UNIVERSITY OF COPENHAGEN
FACULTY OF HEALTH AND MEDICAL SCIENES

Development of a Welfare Assessment Protocol with focus on Body Condition Scoring in year-round grazing cattle in Denmark

Master Thesis

Stella Mastoraki bpg835

Supervisor: Dorte Bay Lastein

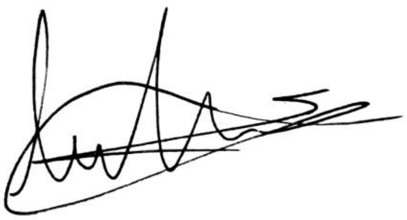
Submitted on: 14 August 2023

Preface

This project was conducted during the final year of my studies and reflects my work as a master student of Animal Science at the University of Copenhagen, Faculty of Health and Medical Sciences. The objective of the master thesis was inspired by current events in Denmark, regarding the use of livestock in rewilding practices and aims to offer an insight on potential welfare issues.

First of all, I would like to thank my supervisor Dorte Bay Lastein, an associate professor at the Department of Veterinary and Animal Sciences at the University of Copenhagen, for guiding me through my thesis and giving me invaluable feedback and opportunities to grow as a scientist. Furthermore, I would like to thank Københavns Kogræsserlaug for allowing me to work with their animals, and more specifically Kirsten Heering, deputy chairperson of the association, for offering key assistance during the visits. I would also like to thank Monica Lønborg Frederiksen, the collaborating veterinarian, for offering motivation and inspiration during the project. Finally, I would like to thank my friend and colleague Paula Ramon Ocampo, an MSc environmental scientist, who helped me conduct the statistical analysis of the data.

August 14, 2023



Stella Mastoraki

Abstract

Human activities have significantly affected fauna and flora populations and many species are now on the verge of extinction. To counteract this loss of biodiversity, alternative methods of farming and land preservation are considered. The method of rewilding ‘nature’ has gained attention, where animal species are reintroduced within selected ecosystems and there is no human intervention. In Europe, a common practice within rewilding is naturalistic grazing using large ruminants and horses within fenced grazing areas. However, this practise raises concerns regarding animal welfare and especially hunger and starvation under harsh climate conditions.

The goal of this project was to develop a welfare assessment protocol, for year-round grazing Scottish Highland cattle in Denmark under naturalist grazing conditions, with a focus on Body Condition Scoring, based only on observations from a distance. Furthermore, behavioural observations are discussed, in connection with the illustrated method for monitoring on herd level, and with the implementation of an alarm system to detect potential ‘out-of-control’ cases. Finally, the relation between carcass composition and the distant Body Condition Score, with its components, was examined.

For these purposes, seven potential animal-based indicators were tested on the field and five (Round, Coat, Rumen Fill, Dewlap, and Shoulder Bone) were eventually selected. The statistical analysis showed that Dewlap and Shoulder Bone scores were statistically significant ($p<0.05$) and with Round being borderline significant ($p=0.051$), demonstrating a positive relation with the distant Body Condition Score. The developed distant Body Condition Scoring guide is limited to scorings ranging from 2.5 to 3.25, because of the limited variation of the observed animals. The proposed method for monitoring on herd level involves the creation of control charts with herd-specific control limits that effectively detected small and medium-sized deviations that occurred on herd level. Even though none of the indicators had statistical significance in relation to carcass classification, animals with a distant Body Condition Score >3 received higher scores than those with a score ≤3.

The results of this study are in agreement with the current literature but are not representative of a larger herd or a different breed of cattle. In conclusion, the welfare assessment protocol developed in this thesis could serve as inspiration for future studies in validation of Body Condition Scoring in nature projects. Additionally, it offers insights in ruminant behaviour in naturalist grazing, under Danish conditions.

Table of contents

Abbreviations

SH (Scottish Highland)
BCS (Body Condition Score)
dBCS (distant Body Condition Score)
WQA (Welfare Quality® Assessment)
RF (Rumen Fill)
ACF (Autocorrelation Function)
SD (Standard Deviation)
RELM (Restricted Maximum Likelihood)

Chapter 1: Introduction

The concept of rewilding was first introduced at the turn of the century (Gordon et al., 2021; Jørgensen, 2015), and in the last decade has gained recognition and the scientific community is taking a step forward (Helmer et al., 2015; Jepson et al., 2018; Pettorelli et al., 2019; Svenning et al., 2016). The environmental impact of human practices has taken a toll on many species of fauna and flora, resulting in a significant reduction in biodiversity and species extinction (Gordon et al., 2021). Rewilding, simply explained, is an attempt to restore an ecosystem to its previous state (before human intervention) by reintroducing species of mega fauna (large mammals) and mega flora (large trees) (Helmer et al., 2015). Many studies have been conducted to evaluate the different aspects of a rewilding program such as animal welfare, biodiversity enhancement, economic consequences and social impact and political agenda. A more common form of rewilding in practice, is naturalist grazing, where livestock is used (ruminants and horses), and is usually connected to landscape preservation (Wallis De Vries et al., 2007). The available literature discusses rewilding from a theoretical point of view, highlighting the lack of rewilding projects in practice, and the need for further research (Garrido et al., 2019; Svenning et al., 2016).
Based on the current literature and research, the main concerns of the Danish public and veterinary community regarding rewilding, and the use of contemporary livestock, can be summarized in the following questions;

1. Is animal welfare compromised according to Danish legislation?

‘’ Are the animals suffering according to the five freedoms; **Freedom of Hunger* and Thirst, Freedom of Pain, Injury or Disease, Freedom of Fear and Distress, Freedom to express normal behavior and Freedom from Discomfort? ‘’

*For the purposes of this project, only Freedom of Hunger was examined.

2. How can we monitor to ensure animal welfare?

‘’ What is the appropriate approach to monitor large year-round grazing herds (monitoring on herd level) to ensure *Freedom of Hunger* and good animal welfare? ‘’

3. Human intervention?

‘’ On what level should humans intervene and when is the right time to do so? What is the proper management strategy to ensure good welfare whilst not compromising the integrity of the ecosystem? ‘’

These questions inspired the main scientific objectives of the thesis which are to be found at the end of the theoretical section.

Theoretical Background

1.1 Rewilding and livestock: a welfare perspective

Rewilding can be linked to many practices, e.g., year-round grazing, naturalistic grazing (MacDonald et al., 2000) and can target different aspects of a chosen ecosystem; cattle grazing to help bird nesting (as referenced by Metera et al, 2010), light grazing to increase local population of insects such as butterflies (Bussan, 2022; Wallis De Vries et al., 2007). The main hypothesis is that by isolating the ecosystem from human intervention and through time and proper species selection, that ecosystem will flourish and return to, or closely resemble, a previous state (Sandom et al. 2012). Consequently, resulting in an increase in biodiversity (Fløjgaard et al., 2021; Isselstein et al., 2005; Tallowin et al., 2005).

As previously mentioned, large mammals play a key role in the rewilding process (Schweiger & Svenning, 2020; Svenning et al., 2016), as they have always been a part of the ecosystem and can have a great influence on the microflora and microfauna; historic evidence dating back to thousands of years show that mega mammals (>1000kg) could be found globally, but, through the years, human intervention has caused most of these species to go extinct (Svenning et al., 2016). Therefore, it is not possible to introduce the original species. In some cases, it is possible to introduce niche substitutes, meaning species that are closely related to the extinct species (Corlett, 2016; Svenning & Faurby, 2017), like elephants (closely related to mammoths) and African lions (closely related to sabretooth cat). In Europe, where there are currently no mega mammals (Fløjgaard et al., 2021; Svenning & Faurby, 2017), rewilding projects use livestock, and more specifically large herbivores (>500kg) like cattle, horses, bison, and buffalo (Fløjgaard et al., 2021). It is believed that domesticated species can have a similar impact on the ecosystem as their ancestors and can even have a positive economic impact as it is presumed that some type of human management will have to take place to maintain the new ecosystem (Gordon et al., 2021). It is also debated whether these domesticated species need to be de-domesticated (return to their ‘wild natural’ behaviour) or as more docile species, need to be included in the rewilding process. Even though there is no accurate research to portrait the full potential of using livestock in rewilding projects (Gordon et al., 2021), there are examples of successful and less successful rewilding initiatives in Europe;

- Knepp Wildland in England, an area of 1,400 hectares that was used for intensive agricultural practices, has been rewilded multiple times since 2002, using populations of longhorn cattle, Exmoor ponies, Tamworth pigs and fallow deer. The animals graze all year and there is no supplementary feeding. The animals are also used for meat production (75 tonnes of animals are slaughtered each year) (Fløjgaard et al., 2021).
- Oostvaardersplassen in the Netherlands is probably the most controversial project; Heck cattle, Konik horses and roe deer, were reintroduced to 5,600 hectares of wetland from 1983 to 1992. A large number of animal deaths were reported (related to starvation and injuries/illness), causing political and public debates, and the management style was changed to human intervention when needed (i.e. weakened animals are killed and the population is regulated in order to avoid starvation in the winter months) (Fløjgaard et al., 2021).
- Kraansvlak in the Netherlands is one of the oldest projects; European bison were reintroduced to an area of 220 hectares in 2007, followed by Konik horses in 2009 and Scottish Highland cattle in 2016. To this day, the area has been expanded to 330 hectares and there is no supplementary feeding (Fløjgaard et al., 2021).

On the other hand, the view on this practice can be very controversial;

Scientists have debated the selection of animal species, more specifically in Europe, as some animals are domesticated, meaning they have gone through years of selection and other husbandry practices (such as cattle), and are not suited for rewilding purposes (Lorimer et al., 2015). Furthermore, this type of practice raises concerns about animal welfare and comes in contradiction with laws regarding fenced animals (Ministeriet for Fødevarer, Landbrug og Fiskeri, 2021).

A survey concerning rewilding, directed to the public and the scientific community, was conducted in Denmark between 2018 and 2022 by Sandøe et al. (2022) and showed that there are four key points, regarding animal management and animal welfare, that seem to be the most controversial; (Sandøe et al., 2022).

- The general conception of animal welfare: absence of suffering vs natural living
- The welfare assessment level: group vs individual animal welfare
- Feeding: supplementary feeding vs no feeding regime
- Death: natural death vs lethal or non-lethal removal

Opinions differ within the scientific community, specifically on welfare issues, with advocates of natural behaviour and the opportunity to live free in a "wild" but natural environment (for each species) (Sandøe et al., 2022) and advocates of a life free of hunger, pain and suffering, meaning that the animals will suffer without human intervention (Sandøe et al., 2022). It is also debatable whether it is possible to monitor these animals as a herd, whilst maintaining animal welfare on the individual level (i.e., if the overall herd is thriving, it is acceptable to ignore an individual animal that is suffering or not thriving) (Sandøe et al., 2022; Winckler, 2019).
The Danish legislation (Animal Welfare Act) (Dyrevelfærdsloven, 2021) states:

§3 'Anyone who keeps animals must ensure that they are treated with care, including that they are housed, fed, watered, and looked after taking into account their physiological, behavioral and health needs in accordance with recognized practical and scientific experience.'

Section 9 'Anyone who keeps animals must ensure that the animal is looked after at least once a day.

PCS. 2. Paragraph 1 does not apply to free-ranging animals on grass etc. However, such animals must be inspected regularly.'

For free-grazing herds in national parks on the other hand, the Animal Welfare Act includes a separate section under *"Special provisions on animals that are exposed in natural national parks"* (Dyrevelfærdsloven, 2021) were it is stated:

§20a 'The Ministry for Food, Agriculture and Fisheries may, in order to meet the consideration of nature and biodiversity in a nature national park covered by a permit under the Nature Conservation Act, exempt certain animal herds that are exposed in such a nature national park, and the animals' offspring, from the provisions of § 3 and section 9, subsection 1 and 2.'

Even though the Ministry recognizes the differences between a production animal and a free-grazing animal, the Welfare Act clearly states that animals under human care (or in this case fenced animals) need to be monitored regularly to ensure good animal welfare.

1.2 Rewilding in practice – naturalist grazing

Although rewilding is hard to achieve in practice, there is a large number of "rewilding" initiatives (i.e. year-round grazing and key species re-introduction) and projects throughout Europe (Helmer et al., 2015). Free grazing and year-round grazing have been closely linked to rewilding initiatives. In Denmark, the National Center for the Environment and Energy (Nationalt Center for Miljø og Energi) published a report mapping, analysing and describing all known rewilding projects in Denmark and the effects on biodiversity (Fløjgaard et al., 2021).

Three different approaches to rewilding are described;

- **Passive* or *Organic* (minimal human intervention)
- *Trophic* rewilding (re-introduction of key species, usually predatorial)
- *Pleistocene* rewilding (long-term evolutionary approach)

*For the purposes of this project, only *Passive* rewilding will be discussed.

Passive or *Organic* rewilding proposes that through minimal human intervention (minimum forestry) the ecosystem will be re-introduced to previously lost populations such as birds, insects, and predators, which will then thrive in the new niches. As livestock grazing has been linked to population increase in birds and butterflies (Garrido et al., 2019; van Klink et al., 2016; Rupprecht et al., 2016) it is considered to be part of the passive rewilding process and is suitable for the European conditions (Pettorelli et al., 2019). Within the report, the authors recognize that there is a larger number of such rewilding initiatives, including Amager Fælled (collaborator of this project), but were not included in the report due to management requirements (relocation of the herd when necessary) (Fløjgaard et al., 2021).

The use of livestock to control vegetation has been a common agricultural practice (Humphrey, 1998; Rook et al., 2004) but, the different effects of grazing can play a key role in rewilding and potentially in biodiversity increase;

1. Grazing behaviour

Depending on the selected species, the grazing behaviour can vary, leading to different outcomes in the fauna biodiversity, due to different dietary choices and needs in each species (Fløjgaard et al., 2021; Rook et al., 2004). Through selective grazing, or selective defoliation, the abundance of fauna species can be altered, resulting in the growth of unpalatable tall plants and the creation of a more mosaic landscape (as referenced by Metera et al, 2010; Schweiger & Svenning, 2020).

2. Treading or trampling

Grazing animals can create certain disturbances in the soil (the degree of which depends on the size of the animal (as referenced by Metera et al, 2010), by creating gaps in the sward and mulches in the soil, that allow new seeds to grow and in some cases, offer protection on plant seeds (Bokdam et al., 2002; Varva, 2005). On the other hand, depending on the stocking rate (Russell et al., 2001) a combination of wet soil and grazing the grass too close to the ground (<20mm) can result in soil erosion (Kauffman et al., 1983; Varva, 2005).

1. Nutrient cycling

The concentration of nutrients by the urine and faeces can alter the animals' grazing behaviour; cattle do not graze near faeces' patches (Bokdam et al., 2002) resulting in more "selective" grazing. Furthermore, grazing animals contribute to seed dispersal, through the process of endozoochorus; while grazing animals consume seeds that pass through their digestive system and are then dispersed with the faeces (Bakker, 1998). Another method of seed dispersal is exozoochorus, which is the transport of seeds by the animals' coat (Bakker, 1998).

There is a lack of research on many aspects of a rewilding project or other naturalistic grazing schemes, and the true effects and side effects of such practices are not fully understood (Fløjgaard et al., 2021; Metera et al., 2010; Rook et al., 2004).

According to Fløjgaard *et al.*, 2021, 85 rewilding projects are currently in progress in Denmark, and the authors recognize that the actual number is larger but only these, fall within their definition of a rewilding project. The naturalistic grazing project, currently in progress at Amager Fælled (collaborating farm of this project) was not included in the report, owing to excessive management (Fløjgaard et al., 2021).

1.3 BCS and welfare assessment

'Good animal welfare' can have many meanings and can focus on various aspects of an animals' life (Welfare Quality®, 2009; Webster J., 1994). A welfare assessment can include direct indicators, such as body condition scores (BCS) (Animal Based Indicators - ABI) or indirect indicators such as environmental enrichment, good bedding, and temperature control (Resource and Management Based Indicators- RBI and MBI) (Welfare Quality®, 2009; Spigarelli et al., 2020). Body Condition Scoring is a method of assessing the subcutaneous stores of fat, by palpation, and scoring designated areas on the animal's body (Welfare Quality®, 2009; Roche et al., 2009). This BCS is commonly used as the need of weighing the observed animals is eliminated, but at the same time, it is possible to assess whether an animal will require supplementary feeding in the long term (Spigarelli et al., 2020). There are several different scoring scales used for BCS but the most commonly used are the 5-point scale (dairy cattle) and the 9-point scale (beef cattle) (Spigarelli et al., 2020).

1.4 Scottish Highland cattle: origins, characteristics, and management

A common breed of cattle used in Denmark for the purposes of landscape preservation, is the Scottish Highland (SH) cattle, which was brought to Denmark approximately 30 years ago. Their thick coat and their robust nature, allows them to adapt and thrive under the Danish weather conditions. Therefore, this breed of cattle was selected for the welfare assessment and the collection of data.

1.4.1 Origins

With records dating back to the 1800s, SH cattle are known for their hardiness, their unique appearance, and their ability to survive in unfavourable conditions (Roberts, 1905). SH represent a good example of a low maintenance breed that can graze year-round with minimum human-animal interaction (Pauler et al., 2020; Roberts, 1905).

It is debated whether the SH are indigenous in Scotland, but there are records of "pure" Highland herds in northern Scotland, and the western islands (Roberts, 1905). Originally, the breed was divided into two classes, based on the coat, colour and size of the animal. The animals that were smaller and shaggier (usually black in colour) were classified as West SH or Kyloe (native name in the west isles of Scotland). The animals that were larger and had a sleeker coat (usually dune in colour) were classified as Mainland Highlander or Highlander (Roberts, 1905). Due to limitations in terms of transferring the animals, and the different environmental conditions between the Scottish Isles and the mainland, these two classes were created (Roberts, 1905). Today, SH are registered as a single breed and records (Herd Book) of the breed have been kept since 1885 by the Highland Cattle Society (Highland Cattle Society, 2023).

1.4.2 Characteristics

Although little information can be found for this breed of cattle, records from various cattle shows (dating back to 1822) give information on prize winning animals as well as fat stock and carcass weight. A detailed description of an animal representing the breed characteristics can be found in the first Herd Book, dating to 1885 (Roberts, 1905; Highland Cattle Society, 2023).

As previously mentioned, the SH have been prize winning show cows, not only because they are considered the most picturesque breed of cattle but also because of their high quality meat (Roberts, 1905) (Highland Cattle Society, 2023), which is high in protein and iron, and is low in fat and cholesterol compared to other beef, whilst maintaining a unique flavour (Highland Cattle Society, 2023).

The points of the breed, defined and described by the Herd Book (Roberts, 1905) are the head, neck, shoulders, back, body, hind quarters, and hair.

The head is described as “the most picturesque” and highly proportionate to the rest of the animal, with broad distance between the eyes, an area usually covered with long hair, and long horns, that are different between males and females (Roberts, 1905; Highland Cattle Society, 2023).

The neck is described as tight, with no dewlap, forming a straight line between the head and the shoulder in cows (Roberts, 1905; Highland Cattle Society, 2023).

The body of the animal is described as well-rounded, with a straight back, full thighs and highly developed hind quarters. The hind legs and the forelegs should be short, a result of inbreeding to achieve black coat colour (Roberts, 1905), with a wide stance, giving the animal a proudful walk; a reliable sign of pure and good breeding (Roberts, 1905; Highland Cattle Society, 2023).

The hair is described as long and slightly waved. As previously mentioned, the original SH were black and dune in colour (Roberts, 1905). Originally, the black animals were favoured, as they were considered to be stronger and more capable of surviving under harsh conditions. It is believed that it is because of inbreeding that these animals have developed this type of dwarfism that we see to this day (Roberts, 1905). On the other hand, in order to satisfy a growing market of noble Englishman, the breeding of red, cream/white, and brindle animals began, as they were much preferred and used as recreational animals, in private parks (Roberts, 1905).

1.4.3 Feeding and management

The SH are a low productive breed, with a slow growth rate but at the same time are sturdy and robust animals and are not as demanding, feed-wise, as other breeds (Albertí et al., 2008). They are known for their foraging skills and their ability to eat everything that is available in order to survive under unfavourable conditions (Roberts, 1905; Pauler et al., 2020). According to Roberts (1905), records from the 1800s show that farmers would simply let their animals graze during the winter, without offering any feed or shelter. This type of management, which was used for years, resulted in great financial losses for the farmers, as many animals would not survive the cases of extreme weather and the grazing areas were not of a high quality, even before the winter months had start (Roberts, 1905). These losses, combined with the rising price of beef, led to new types of management, where the pastures were divided and kept for winter use, the farmers started to offer some feed or hay during the winter. Furthermore, some type of natural shelter (if available) proved to be beneficial for the animals (Roberts, 1905).

In a recent study by Pauler et al. (2020), three types of cattle (low, medium, and high productivity) were used and the differences in anatomy, movement and foraging behaviour were tested, in a controlled grazing area in the Alps for 10 weeks. The SH represented the low productivity type of cattle, and the results showed that on average, they had a positive daily weight gain of 0.08 kg, compared to the other two breeds, which had average losses of 0.3kg (medium) and 0.6kg (high) (Pauler et al., 2020). The SH grazed all the available area evenly and covered a smaller distance, on average, compared to the other breeds, that walked longer distances to find high quality feed (Pauler *et al.*, 2020).

Although the SH are a slow maturing and slow growing breed, their meat is considered to be of high quality; tender, well-formed, and well-marbled flesh (Highland Cattle Society, 2023). This breed of cattle has been compared to other high-producing breeds, with records dating back to 1904 (Roberts, 1905). Figure 1 shows the results of the annual Smithfield Fat Stock Show in London, from December 1904, where several breeds were examined.

236 BUREAU OF ANIMAL INDUSTRY—21st REPORT.

Averages of selected beef breeds at Smithfield Fat Stock Show, 1904.

[Compiled from the London, England, Live Stock Journal.]

Breed.	Number in exhibit.	Average age.	Average weight.	Average daily gain.
Hereford—		*Days.*	*Pounds.*	*Pounds.*
Steers	4	1,004	1,742	1.74
Heifers	4	956	1,586	1.66
Shorthorn—				
Steers	8	1,037	1,838	1.77
Heifers	4	985	1,727	1.75
Aberdeen-Angus—				
Steers	5	1,046	1,852	1.77
Heifers	4	1,055	1,673	1.59
Welsh—				
Steers	7	1,068	1,924	1.80
Heifers	5	1,054	1,575	1.50
Highland—				
Steers	6	1,019	1,470	1.44
Oxen	6	1,348	1,786	1.33
Heifers	5	1,334	1,485	1.11
Crossbred—				
Steers	6	1,015	1,823	1.80
Heifers	6	1,066	1,749	1.64

Figure 1: Fat Stock test of Highland cattle and other well-known breeds in London, 1904 (Roberts, 1905).

Scientific objectives

The goal of this thesis is the demonstration of a welfare assessment in practice, for year-round grazing cattle in Denmark, with focus on distant Body Condition Score (dBCS). The current study is divided into three sub-studies:

Sub-study 1: ''Can animal welfare, related to feeding and prolonged hunger, be assessed on herd level using only observations and no handling?''

Sub-study 1 aims at conducting a welfare assessment on year-round grazing SH cattle by describing and analyzing the composition of an overall dBCS.

Sub-study 2: ''How to monitor on herd level to ensure welfare over time?''

Sub-study 2 aims to illustrate a method of monitoring overall dBCS (absence of prolonged hunger) on herd level over time, in connection to social behaviour, and provide suggestions for an alarm system that identifies out-of-control cases.

Sub-study 3: ''Is dBCS valid for assessing body composition?''
Sub-study 3 aims at describing the relation between carcass scoring and overall dBCS, and the correlation between the components of the dBCS and the carcass scoring.

Chapter 2: Materials and Methods

For the practical demonstration of the welfare assessment and the data collection, a collaboration was made between the University of Copenhagen, the master student and Københavns Kogræsserlaug, an association that has been practicing the year-round grazing system with non-reproductive cattle and horses (naturalistic grazing) for the last 9 years (Københavns Kogræsserlaug, 2015). It is a voluntary association, located in Amager Fælled were they keep a small herd of 18 SH heifers on their pastures during the spring and summer (May to beginning of November 2022), and five heifers and six horses during autumn and winter (November to end of April 2023) (Københavns Kogræsserlaug, 2015). There is no (or occasional and targeted) supplementary feeding and minimum handling year-round (mostly for pasture relocation). With this practise, the association focuses mainly on nature preservation and on a lesser extent, production of meat from the cattle "on an ecologically sound basis" that is later distributed among the members. (Københavns Kogræsserlaug, 2015).
This SH herd was convenience sampled (despite the small size), as the only participating year-round grazing cattle herd, due to practical issues such as location, transportation, and willingness to cooperate.
On the first scoring day, all animals were photographed for identification purposes and recognition of specific traits, although in practice, it was particularly challenging to identify the animals by just looking at them. The animals were observed approximately every two weeks, and each visit lasted one to three hours, depending on the size of the Herd, the weather conditions, and the location of the animals.

2.1 Welfare principles and criteria

For this project, the welfare assessment of year-round grazing SH cattle was executed under the welfare principles used in the Welfare Quality® Assessment protocols. A detail description can be found in Table 1.

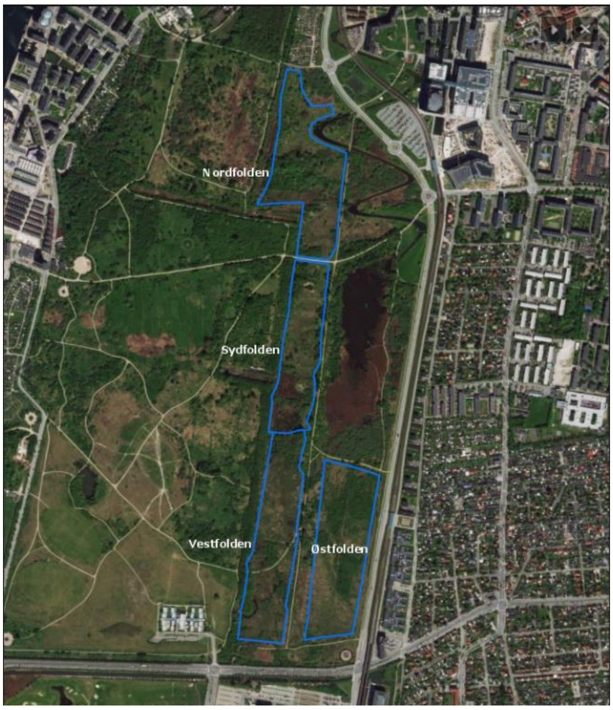
Table 1: Structure description of the project: welfare principles, criteria and measurements used in the project.

Welfare principle	**Welfare criteria**	**Measurement**
Good feeding	Absence of prolonged hunger	1. dBCS developed by the master student 2. WQA (modified)
**Appropriate behaviour*	Expression of social behaviours	Field notes
	Good animal-human relationship	Field notes
	Expression of other behaviours	Field notes

*Secondary assessment (more under Sub-study 2)

2.2 Grazing area and yearly grazing plan 2022-2023.

The grazing area is divided into four fields (Picture 1); Nordfolden, Sydfolden, Vestfolden and Østfolden. During this project, the animals grazed at Nordfolden (approx. 10 hectares), Sydfolden (approx.. 7 hectares) and Østfolden (approx. 10 hectares). The area belongs to the Copenhagen Municipality and the Amager Nature Park and is actively maintained as an open space by human intervention; the forest areas and all unwanted flora in the fields is cleared out by large teams of people who are send during the year and they cut down specific trees and shrubs, not only to preserve the area but to assist the grazing cattle as well. Water is available at all fields and is either a manmade source or natural, like small ponds (Picture 2). The fields have large open spaces covered in grass as well as areas that are covered with shrubs, small forest-like areas, meadows, and marshes (Picture 3&4). The fields also contain areas where the animals do not have access to graze, due to the vegetation or to the path system that is created for human recreation. The grazing plan can be seen in Figure 2.



Picture 1: Aerial photo with marked blue areas showing the four different fields at Amager Fælled (Københavns Kogræsserlaug, 2015a).

Picture 2: A small pond close to the entrance of Sydfolden.

Picture 3: Nordfolden in April 2023

Picture 4: Østfolden in March 2023

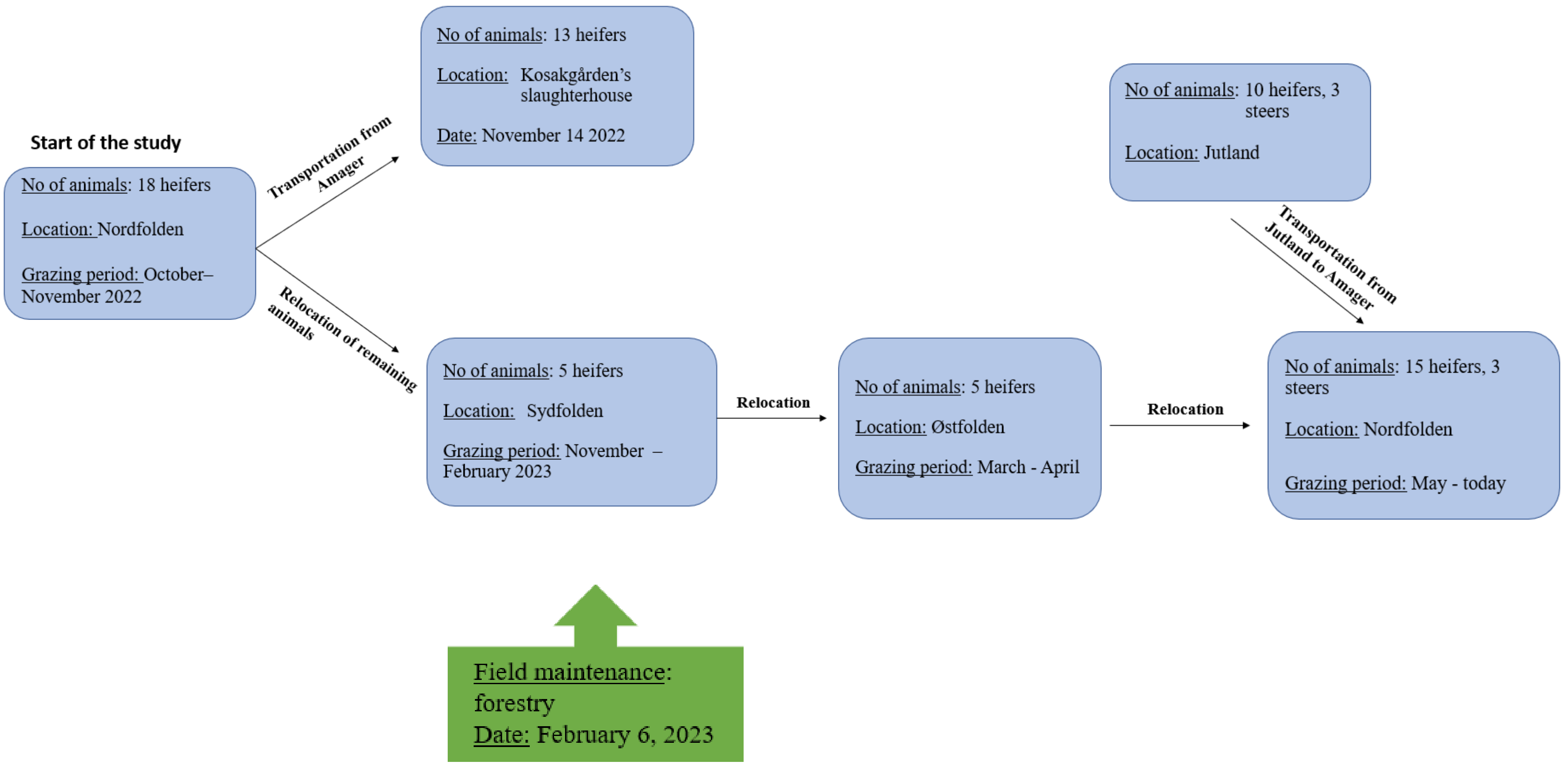


Figure 2: Illustration of the grazing plan at Amager, containing the number of animals, location, grazing period, and human intervention (relocation of the animals or transportation, field maintenance).

On Sydfolden and on Østfolden (recent addition), a wooden enclosure is available for both cattle and horses to rest and take cover from the rain. On Nordfolden, close to the entrance, the cows have access to a mineral rock, which is suspended from a tree. Recently, two more mineral rocks were added at Østfolden, after the suggestion of the collaborating veterinarian. The relocation of the animals from field to field is done with the help of metal bars that form a directional path, and the caretakers lead the animals to the next field e.g., no physical handling (Picture 5).

Picture 5: Metal bars placed at the entrance of Nordfolden a few days before the relocation. The bars were left there for a few days so that the animals would get used to them.

2.3 Sub-study 1

2.3.1 Considerations regarding dBCS: Welfare Quality® Assessment protocol (WQA)

According to the WQA, the areas of importance when doing BCS (under fattening cattle for the purposes of this project) are the Tail Head, the Loin and the Vertebrae. The scoring scheme of the WQA can be seen in Figure 3. This method of scoring was modified in order to address an inconsistency with the classic BCS; in the WQA a + sign is used to indicate thinness in the area of interest and a - sign to indicate satisfactory condition. The final score was high for thin animals, and low ‘satisfactory’ animals. However, this arrangement posed a problem when comparing the final scores with the classic body condition scoring system, where a high number signifies satisfactory condition, and a low number represents thinness.

To ensure consistency and have comparable results, the original scoring scheme was revised (Table 2); a + sign is given to indicate satisfactory condition and a - sign to indicate thinness. Moreover, the final two-scale scoring was changed to a four-scale. This adjustment ensures that the final scores align with the conventional body condition scoring system, where a lower score represents thin animal, and a higher score represents a well-rounded animal. The four-scale scoring was implemented for better representation of the composition of the herd, as not all animals were represented by the original scale. Furthermore, the main goal for this revised scoring scheme is to establish a “reference point” for comparing different scoring methods and thus having a more comprehensive understanding of the strengths and limitations of each method.

Title	**Body condition score**
Scope	Animal-based measure: Fattening cattle
Sample size	Sample size according to § 5.1.5
Method description	View the animal from behind and from the side in the loin, tail head and vertebrae. Animals must not be touched but only watched. Animals are scored with regard to four criteria as follows (see photographic illustration): Body region — Very lean Tail head — • Cavity around tail head Loin — • Visible depression between backbone and hip bones (tuber coxae) Vertebrae — • Ends of transverse processes distinguishable General — • Tail head, hip bones (tuber coxae), spine and ribs visible **Individual level:** **0** – Satisfactory body condition: at most two body regions classified as too thin **2** – Very lean: indicators for ‘too thin’ present in at least three body regions
Classification	**Herd level:** **Percentage** of very lean animals (score 2)

Figure 3: BCS for fattening cattle according to the Welfare Quality® Assessment protocol, 2009

Table 2: Modified scoring system and description, based on WQA.

Modified scoring	**Body Condition**
0 = All 3 regions are classified as very thin (--)	*Very lean*, the animal is emaciated
1 = All 3 regions are classified as thin (-)	*Lean*, the animal is very thin
2 = Classified as satisfactory, maximum two regions classified as thin (+)	*Satisfactory*, some areas are lacking fulness
2.5 = Classified as satisfactory, no regions classified as thin (++)	*Satisfactory*, all areas are well rounded

*Animals that had more than one (++) score, were given a 2.5

2.3.2 Development of dBCS

In total, seven areas of interest (indicators) were chosen for the dBCS; five for the final dBCS and two replacements. The indicators were inspired by the available literature (Edmonson et al., 1989; Hersom & Thrift, n.d.; Lalman et al., 2017; Soares & Dryden, 2011; Spigarelli et al., 2020; Zielke et al., 2018) add guides here) and can be seen in Table 3.

Table 3: Tested indicators during the project.

INDICATORS						
Thighs (Replaced)	Horns (Replaced)	Round	Coat	Rumen Fill (R.F.)	Shoulder Bone	Dewlap

The final assessment sheet used for the scoring the indicators can be seen in the Appendix A, and the WQA assessment table can be seen in Appendix B.

On every visit, each animal was photographed from all sides, or a video was taken in cases where the animal was anxious, or the weather conditions were unfavourable. Each heifer/steer was observed as closely as possible (approximate distance ranging from 1 to 20 meters) in each region of interest and a score was assigned (--, -. +, ++). Each animal was scored twice independently, using the dBCS and the modified WQA. Finally, each animal was given a dBCS, based on a 5-point scale, with intervals of 0.25, and ranging from 1 (severely emaciated animal) to 5 (extremely obese animal), either on the field or based on the obtained photographs.

For fattening cattle, a 9-scale BCS is commonly used. To help assign the final dBCS during the first scoring weeks, multiple BCS guides were consulted (Department for Environment, Food & Rural Affairs, n.d.; Lalman et al., 2017; Selk, n.d.). The master student chose to develop a 5-scale dBCS for simplicity reasons (Soares & Dryden, 2011), and for easy-use by inexperienced users. The final dBCS can be found under Results.

The development and usage of the dBCS was done only by the master student and there were no intra-observer agreement studies made, to assess the validity of the scoring scheme.

2.4 Sub-study 2

During the scoring, the health status and the entire herds' social behaviour was noted along with the time, date, and location. The surrounding environment (including presence of people and weather), and the behavioural observations, inspired by the study of Geven and de Graaf (2014) on SH natural behaviour, were noted. As the focus of the project was to develop and assess an overall dBCS, social behaviour observations and grazing behaviour observations, were reduced to field notes, instead of creating an ethogram (Banks, 1982), taken at the end of every visit, or during the scoring when possible (to be further discussed in the Discussions section). With this approach, the goal is to explore the relationship between social behaviour, by pinpointing specific events during the winter scoring, and dBCS, by comparing the development in the scores pre and post the event. The final herd assessment sheet can be found in Appendix C.

2.5 Sub-study 3

On November 14, 2022, all heifers that were not selected for the winter grazing period were transported to the Kosakgårdens slaughterhouse. On November 15th, the master student visited the location and photographed the carcasses of the 13 heifers. Pictures were taken from all angles (Pictures 11&12), in order to cover all areas of interest for the carcass classification. A detailed description of the carcass classification scheme used can be seen in Table 4.

Table 4: Carcass classification scheme; Shape indicates the physique and muscle density (EUROP system) and has five classes. Each class has two subclasses (+ & -), making Shape a 15-class category. Fatness indicates the degree of thickness of the tallow (fat) cover (EUROP system) and has five classes. Colour indicates how light or dark the tallow is (Danish system) and has five classes (AHDB, 2023; *Kreaturer*, 2023).

Category	**Classes**
Shape	E (Excellent), U (Very good), R (Good), O (Satisfactory), P (Rings).
Fatness	1 (Very poor), 2 (Poor), 3 (Normal), 4 (Good), 5 (Very Good)
Colour	1 (extra light), 2 (quite light), 3 (normal), 4 (slightly dark/yellowish), 5 (dark/yellow)

Pictures 11&12: Panoramic shots of a heifers' carcass at the slaughterhouse on November 14th, 2022.

2.6 Statistical analysis

Sub-study 1

The data was initially collected on paper and was transferred to Excel sheets (Microsoft 365) at the end of every visit. The data was converted from symbols to ordinal scorings in order to proceed with the analysis. All converted data was then inserted to an open-source statistics program (JASP) for the descriptive analysis to obtain the mean and the standard deviation (SD). The data was divided into three 'Herds'; all animals observed from October until slaughtering date were Herd 1, the 5 overwintering animals (November-April) were Herd 2 and the new animals (end of April) along with the 5 overwintering heifers, were Herd 3. Each Herd was analysed separately, and interval plots were created to illustrate the distribution of the scorings (Appendix D).

Two out of the five tested Indicators (Thighs and Horns) were replaced by Round and Coat, four weeks into the study. For this reason, Herd 1 was excluded from the autocorrelation tests for Round and Coat. There was missing data across all Herds, for several reasons (weather conditions, the animal was not cooperating etc.) which caused difficulties during the analysis. For this reason, the mean/median imputation was used in R studio, to replace the missing values in the data with the mean/median of the previously obtained observations. This approach assumes that the missing values are missing at random and that the mean or median is a reasonable estimate for the missing values.

The data was then tested for autocorrelation in R studio to define the level of dependency in the timeseries. A Box-Ljung test was used to check each parameter for autocorrelation and to determine the linear relationship between lagged scorings across all indicators. Autocorrelation Function (ACF) plots were created to identify any patterns between the scoring of each indicator and dBCS and determine whether the scoring is affected by that of previous visits.

A Spearman test was used to assess the correlation co-efficient between indicators and dBCS. This test examines the strength and direction of the monotonic relationship between two variables; Indicators (independent variables) and dBCS (dependent variable). The correlation coefficient (r) ranges from -1 to +1, where -1 indicates a perfect negative correlation, +1 indicates a perfect positive correlation, and 0 indicates no correlation. With this approach, the variables do not have to follow a linear pattern and a basis for further analysis is provided.

To provide a better understanding of the relationship between the indicators and the overall dBCS, a linear mixed model was fitted using the Restricted Maximum Likelihood (REML) method to analyse the data with the following formula:

$$\text{`dBCS`} \sim \text{‘Indicator}_i\text{’} + (1 \mid \text{Herd}_j)$$

Where: *dBCS* is the mean overall dBCS per Herd (dependent factor)

Indicator$_i$ is one of the *i*th indicators (5 in total) used for the dBCS (affecting variables/ fixed effects)

Herd$_j$ is the *j*th Herd (random effects)

With this analysis, the goal is to estimate the effects of the indicators on the mean overall dBCS while considering the variability between herds. The REML method is used to obtain the estimates of the fixed effects and the random effects in the model. The confidence interval was set to 95% (significant p-value 0.05). All indicators were tested together, and the model was not reduced. The residuals of the model are assumed normally distributed around zero (assumptions tested by QQ-plot).

Sub-study 2

Even though the animals were scored and observed on the individual level, the data was used to illustrate the overall dBCS and variation (assessment on Herd level) through time by calculating the mean dBCS per visit. With this approach the overall dBCS status per visit and per Herd was obtained. Subsequently, the mean and the SD of the mean dBCS (mean data) was calculated, providing an overall measure of the dBCS through time and the central tendency of the data.

To identify any out-of-control cases during the monitoring period, three control limits were calculated according to the Montgomery “Rules of Thumb” (Montgomery, 2009) by adding, or subtracting from the mean, the SD multiplied by the distance parameter a:

$$\text{Control limits} = \text{Mean}(x) \pm a * \text{SD}$$

Where: *Mean(x)* is mean overall dBCS per Herd

a is the distance parameter, ranging from 1 to 3

SD is the standard deviation per Herd

The purpose of using control limits and the Montgomery Rules of Thumb is to provide an "alarm system" to monitor data over time, were "out-of-control" cases are identified and the decision-making process is improved. Finally, the mean dBCS scores per Herd were plotted against time and the three control limits were applied.

Sub-study 3

To test the different indicators and their relationship with the carcass characteristics (fatness and shape) and assess whether any of the areas of interest provides a good representation of body composition, the mean values of the indicators and dBCS of the slaughtered animals were calculated. A generalized linear model was used twice (two models) with the following formula:

Carcass characteristic ~ 'Indicator$_i$' + dBCS + Age + Chilled carcass weight

Where: *Carcass characteristic* is Fatness and Shape

Indicator$_i$ is the mean value of the *i*th indicator used for the dBCS

dBCS is the mean value of the dBCS

Age is the age of the animal

Chilled carcass weight is the weight of the chilled carcass of each animal

With this approach the data is analyzied with the assumption that it is not normally distributed and there is no linear relationship between data points. The confidence interval was set to 95% (significant p-value 0.05).
Finally, four line plots were created based on the different Fatness and Shape categories of the slaughtered animals. Each plot contains the animals' ID and the distribution of the different indicator scorings and dBCS per animal.

Chapter 3: Results

3.1 Sub-study 1: practical results related to herd structure and development of dBCS

The master student observed the animals from October 2022 until May 2023 and the animals were divided into three Herds. The five selected animals for the winter (Herd 2) were observed for a total of eight months (start until the end of the study) and are included in all 3 Herds. The composition of each Herd can be seen in the following Tables 5, 6, 7.

Table 5: Composition of Herd 1, including ID number, age in years and colour of coat.

*Animal ID	Age	Colour
105367-00528	3	Red
105367-00537	3	Red
105367-00539	3	Red
105367-00563	3	Brown-White
105367-00575	2	Red
105367-00605	2	Red
105367-00610	2	Brown-White
105367-00639	2	Red
105367-00651	2	Brittle
60434-00314	2	Dun
60434-00325	3	Brown-White
60434-00361	2	Brittle
79834-00155	2	Black

*Animals from Herd 2 not included

Table 6: Composition of Herd 2 (main Herd), including ID number, age in years, colour of coat and place in the hierarchical chain.

Animal ID	Age (years)	Colour	*Hierarchical chain
112135-00450	5	Beige	1 (Leader of the herd)
60434-00313	3	Black	3
**105367-00555	3	Black	3
60434-00309	3	Red/brittle	2 (Second leader)
60434-00335	3	Beige	4 (Smallest in size)

*Based on observations by the master student and the caretakers (in detail under discussion)

**This heifer is a mixed breed of SH and another unknown breed

Table 7: Composition of Herd 3, including ID number, age in years and colour of coat.

*Animal ID	Age (years)	Colour
116791-00059	3	Red
80671-00126	3	Beige
60434-00351	3	Black
105367-00594	3	Red
105367-00620	3	Beige/Brown
105367-00624	3	Red
105367-00643	3	Red
105367-00673	3	Beige
105367-00677	3	Red
105367-00679	3	Black
60434-00346 (steer)	3	Black
105367-00674 (steer)	3	Beige
105367-00680 (steer)	3	Red

*Animals from Herd 2 not included

3.1.1 Chosen indicators for dBCS

The seven potential indicators were tested to help evaluate the body condition of the cattle and to help assign a dBCS. After one practise visit, and two scoring visits, two indicators were rejected and replaced as they were not suitable for this breed of cattle, whilst keeping in mind the living conditions, or there was a lack of observable changes;

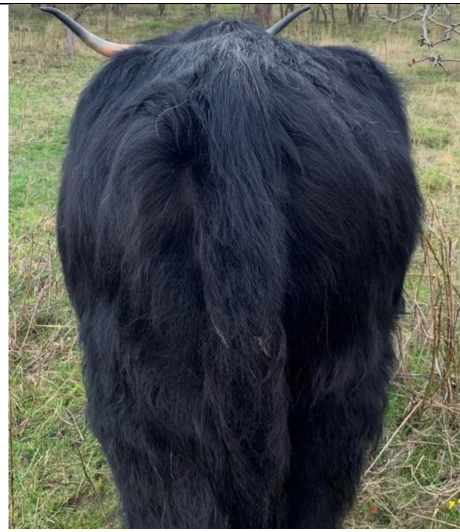
- *Thighs* were rejected as it was exceedingly difficult to assess and score them, due to the area being covered in long, thick hair. As the weather grew colder, the coat grew longer and thicker and therefore this indicator was rejected. Furthermore, the area was difficult to assess due to the weather conditions, were the differences between a wet animal and a dry animal were too hard to assess. This indicator was replaced by *Round* which is also located in the hind legs.
- *Horns* were rejected as there were no observable changes, even though the animals were using the trees to scratch their heads and there was some mild fighting during the winter months. This indicator was replaced with *Coat*, which was chosen for its use as a health status indicator and because the master student wanted to examine whether the thick coating of SH affected the final scoring, especially during the winter where the coat is long and thick (more under Discussion). For a better understanding of the differences in coat quality during the different seasons, an illustration can be seen in Figure 5.

Moreover, a Rumen Fill guide (Agriculture and Horticulture Development Board 2020) was used as a reference to score the R.F. which is used as an indicator of acute hunger but can potentially be connected to behavioural changes (the animal is hungry) and be used as a measurement of prolonged hunger and thus influencing the dBCS (starvation/obesity). For a better understanding of the R.F. during the project, an illustration can be seen in Figure 5. Finally, the five indicators were divided into two categories, *primary* and *secondary* based on the direct or indirect effect they have on the final dBCS score.

3.1.2 Final dBCS

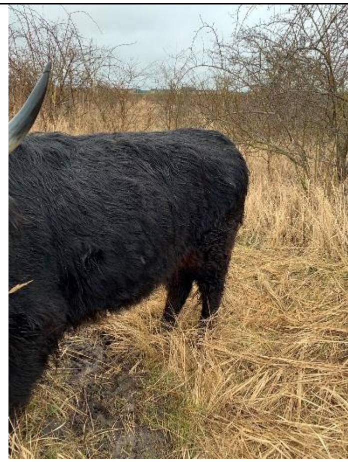
Due to the small size of the observed Herds and their common origin, there was minor variation among the animals when it comes to dBCS; the dBCS ranged from 2.5 to 3.5 with most of the animals ranging from 2.75 to 3. The lowest score of 2.5 was observed only when Herd 3 arrived at the end of April and the highest score of 3.5 was documented during December and January and only the oldest animal scored that high. Therefore, the final dBCS illustrates only the scores that were obtained during this study.

The final list of the chosen indicators can be seen in Appendix E, and the final dBCS can be seen in Figure 4.

dBCS				
Final scoring	2.5	2.75	3	3.25
	Very Thin	Thin	Nourished	Well Nourished
INDICATORS				
Round				
Shoulder Bone				

Dewlap				

Figure 4: Illustration of the dBCS scoring scheme of the primary indicators, with the use of pictures obtained during the project. The scores range from 2.5 to 3.25.

Secondary	October	December	February	March	April
**R.F.*					
Coat					

*Same heifer, 105367-00555

Figure 5: Variation of Coat quality for SH (with different colours of coat) and R.F. during the project, starting from October 2022 until March 2023 (bimonthly).

3.2 Sub-study 2

Along with the individual assessment of each heifer, the entire herd was also assessed based on social behaviour and health status (Table 8). For the herd assessment, the total number of animals that fell in each category (percentage), were noted along with the presence of injuries or other “abnormalities”.

Table 8: Herd assessment

***Social Behaviour**	Grazing, ruminating, sleeping, interaction with other cattle/observer, fighting
***Health Status**	Injuries in body and/or horns and hoofs
Scoring scheme % of Animals observed	- - No animals observed (0%) - One quarter of the herd (25%) + Half of the herd (50%) ++ Three quarters of the herd (75%) +++ All animals (100%)

*Field notes

No injuries were observed during the project. All animals were usually displaying the same behaviour (within each Herd) that differed depending on the time of the visit (Table 9).

Table 9: Social behaviours observed during the project divided into morning and afternoon hours.

Time of day	***Observed Behaviours***
Morning 10.00-11.00	Grazing and interacting with other heifers and observer
Afternoon 13.00-14.00	Ruminating, sleeping, allogrooming

The social behaviour observations are discussed in detail and are compared to the mean overall dBCS of each Herd (Figure 8), under Discussion.

3.3 Sub-study 3

The carcass classification for the 13 slaughtered animals can be seen in Table 10. All the scores were given based on the obtained photographs. The average weight of the carcasses was 171 kg, minimum of 126kg and maximum of 195kg. Although all carcasses seem to fall into the same classification category ranging from good (R) to very good (U), there are clear differences in fat deposition.

Table 10: Carcass scoring based on the EUROP scoring system, including animal ID, age in years, chilled carcass weight in kgs and average of each category.

Animal ID	**Age (years)**	**Shape (categorical variable)**	**Fatness (ordinal variable)**	**Colour (ordinal variable)**	**Chilled carcass weight (kgs)**
105367-00528	3	U- (10)	3	4	195
105367-00537	3	U- (10)	4	4	179
105367-00539	3	U (11)	4	3	190
60434-00314	3	R (8)	3	3	190
105367-00563	3	R+ (9)	3	4	198
105367-00575	2	R- (7)	3	3	149
105367-00605	2	R (8)	3	4	171
105367-00610	2	R (8)	3	4	147
105367-00639	2	U (11)	4	3	151
105367-00651	2	R- (7)	3	2	147
60434-00325	3	R (8)	3	3	185
60434-00361	2	R (8)	3	4	191
79834-00155	2	R (8)	3	3	126
Average	2.5	R/R+ (8.7)	3.2	3.4	171

3.4 Statistical Analysis

Sub-study 1

The descriptive analysis of the data can be seen in Figure 6; The valid and the missing values for each factor within each Herd can be seen. N represents the number of animals in each Herd and Min and Max represent the minimum and the maximum values for each Indicator, the dBCS and the WQA. The Shapiro-Wilk test showed that the data is not normally distributed, which was expected, due to the limited data that was obtained during the study; if there was a larger collection of data during a greater period of time, the data would probably be normally distributed. Furthermore, the mean and the SD for each Herd and each Indicator were also calculated.

	Herd	N	Valid	Missing	Mean	SD	Shapiro-Wilk	P-value of Shapiro-Wilk	Min.	Max.
Round	1	18	36	36	2.31	0.62	0.76	3.4×10^{-6}	1	3
	2	5	42	8	2.19	0.46	0.61	2.0×10^{-9}		
	3	18	54	0	1.78	0.63	0.78	1.0×10^{-7}		
R.F.	1	18	65	7	4.39	0.36	0.79	3.2×10^{-8}	1	5
	2	5	42	8	4.42	0.43	0.83	2.0×10^{-5}		
	3	18	53	1	4.11	0.35	0.82	1.2×10^{-6}		
Coat	1	18	36	36	2.67	0.79	0.57	4.6×10^{-9}	0	4
	2	5	44	6	2.93	0.70	0.82	6.9×10^{-6}		
	3	18	54	0	2.15	1.09	0.87	3.6×10^{-5}		
Dewlap	1	18	69	3	3.20	0.68	0.75	1.8×10^{-9}	1	4
	2	5	42	8	3.33	0.48	0.60	1.5×10^{-9}		
	3	18	53	1	2.32	0.83	0.86	2.3×10^{-5}		
Shoulder bone	1	18	59	13	2.09	0.47	0.63	7.0×10^{-11}	1	3
	2	5	42	8	2.50	0.51	0.64	5.9×10^{-9}		
	3	18	54	0	1.87	0.65	0.79	1.8×10^{-7}		
dBCS	1	18	72	0	2.95	0.16	0.77	2.9×10^{-9}	1	5
	2	5	45	5	3.14	0.16	0.80	2.8×10^{-6}		
	3	18	54	0	2.79	0.21	0.86	1.2×10^{-5}		
WQA	1	18	66	6	2.07	0.18	0.42	1.3×10^{-14}	0	2.5
	2	5	44	6	2.17	0.24	0.59	9.6×10^{-10}		
	3	18	54	0	1.64	0.64	0.78	1.5×10^{-7}		

Figure 6: Descriptive analysis of the data

The ACF plots showed no evidence of autocorrelation in the data (example in Figure 7). The p-values from the Box-Ljung test were not statistically significant and therefore, the data is not autocorrelated. Due to a large number of missing data from Herd 1, this herd was excluded from the autocorrelation test for Coat and Round.

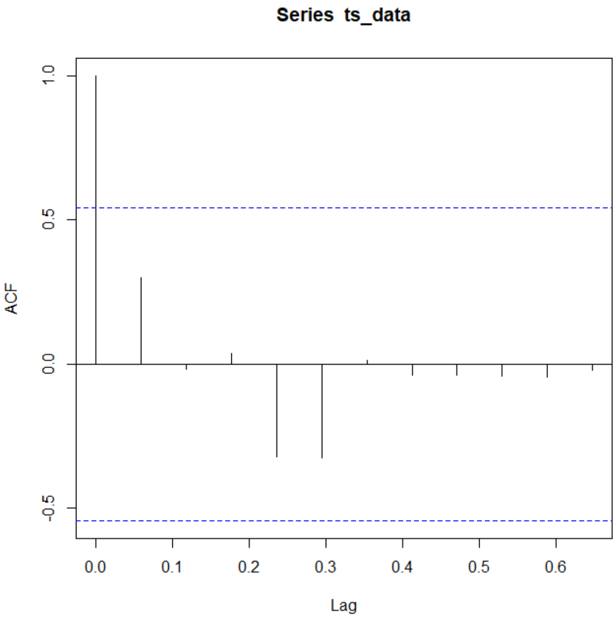


Figure 7: Example of an ACF plot for the autocorrelation test (Dewlap)

The Spearman test showed that all indicators had a moderate positive monotonic relationship with the dBCS, except for R.F. that showed a weak positive relationship (Table 11).

Table 11: Results of the Spearman test

Indicator	*Correlation Coefficient (r value)**
Round	0.49
Dewlap	0.54
Shoulder Bone	0.58
Coat	0.53
Rumen Fill	0.34

*Range: -1 (perfect negative correlation), 0 (no correlation), 1 (perfect positive correlation)

The mixed model showed (Table 12) that Dewlap and Shoulder Bone are statistically significant with p-values of <0.0001 and 0.00207 respectively. The coefficient estimates indicate that a one-unit increase in Dewlap or Shoulder Bone score is associated with a 0.099 and a 0.083 unit increase of dBCS, respectively. Round was found borderline significant were a one-unit increase is associated with a 0.344 unit increase in dBCS. Coat and R.F.

where not statistically significant (p>0.05). Model assumptions were tested by examining the normality of the residuals using a Q-Q plot (Figure 8) (Filliben, 1975).

Table 12: Results of the mixed model, illustrating the indicators and the respective p-values and correlation coefficients.

Indicator	*P-value (confidence interval 95%)*	*Parameter Estimates*** *(+,-, NI)****
Round	0.051*	0.053 +
Dewlap	<0.0001	0.099 +
Shoulder Bone	0.00207	0.083 +
Coat	0.65*	0.007 *NI*
Rumen Fill	0.94*	0.003 *NI*

*not statistically significant **approx. values ***indication of an increase (+) or decrease (-) in dBCS or No Impact (NI)

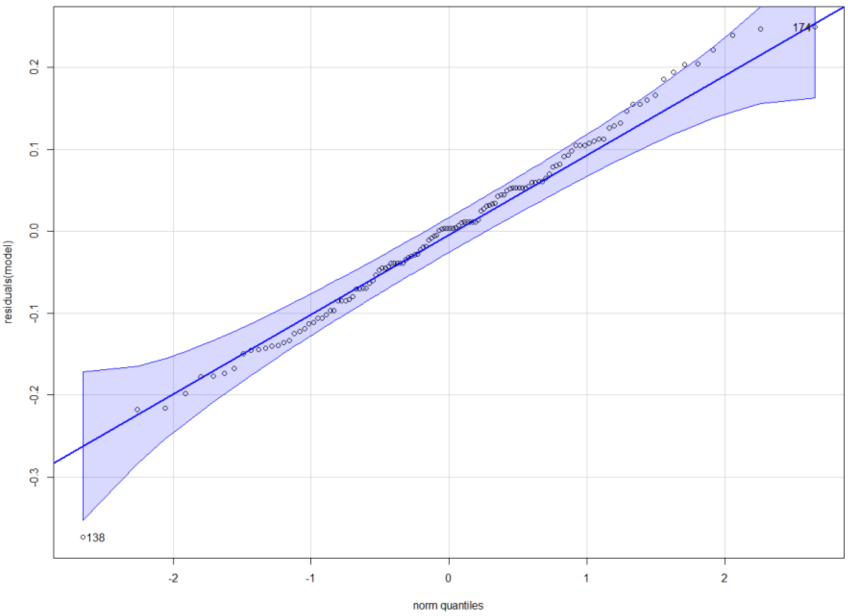


Figure 8: Q-Q plot of the residuals from the mixed model.

Sub-study 2

The mean dBCS per Herd from October (start of the study) until the end of May (end of study) with the three control limits can be seen in Figure 9.

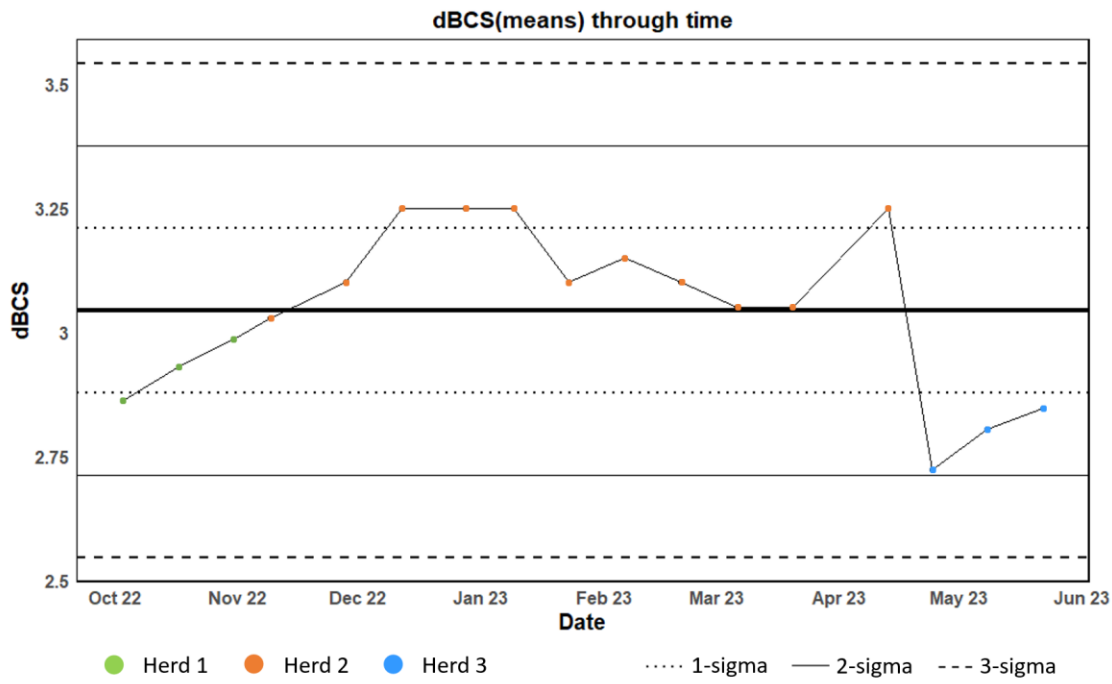


Figure 9: Mean dBCS per Herd from the beginning until the end of the project including the central line (mean) and three control limits (1-2-3sigma lines).

The central line represents the target value of dBCS (>3). The mean dBCS of Herd 1 shows an increase from October to November, with one point outside the lower 1-sigma line. This indicates a possible out-of-control case, were one or more animals fall below the standard variation of the Herd.

Herd 2 shows a similar increase to Herd 1 from the end of November, until the end of December, followed by a steep increase in mean dBCS during January. The dBCS remained constant untill the end of February, followed by a steep decrease. In March, the mean dBCS is decreased until April were it falls in the target central line. At the end of April, the mean dBCS shows a large increase in value (approx. 0.25 points). In total there are four points outside the upper 1-sigma line, meaning that one or more animals have a higher score than the standard variation of the Herd.

Even though Herd 3 shows an increase in dBCS duting May, all points fall outside the lower 1-sigma line with one point almost reaching the 2-sigma line.

Sub-study 3

The descriptive analysis of the data can be found in Table 13. The generalized linear model showed that none of the variables were statistically significant for Fatness or Shape ($p>0.05$) (Table 14). For Fatness, 10 animals were categorized as 'normal' with a scoring of 3, and three animals were categorized as 'good' with a scoring of 4. For Shape, nine animals were categorized as 'good' with a score ranging from seven to nine (-R, R, +R) and four animals were catgorized as 'very good' with a score ranging from 10 to 12 (-U, U, +U). The respective plots can seen in Figures 10, 11, 12 and 13. These plots were created in order to have a better understanding of the variation of the mean indicator scores and the mean dBCS for each animal that was given the same score of Fatness or Shape.

Table 13: Descriptive analysis of the data.

Carcass Scoring	**No of animals**	**Percentage (%)**
	Category Fatness	
Normal (3)	10	76.92%
Good (4)	3	23.08%
	Category Shape	
Good (R)	9	69.23%
Very Good (U)	4	30.77%

Table 14: Results of the generalized linear model.

Indicator	*P-value (confidence interval 95%)*
Round	0.397*
Dewlap	0.760*
Shoulder Bone	0.153*
Coat	0.239*
Rumen Fill	0.8*
dBCS	0.141*
Age	0.190*
Chilled Carcass Weight	0.213*

*not statistically significant

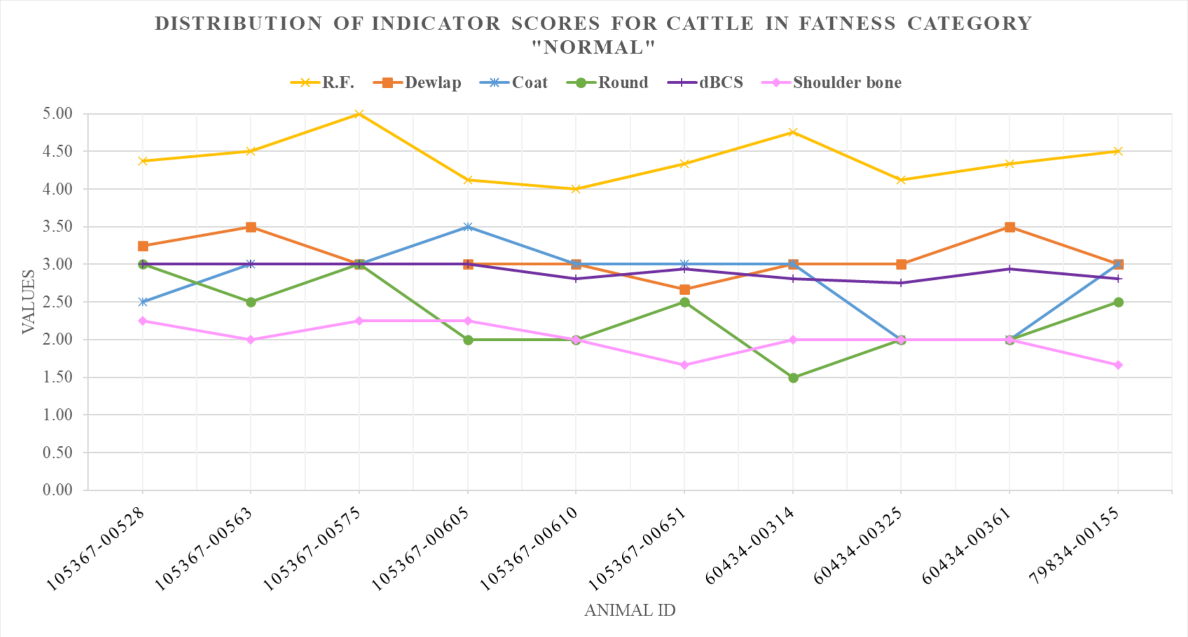


Figure 10: Mean indicator scores and mean dBCS of each animal in Fatness category ‘normal’.

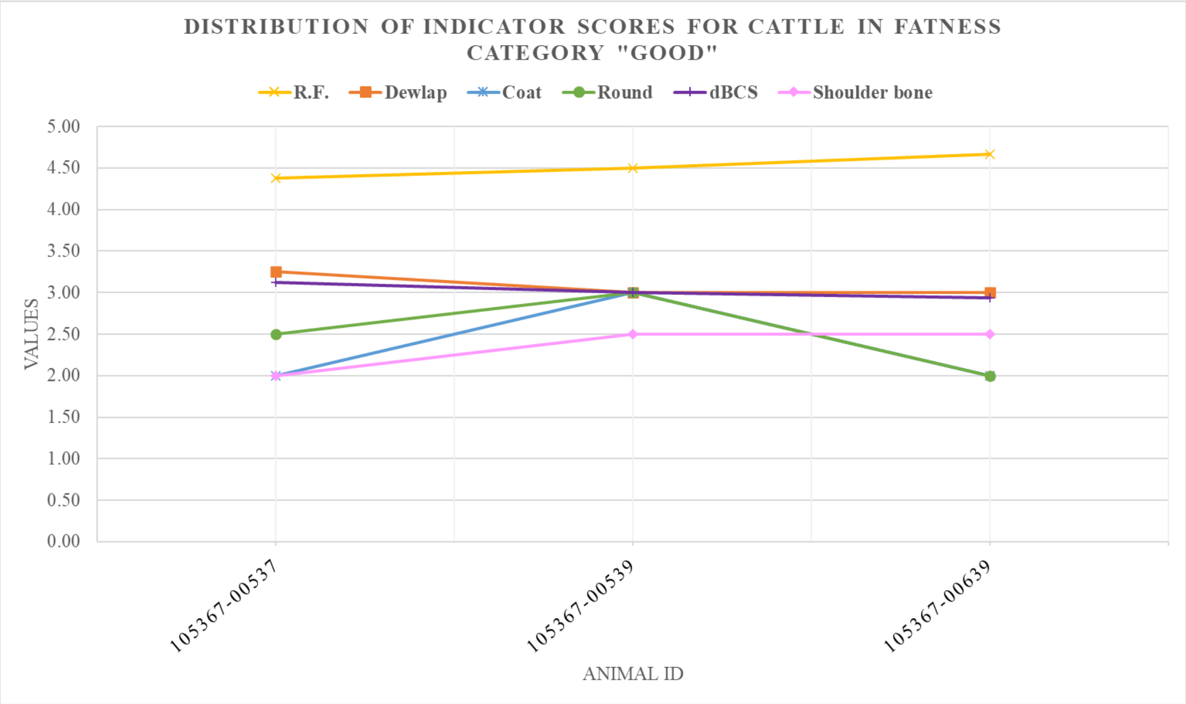


Figure 11: Mean indicator scores and mean dBCS of each animal in Fatness category ‘good’.

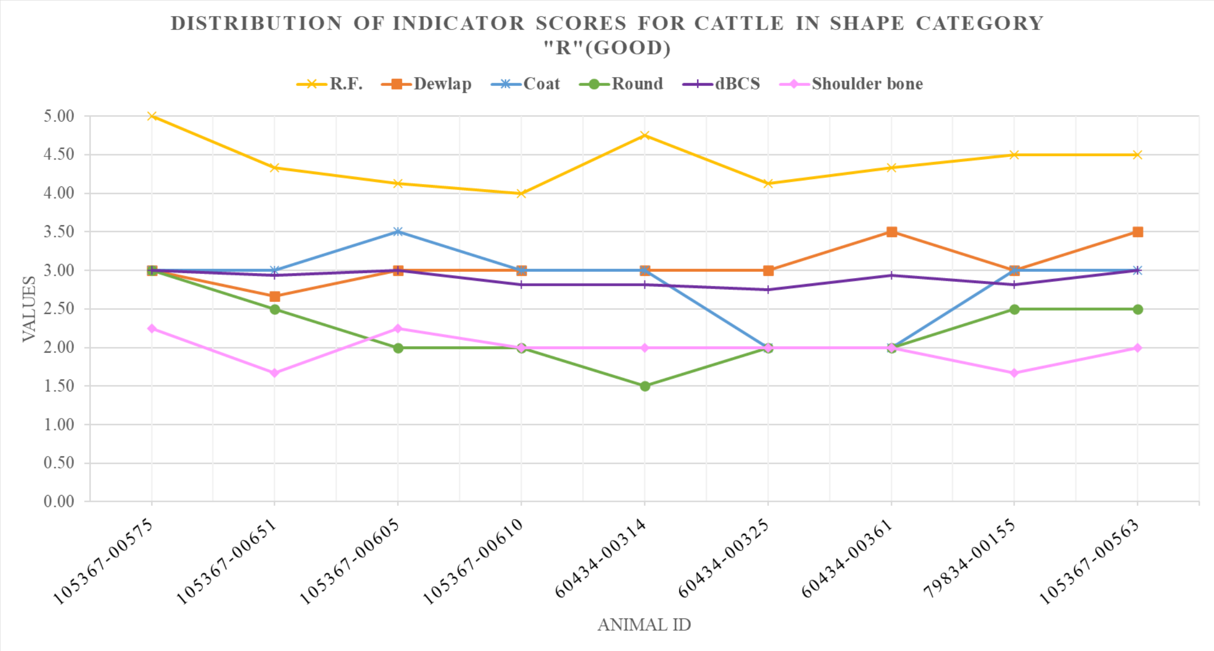


Figure 12: Mean indicator scores and mean dBCS of each animal in Shape category ‘good’ (-R, R, +R).

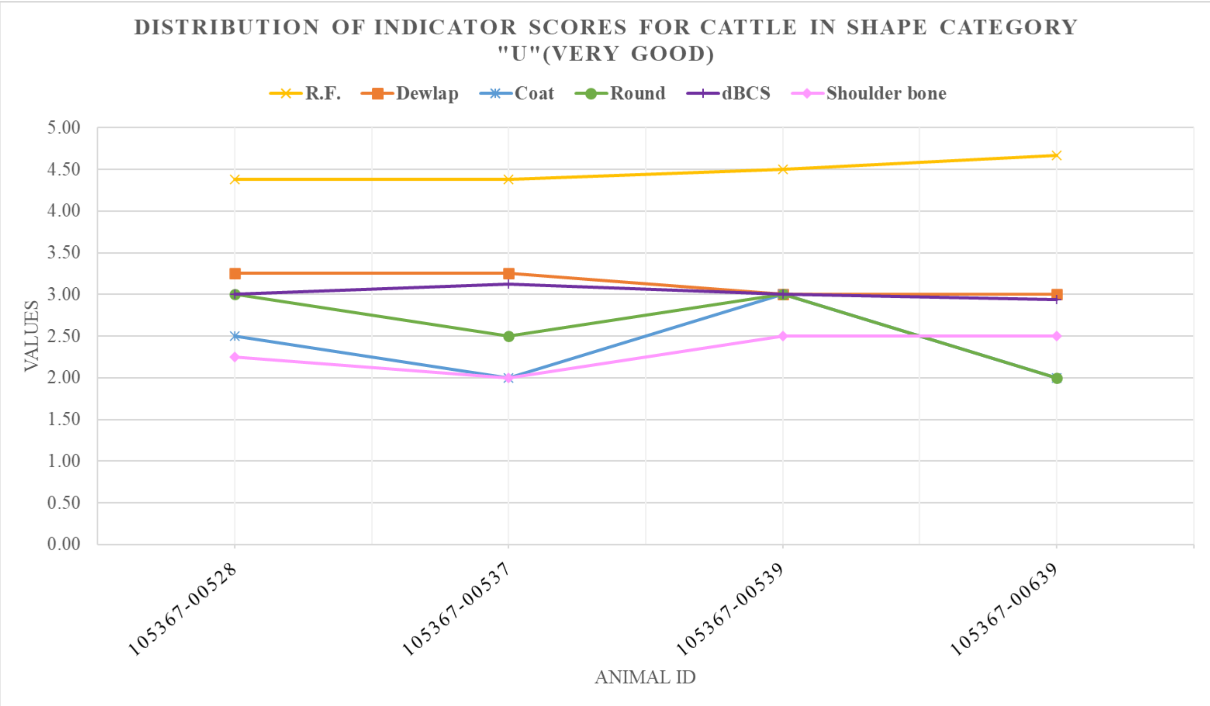


Figure 13: Mean indicator scores and mean dBCS of each animal in Shape category ‘very good’ (-U, U, +U).

Chapter 4: Discussion

In this chapter, the Results of the project are discussed, analysed, and compared to other similar studies. Limitations and future perspectives are also discussed, including the conclusion of the thesis.

4.1 Sub-study 1

4.1.1 Indicators

Based on the statistical analysis, two out of the five Indicators were significant in the final dBCS (Dewlap and Shoulder Bone) which, in practice, were the most difficult areas to score. One of the biggest challenges was the thick coat and the animals' semi-wild behaviour. More specifically, the long hair surrounding the area, in combination with the animals' movement of the neck (standing straight/grazing, turning to keep eye-contact), made it almost impossible to photograph the area and assess the fulness of the Dewlap or score the Shoulder Bone (Aubé et al., 2022; Zielke et al., 2018). This problem became more manageable as time progressed, and the master student adapted to the animals' behaviour and the surrounding area, meaning that with experience and practice, the scoring process and the final dBCS becomes more accurate (Kristensen et al., 2006). On the other hand, if the selected indicator is effectively representative of the BCS, the influence of individual expertise on the scoring process diminishes and results in minimum variation of BCS among assessors (Edmonson et al., 1989; Ferguson et al., 1994).

Round was found borderline ($p=0.051$) significant when it comes to dBCS and can potentially be replaced by a different area of interest in the same region on the animals body (rear), like Tail Head, Hooks and Pins (Edmonson et al., 1989; Soares & Dryden, 2011; Zielke et al., 2018). Some studies suggest that a combination instead of replacement of indicators could possibly increase the credibility of the final assessment (Rousing et al., 2001). Despite the semi-wild nature of the cattle, the rear can be viewed relatively easily, in comparison to Dewlap and Shoulder Bone, as the animals' movement does not disturb the scoring process, and the area has distinctive features for assessing the body condition such as prominent bones of the hip area. Furthermore, even though the area is covered in thick coating, the hair lies mainly flat, and there are small observable differences between a wet and a dry animal. Coat and R.F. were also not statistically significant for the final dBCS, which is contradictory to the results of a study by Edmonson (1989) et al where R.F. was significant. In another study, Coat was also used to assess the body condition of Bali cattle but was eliminated from the final BCS for simplicity reasons (Soares & Dryden, 2011). In this project, Coat seemed to have no effect on body condition scoring but still presented problems in assessing the animals even more so, due to their living conditions (year-round grazing).

4.1.2 Distant Body Condition Score

Originally, only Herd 1 and 2 were going to be scored and observed during the project. When the new animals arrived in April, there were clear differences in body condition, compared to the two original Herds, with a mean dBCS of 2.79, 2.95 for Herd 1 and 3.14 for Herd 2. The new Herd was comprised of older heifers, compared to Herd 1, and it was brought to Amager from a year-round feeding farm, were the animals also grazed outside. The animals seemed very thin, with low coat quality (matted hair on hind legs) and were very difficult to approach. Finally, this Herd included three steers, which were significantly smaller in size than the females. For these reasons, Herd 3 was included in the project (increase of variation).

Body conditioning without the ability to palpate the animal, can be very challenging, specifically when it comes to long-haired breeds, and even more so for rewilding animals. Despite these challenges, none of the observed animals were given a lower score than 2.5 (mostly Herd 3) or a higher score than 3.5 (only one heifer). In Figure 8, the distribution of dBCS scorings can be observed throughout the duration of the project for each Herd. The overwintering animals (Herd 2) seemed to adapt well to their environment and were able to sustain their physique throughout the winter without supplementary feeding, with a dBCS ranging from 2.75 to 3.5. Nevertheless, these results are not representative of a larger herd, or a different size pasture and can be a matter of further discussion; the collaborating veterinarian who visited the animals in March, consulted the caretakes to start supplementary feeding of the smallest heifer, which was given a score of 2.75. The master student scored the animal differently (dBCS=3), which shows that the final scoring can vary among observes (Edmonson et al., 1989; Ferguson et al., 1994; Kristensen et al., 2006). Furthermore, supplementary feeding in naturalist grazing programs can have many negative impacts such as changes in feeding habits, behaviour, genetics as well as transmission of diseases and parasites (Milner et al., 2014). Further research is required to determine whether or not a dBCS is an appropriate way to monitor prolonged hunger in rewilding animals (any form of rewilding) (Matthews et al., 2012).

4.1.3 Welfare Quality® Assessment

There seems to be a positive correlation between the scores obtained by the WQA and the dBCS; an increase in dBCS corresponds to an increase in WQA with similar SD in Herds 1 and 2. Herd 3 on the other hand, showed lower mean scores of WQA with larger SD, but higher mean dBCS scores with lower SD, indicating limitations in the protocol. The WQA was developed to assess one or multiple welfare criteria of indoor beef cattle on a mass production scale. The final score serves as a comprehensive evaluation of the animal's BCS, and the percentage of lean animals, serves as a herd level assessment. However, this approach may not be suitable for rewilding purposes (naturalist grazing)(Aubé et al., 2022), where an accurate scoring of individual BCS is essential for monitoring acute and/or prolonged hunger. More specifically, there can be cases of misrepresentation of thin animals, were a score of 2 (satisfactory) is given according to the WQA but, in reality, the animal is thin (BCS of 2.5). Consequently, the statistical analysis between these two values and making direct comparisons proved challenging. Finally, the Welfare Quality® Assessment Protocol has been compared to other protocols (Andreasen et al., 2023), and other limitations have been observed.

4.2 Sub-study 2

There was a steady increase in dBCS for Herd 1 (Figure 9), gaining an average score of 0.25 from the beginning of the study in October until the slaughtering date in November 2022. During October, one-point falls outside the lower 1-sigma control limit, raising an alarm, indicating a larger variation in dBCS among the individual animals of the herd. This indication is representative of the herd, as there were animals that were scored with a 2.75 throughout October, whilst the majority showed an increase in dBCS, reaching a score of 3. The animals were social within and outside the herd, with no excessive amount of fighting or display of fear towards people. The herd usually moved and acted as a group, and spend most time grazing, ruminating or resting, which is in agreement with the results of other behavioral studies (Geven & de Graaf, 2014; Kilgour, 2012). There was no clear hierarchical chain, but there was obvious competition between the larger animals; scratching on a tree, licking the saltlick, interacting with caretaker and master student or the public.

Herd 2 followed the same steady increase in dBCS as Herd 1, from November to December where the herd was relocated to the next pasture along with six horses. The mean dBCS increases even more (approximately 0.25) in the beginning of January and remains the same until the beginning of February, 2023. This increase places the entire herd outside the upper 1-sigma control limit, raising an alarm, indicating the collective (entire herd) deviation from the target dBCS. This outcome can potentially be explained by the relocation to the new pasture where there were no animals grazing since the beginning of the year and there was plenty of available feed. Furthermore, according to a study by Gilhaus and Hölzel (2016), the nutrient value of nutrient-rich pastures remains sufficient until the beginning of winter and biomass quantity showed no seasonal differences (Gilhaus & Hölzel, 2016), which potentially allowed the small herd of five heifers to grow in dBCS. Initially, the animals showed signs of stress during the first scoring days, which could be explained by the relocation and sudden appearance of the horses. As the weather conditions deteriorated (constant rain, snowing, excessive wind) the animals started to become more alert and more aggressive; even though the animals were familiar with the master student, they would constantly maintain eye contact and would not allow to stand behind them (always facing the observer). They were anxious in the presence of people, and they would run if approached (keeping a distance of approximately 5 meters). The animals would graze in close proximity but would keep a larger distance than that observed in November and show minimum to no social interaction with each other. During February 2023, the dBCS reverts to a lower score and keeps decreasing until end of March. During that time, the animals were again relocated to the next pasture, along with the six horses. This pasture had large areas that were unreachable by the master student and the animals had to walk longer distances to graze or find feed. Even though SH will travel long distances to find feed and are very versatile when it comes to feed selectivity (Pauler et al., 2020), these animals are still semi-wild (raised in a year-round feeding farm) and probably not as accustomed to finding feed under challenging circumstances. The herd was observed grazing as one unit, which is contradictory to the results of Geven & de Graaf (2014) were distance while grazing was age and status dependent (hierarchical chain). In April, the animals started to show aggressive behaviour, mostly towards the smallest member which led to an increase in grazing distance between the animals; on the 13th of April, only one heifer could be found (oldest animal). This behaviour could be connected to the limited available resources, as it is otherwise contradictory to other behavioral studies for SH (Geven & de Graaf, 2014), were the animals are the most social during spring. Finally, this behaviour could also be connected to the supplementary feeding of the smallest heifer, that made all herd members more people focused.

The steep decrease in dBCS observed in the end of April, represents the new animals (Herd 3) and despite their origin and age, their dBCS were significantly different than that of Herd 1 and 2. The mean dBCS falls close to the lower 2-sigma control limit indicating a medium size deviation from the target dBCS. In a short period of time (less than a month) the animals showed an increase in dBCS which can potentially be explained by the fact that the pasture on which they were placed was not used since November (no grazing pressure) (Fløjgaard et al., 2021) and the grass had grown (spring) (Gilhaus & Hölzel, 2016). Even though the animals seemed to be thriving on the field, the mean dBCS was still low, and under the 1-sigma control limit, indicating a larger variation of dBCS scoring among the individual animals. Again, this is representative of Herd 3, as most of the animals had a low dBCS (2.5) that increased with time, but still was under the target dBCS (raised to a 2.75). Along with the dBCS increase, the new animals became less fearful with every visit, but still maintaining a distance of approx. 3 meters. The overwintering animals showed strong territorial behaviour towards the new animals and would keep a large distance when grazing. This behaviour seemed to change after approximately 3 weeks, where all cattle seemed to be grazing together.
This method of monitoring animals longitudinally is commonly used for out-of-control observations. Since the control limits are calculated based on the observed animals and the SD of the herd, this method of monitoring can be specifically tailored for the needs of the herd or the respective needs of the farmer and/or veterinarian. Depending on the number of points (observations) that lay outside these limits, and depending on the observed subject, very small and very large deviations from the mean can be seen, along with potential patterns of the data (Montgomery, 2009). Furthermore, control charts are a relatively simple way of observing data; commonly used to differentiate between normal variation (data points fall within the control limits) and non-random variation (data points fall outside the control limits), control charts can be used in making comparisons between past and present observations and/or between herds (Montgomery, 2009).

4.3 Sub-study 3

For the relation between body composition and dBCS, the 13 slaughtered animals were given a carcass classification score. Colour was not included in the statistical analysis (more under limitations).

All carcases seem to fall within two classes for each category, despite the differences in weight. The most noteworthy example was the carcass weighing 126kg, which was covered evenly in tallow and the ribs were surrounded by fat; this heifer, started with a dBCS of 2.75 and reached a 3 by the last scoring (six days before slaughter). Even though she was within the target dBCS, she was shorter and smaller in size compared to the rest of the herd. Her size and to a lesser extent, her personality, where the main reasons for not keeping her during the winter. This discrepancy can potentially be explained by the results of a study by Gregory et al (1998) where high scoring animals in BCS had lean carcasses which appears contradictory to the correlation between BCS and body fatness, i.e. a low BCS identifies a lean cow (Gregory et al., 1998).

Apart from three heifers (105367-00537;105367-00539;105367-00639) that were scored U (very good) for Shape and 'good' for Fatness, the remaining animals were scored as R (good) and 'normal' respectively (heifer 105367-00528 scored U in Shape). The indicator scorings (Figures 10,11,12,13) are of similar values between the animals in the same category, except for Round and Coat where the values differ by 0.5 to 1.5. The distribution of R.F. scorings is almost identical for the high scoring carcasses (ranging from 4.45 to 4.55) for both categories, whereas the lower scoring carcasses have multiple values (ranging from 4 to 5). Despite these differences, the dBCS is similar for all carcasses in each category; 3 to 3.05 for high scoring carcasses and 2.75 to 3 for lower scoring carcasses. These results appear to place animals with a dBCS >3 in a higher class and animals with a dBCS of ≤3 to a lower class. These results seem to be in agreement with the findings by Shemeis et al (1994) and Apple et al (1999), where carcass quality was better for high dBCS scores in dairy cattle (Apple, 1999; Shemeis et al., 1994).

Limitations and future perspectives

Sub-study 1

The small size of the Herds limited the variation of indicator scorings and with no intra-observer agreement studies taking place, the validity of the chosen indicators and their effect on the final dBCS scoring requires more research. There is a lack of case studies when it comes to long-haired breeds of cattle and with no known BCS guide or detail description of body composition of SH, made the assessment even more challenging.

The need for evaluating the potential indicators in practice, limited the amount of collected data, resulting in no scorings for Round and Coat until week six of the project. Future studies

should consider testing all potential indicators prior to the beginning of the official scoring, to ensure that each one can be scored and observed easily (Rousing et al., 2001), under all weather conditions. Finally, for weather conditions like Denmark, both the indicator and the scoring method need to be simple and quick, as heavy rain and frozen mud can limit the observer's ability to see clearly or walk. Taking photographs of all areas of interest is crucial, as they help assessing the animal at a later time and under more favorable conditions.
The final dBCS guide is limited to four scorings (2.5-3.25) as no other scores were observed, due to small variation among the individual animals. Most of the dBCS scores were given after the visit and were based on the obtained photographs, as in most visits it was raining and the scoring equipment was getting wet, or it was impossible to reach the animals due to obstacles (deep water, tree roots etc.). Having to use two independent scoring protocols took a lot of time and the animals were not always cooperating or patient with the observer. Lastly, as the focus of the project was the dBCS and accurate scoring, there was a lack of useable photographs, as most time was spent on scoring and observing. Future studies should consider photographing the animals first, and then proceed to the scoring, as both weather conditions and the animal's behaviour, can suddenly change.

Sub-study 2

The herd level assessment chosen for this project was limited due to the focus on body condition scoring, and only the health status and social behaviour were examined. No animals presented signs of injuries and mostly acted and moved as a group. Furthermore, only a few aspects of appropriate behaviour were considered and served more as method of better understanding the dynamics of the herd under naturalist grazing conditions in Denmark. Future studies that include observations of behaviour under similar conditions, should consider observing the herd closely, prior to the herd assessment, and should include a larger number of animals, and a larger variety of individuals (not only heifers). Finally, the suggested method for monitoring the dBCS longitudinally, requires some level of knowledge in order to be executed successfully, and requires a steady collection of data which might prove inappropriate for rewilding purposes.

Sub-study 3

In retrospect, the classification should have taken place on location; the freezer walk-in area was relatively small for the number of carcasses that were stored, and it proved difficult to manoeuvre and handle the carcasses and take proper photos at the same time. Due to lack of space, the angle was not very wide, and it was impossible to take one picture to showcase the entire half of the carcass. Because of this difficulty, all pictures used to score Fatness, and half of the pictures used to score Shape, were taken using panoramic shots. The lighting was not ideal, which led to difficulties assigning the proper score for Colour. The biggest limitation during the carcass classification was the lack of observer experience. With only theoretical knowledge about carcass classification, combined with the poor-quality photographs, the final scoring was very challenging. Future studies should consider having training sessions for carcass classification or should include experts that either assist or assign the final scoring. Finally, carcass classification could be combined with other methods of carcass analysis, for obtaining more accurate results such as assessing muscle mass, fat thickness, dry matter content etc (Shemeis et al., 1994).

Conclusion

Objective 1:

Based on the outcome of this project, the animals seemed to adapt well to their environment, displaying both positive and negative behaviors. There were no signs of compromised welfare (absence of prolonged hunger, unnatural behaviors) but, some behaviors could be connected to signs of acute hunger. The final distant Body Condition Score (dBCS) guide is limited to four scorings (2.5-3.25) but could be used and developed in future similar projects, as it could be considered representative of the Danish conditions if larger variation is described.

Objective 2:

Based on the results and the master students' observations, the suggested scoring frequency of the herd is every second week (no observable changes in dBCS every week under present management conditions). For monitoring reasons, the suggested visiting frequency is every week, so that any behavioral changes can be observed (potential signs of acute hunger e.g. Rumen Fill, behavioral changes).

The need for human intervention for naturalistic grazing programs such as the one at Amager is clear, as the animals cannot move freely from pasture to pasture, and some level of forestry (Fløjgaard et al., 2021) is also required to minimize the environmental impact (Hansen et al., 2001) and to avoid injuries.

Creating control charts for monitoring cattle over time and the implementation of "alarms" is a common method of data observation. Despite the limited data, smaller and medium size deviations could be observed throughout the project. Finally, this method of monitoring needs to be tested again on a larger herd, with multiple dBCS scorings and a larger distribution of data points.

Objective 3:

Based on the results, it seems that dBCS is representative of the body composition, to a certain level; high scoring animals in dBCS were given higher carcass classification scores. The data was limited, and the scoring conditions were not ideal. Further research is required to have a better understanding of the relationship between dBCS and carcass quality.

References

1. AHDB. (2023, August 4). Using the EUROP grid in beef carcase classification. https://ahdb.org.uk/knowledge-library/using-the-europ-grid-in-beef-carcase-classification
2. Albertí, P., Panea, B., Sañudo, C., Olleta, J. L., Ripoll, G., Ertbjerg, P., Christensen, M., Gigli, S., Failla, S., Concetti, S., Hocquette, J. F., Jailler, R., Rudel, S., Renand, G., Nute, G. R., Richardson, R. I., & Williams, J. L. (2008). Live weight, body size and carcass characteristics of young bulls of fifteen European breeds. Livestock Science, 114(1), 19–30. https://doi.org/10.1016/j.livsci.2007.04.010
3. Andreasen, S., Sandøe, P., & Forkman, B. (2023). Can animal-based welfare assessment be simplified? A comparison of the Welfare Quality® protocol for dairy cattle and the simpler and less time-consuming protocol developed by the Danish Cattle Federation.
4. Apple, J. K. (1999). Influence of body condition score on live and carcass value of cull beef cows. Journal of Animal Science, 77(10), 2610. https://doi.org/10.2527/1999.77102610x
5. Aubé, L., Mialon, M. M., Mollaret, E., Mounier, L., Veissier, I., & de Boyer des Roches, A. (2022). Review: Assessment of dairy cow welfare at pasture: measures available, gaps to address, and pathways to development of ad-hoc protocols. Animal, 16(8), 100597. https://doi.org/10.1016/j.animal.2022.100597
6. Bakker, J. P. (1998). The impact of grazing on plant communities. In M. F. WallisDeVries, S. E. Van Wieren, & J. P. Bakker (Eds.), Grazing and Conservation Management (pp. 137–184). Springer Netherlands. https://doi.org/10.1007/978-94-011-4391-2_5
7. Banks, E.M., (1982). Behavioral research to answer questions about animal welfare. *Journal of Animal Science*, *54*(2), pp.434-446.
8. Bekendtgørelse af lov om dyrevelfærd (dyrevelfærdsloven), LBK nr 1597 af 08/07/2021 (2021). https://www.retsinformation.dk/eli/lta/2021/1597
9. Bokdam, J., van Braeckel, A., Werpachowski, C., & Znaniecka, M. (2002). Report of a Workshop held 22-26 April 2002 in Goniadz (PL).
10. Bussan, S. K. (2022). Can cattle grazing benefit grassland butterflies? Journal of Insect Conservation, 26(3), 359–374. https://doi.org/10.1007/s10841-022-00373-8
11. Corlett, R. T. (2016). Restoration, Reintroduction, and Rewilding in a Changing World. Trends in Ecology & Evolution, 31(6), 453–462. https://doi.org/10.1016/j.tree.2016.02.017

12. Cow Caretaker. (2022, August 26). Highland Cow: Guide, Info & Facts. https://cowcaretaker.com/highland-cow/
13. Department for Environment, Food & Rural Affairs, D. (n.d.). Condition scoring of beef suckler cows and heifers.
14. Edmonson, A. J., Lean, I. J., Weaver, L. D., Farver, T., & Webster, G. (1989). A Body Condition Scoring Chart for Holstein Dairy Cows. Journal of Dairy Science, 72(1), 68–78. https://doi.org/10.3168/jds.S0022-0302(89)79081-0
15. Ferguson, J. D., Galligan, D. T., & Thomsen, N. (1994). Principal Descriptors of Body Condition Score in Holstein Cows. Journal of Dairy Science, 77(9), 2695–2703. https://doi.org/10.3168/jds.S0022-0302(94)77212-X
16. Filliben, J. J. (1975). The Probability Plot Correlation Coefficient Test for Normality. Technometrics, 17(1), 111–117. https://doi.org/10.2307/1268008
17. Fløjgaard, C., Buttenschøn, R. M., Byriel, D. B., Clausen, K. K., Gottlieb, L., & Kanstrup, N. (2021). Biodiversitetseffekter af rewilding. Aarhus Universitet, nr 425, 124.
18. Garrido, P., Mårell, A., Öckinger, E., Skarin, A., Jansson, A., & Thulin, C.-G. (2019). Experimental rewilding enhances grassland functional composition and pollinator habitat use. Journal of Applied Ecology, 56(4), 946–955. https://doi.org/10.1111/1365-2664.13338
19. Geven, M., & de Graaf, E. (2014). A herd of Scottish Highland cattle (Bos taurus) in a semi-wild setting representing naturalness in behaviour.
20. Gilhaus, K., & Hölzel, N. (2016). Seasonal variations of fodder quality and availability as constraints for stocking rates in year-round grazing schemes. Agriculture, Ecosystems & Environment, 234, 5–15. https://doi.org/10.1016/j.agee.2016.03.013
21. Gordon, I. J., Pérez-Barbería, F. J., & Manning, A. D. (2021). Rewilding Lite: Using Traditional Domestic Livestock to Achieve Rewilding Outcomes. Sustainability, 13(6), 3347. https://doi.org/10.3390/su13063347
22. Gregory, N. G., Robins, J. K., Thomas, D. G., & Purchas, R. W. (1998). Relationship between body condition score and body composition in dairy cows. New Zealand Journal of Agricultural Research, 41(4), 527–532. https://doi.org/10.1080/00288233.1998.9513335
23. Hansen, B., Alrøe, H. F., & Kristensen, E. S. (2001). Approaches to assess the environmental impact of organic farming with particular regard to Denmark. Agriculture, Ecosystems & Environment, 83(1–2), 11–26. https://doi.org/10.1016/S0167-8809(00)00257-7

24. Helmer, W., Saavedra, D., Sylvén, M., & Schepers, F. (2015). Rewilding Europe: A New Strategy for an Old Continent. In H. M. Pereira & L. M. Navarro (Eds.), Rewilding European Landscapes (pp. 171–190). Springer International Publishing. https://doi.org/10.1007/978-3-319-12039-3_9
25. Hersom, M., & Thrift, T. (n.d.). How to Measure Body Condition Score in Florida Beef Cattle. Retrieved March 21, 2023, from https://edis.ifas.ufl.edu/publication/AN347
26. Highland Cattle Society. (2023). The Highland Breed. Highland Cattle Society. https://www.highlandcattlesociety.com/the-highland-cattle-breed
27. Humphrey, J. (Ed.). (1998). Grazing as a management tool in European forest ecosystems. Forestry Commission.
28. Isselstein, J., Jeangros, B., & Pavlu, V. (2005). Agronomic aspects of biodiversity targeted management of temperate grasslands in Europe – A review.
29. Jepson, P., Schepers, F., & Helmer, W. (2018). Governing with nature: A European perspective on putting rewilding principles into practice. Philosophical Transactions of the Royal Society B: Biological Sciences, 373(1761), 20170434. https://doi.org/10.1098/rstb.2017.0434
30. Jørgensen, D. (2015). Rethinking rewilding. Geoforum, 65, 482–488. https://doi.org/10.1016/j.geoforum.2014.11.016
31. Kauffman, J. B., Krueger, W. C., & Vavra, M. (1983). Impacts of Cattle on Streambanks in Northeastern Oregon. Journal of Range Management, 36(6), 683. https://doi.org/10.2307/3898184
32. Kilgour, R. J. (2012). In pursuit of "normal": A review of the behaviour of cattle at pasture. Applied Animal Behaviour Science, 138(1), 1–11. https://doi.org/10.1016/j.applanim.2011.12.002
33. Københavns Kogræsserlaug. (2015, March 31). Københavns Kogræsserlaug. Københavns Kogræsserlaug. https://kkgl.dk/
34. Kreaturer. (2023). Klassificeringskontrollen. https://klassificeringskontrollen.dk/kreaturer
35. Kristensen, E., Dueholm, L., Vink, D., Andersen, J. E., Jakobsen, E. B., Illum-Nielsen, S., Petersen, F. A., & Enevoldsen, C. (2006). Within- and Across-Person Uniformity of Body Condition Scoring in Danish Holstein Cattle. Journal of Dairy Science, 89(9), 3721–3728. https://doi.org/10.3168/jds.S0022-0302(06)72413-4
36. Lalman, D., Selk, G., & Stein, D. (2017). Body Condition Scoring of Cows. 4.
37. Lorimer, J., Sandom, C., Jepson, P., Doughty, C., Barua, M., & Kirby, K. J. (2015). Rewilding: Science, Practice, and Politics. Annual Review of Environment and Resources, 40(1), 39–62. https://doi.org/10.1146/annurev-environ-102014-021406

38. MacDonald, D., Crabtree, J. R., Wiesinger, G., Dax, T., Stamou, N., Fleury, P., Gutierrez Lazpita, J., & Gibon, A. (2000). Agricultural abandonment in mountain areas of Europe: Environmental consequences and policy response. Journal of Environmental Management, 59(1), 47–69. https://doi.org/10.1006/jema.1999.0335

39. Matthews, L. R., Cameron, C., Sheahan, A. J., Kolver, E. S., & Roche, J. R. (2012). Associations among dairy cow body condition and welfare-associated behavioral traits. Journal of Dairy Science, 95(5), 2595–2601. https://doi.org/10.3168/jds.2011-4889

40. Metera, E., Sakowski, T., Słoniewski, K., & Romanowicz, B. (2010). Grazing as a tool to maintain biodiversity of grassland – a review. 20.

41. Milner, J. M., Van Beest, F. M., Schmidt, K. T., Brook, R. K., & Storaas, T. (2014). To feed or not to feed? Evidence of the intended and unintended effects of feeding wild ungulates. The Journal of Wildlife Management, 78(8), 1322–1334. https://doi.org/10.1002/jwmg.798

42. Ministerium: Ministeriet for Fødevarer, Landbrug og Fiskeri, (2021). Bekendtgørelse af lov om dyrevelfærd (dyrevelfærdsloven).

43. Montgomery, D.C., 2009. *Statistical quality control* (Vol. 7). New York: Wiley.

44. Pauler, C. M., Isselstein, J., Berard, J., Braunbeck, T., & Schneider, M. K. (2020). Grazing Allometry: Anatomy, Movement, and Foraging Behavior of Three Cattle Breeds of Different Productivity. Frontiers in Veterinary Science, 7. https://www.frontiersin.org/articles/10.3389/fvets.2020.00494

45. Pettorelli, N., Durant, S. M., & Du Toit, J. T. (2019). Rewilding: A captivating, controversial, twenty-first-century concept to address ecological degradation in a changing world. In N. Pettorelli, S. M. Durant, & J. T. Du Toit (Eds.), Rewilding (1st ed., pp. 1–11). Cambridge University Press. https://doi.org/10.1017/9781108560962.001

46. Roberts, J., 1905. *Highland Cattle*. US Department of Agriculture, Bureau of Animal Industry.

47. Roche, J. R., Friggens, N. C., Kay, J. K., Fisher, M. W., Stafford, K. J., & Berry, D. P. (2009). Invited review: Body condition score and its association with dairy cow productivity, health, and welfare. Journal of Dairy Science, 92(12), 5769–5801. https://doi.org/10.3168/jds.2009-2431

48. Rook, A. J., Dumont, B., Isselstein, J., Osoro, K., WallisDeVries, M. F., Parente, G., & Mills, J. (2004). Matching type of livestock to desired biodiversity outcomes in pastures – a review. Biological Conservation, 119(2), 137–150. https://doi.org/10.1016/j.biocon.2003.11.010

49. Rousing, T., Bonde, M., & Sørensen, J. T. (2001). Aggregating Welfare Indicators into an Operational Welfare Assessment System: A Bottom-up Approach. Acta Agriculturae Scandinavica, Section A — Animal Science, 51(sup030), 53–57. https://doi.org/10.1080/090647001300004790

50. Rupprecht, D., Gilhaus, K. & Hölzel, N. (2016). Effects of year-round grazing on the vegetation of nutrient-poor grass- and heathlands—Evidence from a large-scale survey. Agriculture, Ecosystems & Environment 234; 16–22. https://doi.org/10.1016/j.agee.2016.02.015

51. Russell, J. R., Betteridge, K., Costall, D. A., & Mackay, A. D. (2001). Cattle treading effects on sediment loss and water infiltration. JOURNAL OF RANGE MANAGEMENT.

52. Sandøe, P., Gamborg, C., & Palmer, C. (2022). 23. Will the use of domesticated animals in rewilding projects compromise animal welfare? Transforming Food Systems: Ethics, Innovation and Responsibility, 159–164. https://doi.org/10.3920/978-90-8686-939-8_23

53. Sandom, C., Donlan, C.J., Svenning, J.C. and Hansen, D., 2013. Rewilding. Key topics in conservation biology 2, pp.430-451.

54. Schweiger, A. H., & Svenning, J.-C. (2020). Analogous losses of large animals and trees, socio-ecological consequences, and an integrative framework for rewilding-based megabiota restoration. People and Nature, 2(1), 29–41. https://doi.org/10.1002/pan3.10066

55. Selk, G., 2004. Body condition scoring of beef cows. Oklahoma Cooperative Extension Service.

56. Shemeis, A., Liboriussen, T., Andersen, B., & Abdallah, O. Y. (1994). Changes in carcass and meat quality traits of Danish Friesian cull cows with the increase in their age and body condition. Meat Science, 37, 161–167. https://doi.org/10.1016/0309-1740(94)90077-9

57. Soares, F. S., & Dryden, G. McL. (2011). A Body Condition Scoring System for Bali Cattle. Asian-Australasian Journal of Animal Sciences, 24(11), 1587–1594. https://doi.org/10.5713/ajas.2011.11070

58. Spigarelli, C., Zuliani, A., Battini, M., Mattiello, S., & Bovolenta, S. (2020). Welfare Assessment on Pasture: A Review on Animal-Based Measures for Ruminants. Animals : An Open Access Journal from MDPI, 10(4), 609. https://doi.org/10.3390/ani10040609

59. Svenning, J.-C., & Faurby, S. (2017). Prehistoric and historic baselines for trophic rewilding in the Neotropics. Perspectives in Ecology and Conservation, 15(4), 282–291. https://doi.org/10.1016/j.pecon.2017.09.006

60. Svenning, J.-C., Pedersen, P. B. M., Donlan, C. J., Ejrnæs, R., Faurby, S., Galetti, M., Hansen, D. M., Sandel, B., Sandom, C. J., Terborgh, J. W., & Vera, F. W. M. (2016). Science for a wilder Anthropocene: Synthesis and future directions for trophic rewilding research. Proceedings of the National Academy of Sciences of the United States of America, 113(4), 898–906. https://doi.org/10.1073/pnas.1502556112
61. Tallowin, J. R. B., Rook, A. J., & Rutter, S. M. (2005). Impact of grazing management on biodiversity of grasslands. Animal Science, 81(2), 193–198. https://doi.org/10.1079/ASC50780193
62. van Klink, R., Ruifrok, J. L., & Smit, C. (2016). Rewilding with large herbivores: Direct effects and edge effects of grazing refuges on plant and invertebrate communities. Agriculture, Ecosystems & Environment, 234, 81–97. https://doi.org/10.1016/j.agee.2016.01.050
63. Vavra, M., 2004. Biodiversity: Grazing Management. Encyclopedia of Animal Science (Print), p.127.
64. Wallis De Vries, M. F., Parkinson, A. E., Dulphy, J. P., Sayer, M., & Diana, E. (2007). Effects of livestock breed and grazing intensity on biodiversity and production in grazing systems. 4. Effects on animal diversity. Grass & Forage Science, 62(2), 185–197. https://doi.org/10.1111/j.1365-2494.2007.00568.x
65. WARDA M., ROGALSKI M., 2004 – Grazing animals as an element of natural landscape. Annales of Univeristy of Maria Curie Sklodowska, Sec. E, 59(4), 1985-1991.
66. Webster, J., 1994 Animal Welfare-A Cool Eye Towards Eden; Blackwell Science: Oxford, UK, 1994.
67. Winckler, C. (2019). Assessing animal welfare at the farm level: Do we care sufficiently about the individual? Animal Welfare, 28(1), 77–82. https://doi.org/10.7120/09627286.28.1.077
68. Zielke, L., Wrage-Mönnig, N., & Müller, J. (2018). Development and Assessment of a Body Condition Score Scheme for European Bison (Bison bonasus). Animals, 8(10), 163. https://doi.org/10.3390/ani8100163

Appendix

A. Indicator scoring (individual assessment)

Individual assessment of Highlanders / (number of animals)/(herd number)									
Ear tag	Comments	Back	Left Side	Body	Dewlap		Date		
		Round	R. F.	Coat	Depth/ No folds	Shoulder bones	Time	Location	Comments

B. Welfare assessment based on the WQA, including final dBCS.

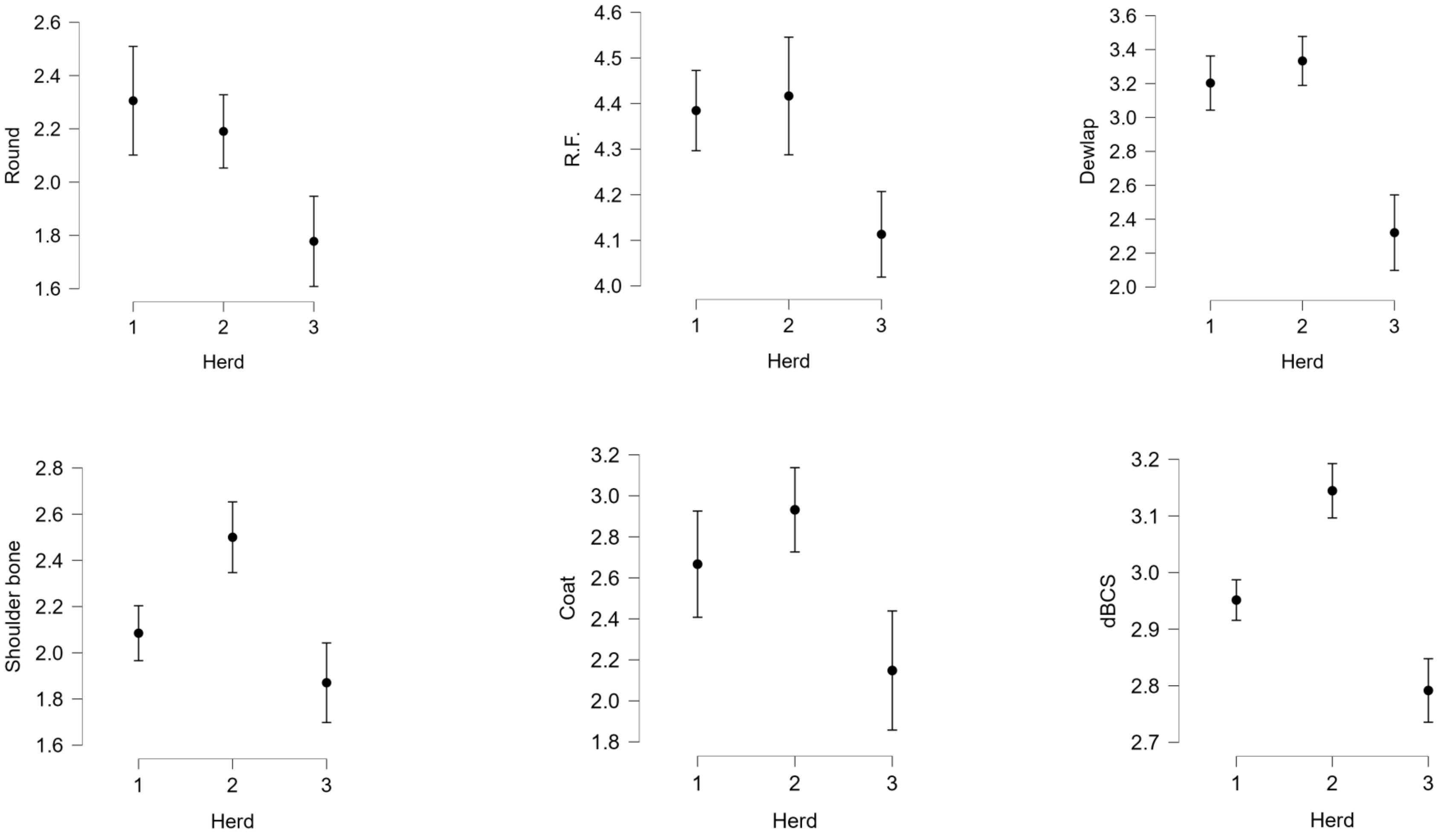
Ear tag	BCS based on welfare quality assessment			Total score of WQA	dBCS
	Tail Head	Loin	Vertebrae		

Scoring based on the Welfare Quality® Assessment (++/+ /-/--)

C. **Herd assessment**

Herd Assessment / Date: Location:		No animals observed: Time frame:	Comments
Social Behavior	Grazing		
	Ruminating		
	Sleeping		
	Interaction with other animals/observer		
Injuries	Type of injury		
	Severity of injury		
Hygiene			

D. Interval plots of the chosen indicators and dBCS per Herd



E. **List of chosen indicators, location on the body, definition of each indicator, description of the area and scoring scheme**

Location	*Front*	*Back*	*Left Side*	*Body*
Indicator and priority	Dewlap and Shoulder definition (Primary)	Round (Primary)	Rumen Fill (Secondary)	Coat quality (Secondary)
Definition	Dewlap: A long fold or flap of skin extended from under the head to the brisket Shoulder: or Point of Shoulder, greater and lesser tubercle (vet-Anatomy, no date).	Area of the hind legs, divided into top round, eye of round and bottom round	Fulness of the rumen, observed from the left side of the animal	Thick, double coat, comprising a downy undercoat and outer hair that could be 13 inches long (≈33cm) (Cow Caretaker, 2022)
Description	Dewlap: Fulness, number of observed folds Shoulder bone: Visibility under coat when animal is standing straight/grazing	Fulness, compared to the tail bone and pin head	Fulness of the rumen	Appearance (matted, coarse, fluffy and shiny, observable patches), texture, and length

Scoring Scheme	*Dewlap*	*Round*	*Rumen Fill*	*Coat*
	- -1 = the skin is not stretched, multiple small flaps can be observed (e.g., 4-5), neck area narrow, area in front of brisket not filled in, not prominent (1) -1 = the skin is a little stretched, bigger flaps can be observed (e.g., 3-4), neck area less narrow, area in front of brisket a little filled in, area a little prominent (2) + 1 = the skin is a more stretched, some flaps can be observed (e.g., 2-3), neck area less narrow, area in front of brisket a little filled in, area a little prominent (3) + 2 = the skin is more stretched creating two big flaps of skin, neck area less narrow, area in front of brisket more rounded, more prominent (3)	-= area less curved, tail bone more prominent (1) + = area curved; tail bone not as prominent (2) + + = area rounded and prominent, tail bone not prominent (3)	Scoring modified and based on the Rumen Fill guide for Dairy cattle, (Agriculture and Horticulture Development Board 2020) with added intervals of 0.5. 1: Deep dip in left flank, more than one hand width deep after last rib. 2: Dip in left flank, one hand width deep after last rib. 3: Slight dip visible in left flank, after last rib. 4: No dip is visible in left flank, after last rib. 5: Skin is flat, or slightly bulging, on the left flank, after the last rib.	4 = fluffy, long and shiny 3 = fluffy and long, not as shiny 2 = long, rough, not shiny 1 = fluffy, short, not shiny 0 = matted, rough, not shiny

Scoring scheme	+ + 1 = the skin is stretched (no visible flaps), neck area well rounded, area in front of brisket well rounded (4)			
	Shoulder Bone -= the bone is prominent, clearly visible under the coat when the animal is standing straight (1) + = the bone is visible but not prominent under the coat when the animal is standing straight (2) ++ = the bone is not visible under the coat when the animal is standing straight, visible when animal is grassing (3)			