	1.555	0.12003
factor(animalrace)4	-0.1226259	0.0235565	-5.206	1.93e-07 ***
factor(animalbcs)3	0.1279179	0.0639190	2.001	0.04537 *
factor(animalbcs)4	-0.0038437	0.0644483	-0.060	0.95244
factor(animalbcs)5	0.0379947	0.0880585	0.431	0.66613
animalinj	-0.1195634	0.0111730	-10.701	< 2e-16 ***
loadtime	-0.0017886	0.0003361	-5.322	1.03e-07 ***
factor(loadcourse)2	0.1165963	0.0293447	3.973	7.09e-05 ***
factor(loadcourse)3	0.3427254	0.0672701	5.095	3.49e-07 ***
jlength	-0.0007591	0.0001502	-5.054	4.32e-07 ***
factor(upark)1	0.1334934	0.0535670	2.492	0.01270 *
factor(ubehav)1	0.0827723	0.0255660	3.238	0.00121 **
factor(ubehavl)1	0.1235005	0.0273785	4.511	6.46e-06 ***
factor(unpeople)2	-0.1203554	0.0254061	-4.737	2.17e-06 ***
factor(unpeople)3	-0.5866412	0.0713744	-8.219	< 2e-16 ***
factor(unpeople)5	0.0407485	0.1082808	0.376	0.70668
factor(ushout)1	0.1290467	0.0258556	4.991	6.01e-07 ***
factor(uflag) 1	-0.1665701	0.0256584	-6.492	8.48e-11 ***
log(nanimals)	1.3145277	0.0389455	33.753	< 2e-16 ***

(Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Dispersion parameter for poisson family taken to be 1)

Null deviance: 2690.14 on 91 degrees of freedom
Residual deviance: 712.96 on 66 degrees of freedom
AIC: 1366.2

Legend for model abbreviations:
group = group number
nanimals = Number of animals
bruise = average bruises per animal
a0 = Animals with no bruises
a1 = Animals with 1 bruises
a2 = Animals with 2 bruises
a3 = Animals with 3 bruises
a4 = Animals with 4 or more bruises
tyoc = Truck: Year of construction
tpop = Truck: Points of protrusion
dyoe = Driver: Years of experience

dwelfare = Driver: Welfare course (Yes=1, No=0)
catanimal = Animals: Category (Heifer=0, Steer=1, Cow=2, Bull=3, Mix=4)
animalrace = Animals: Race (Hereford= 0, Angus=1, HF=3, Other=4)
animalbcs = Animals: BCS
nanimalhorn = Animals: Horns
animalinj = Animals: Injuries
loadtime = Loading: Time(min)
loadcourse = Loading: course of loading (Good = 1, Neutral = 2, Bad = 3)
loaddev = Loading: Use of devices (Yes=1, No= 0)
loadflag = Loading: Use of flags (Yes=1, No= 0)
loadshout = Loading: Use of Shouts (Yes=1, No= 0)
jtime = Journey: Time journey takes
jlength = Journey: Length (km)
jbad = Journey: Roads in bad condition (km)
jweather = Journey: Weather conditions (Normal=0, Rain=1, Wind=2, Rain+Wind=3, Thunderstorms=4)
jtemp = Journey: Temperature (Normal=0, Hot=1)
untime = Unloading: Unloading time
upark = Unloading: Correct parking (Yes=0, No=1)
ubehav = Unloading: Behaviour on truck (Quiet=0, Nervous=1)
ubehavl = Unloading: Behaviour when leaving truck(Quiet=0, Nervous=1)
unpeople = Unloading: Number of people
ushout = Unloading: hard shouts (No=0, Yes=1)
usound = Unloading: hard sounds (No=0, Yes=1)
udev = Unloading use of devices (1=Yes, 0=No)
uflag = Unloading: Use of flags (No=0, Yes=1)