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# Influence of space availability and weather conditions on shelter use by beef cattle during winter

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ABSTRACT

The objective of this experiment was to evaluate shelter use by beef cattle in relation to space allowance per individual and weather conditions. Nine groups of Angus cattle (n = 35 in total, 3–6/group) were kept on paddocks with a squared shelter (5 × 10 m) with an open long side. In a 3 × 3 crossover design, three experimental treatments were tested based on national recommendations: 1) 100% of the recommended $m^2$/individual (4 $m^2$ per adult), 2) 150% (6 $m^2$ per adult) and 3) 200% (8 $m^2$ per adult). The shelter area was fenced off according to treatment and the number and size of animals in each group. Shelter use was estimated from pictures taken every 15 min with infrared trail cameras placed in all shelters. When the available space per individual was 100% of the recommended space, the shelters were used less compared to when 150% and 200% of the recommended space was available (e.g. percentage of pictures where all animals were inside the shelter (*%all_animals*): $P < 0.001$). There was a significant effect of weather conditions on shelter use (e.g. *%all_animals*; chill factor index: $P = 0.03$, and precipitation: $P = 0.006$), i.e. the shelters were used more with decreasing chill factor index and with increased precipitation. In conclusion, beef cattle increased their use of the shelters when the space allowance per individual increased with 50% or 100% compared to the current, national recommendations; e.g. simultaneous use by a whole group doubled with increased space. Furthermore, cold and wet weather increased shelter use.

## 1. Introduction

During winter, cattle housed outside are exposed to cold, rainy and windy conditions and might, therefore, benefit from protection by natural vegetation or artificial shelters. In general, beef cattle breeds such as Angus Aberdeen, in good body condition and health, can tolerate low ambient temperatures without being in risk of cold stress (Webster, 1970). This cold resistance depends on the combined effect of the individuals' own heat production and its insulation by fat tissue and fur coat. However, wind lowers the insulating effect of the fur coat and increases heat loss by transduction, which can be exacerbated by rain as heat loss is increased from wet skin (Schütz et al., 2010). Previous studies have shown that outdoor-wintered beef cattle increase their use of protected areas during times with precipitation, lower temperatures and increased wind speed (Graunke et al., 2011; Van laer et al., 2015). Thus, cattle kept in areas with limited natural protection against wind and rain might benefit from a well-designed shelter to mitigate the risk of cold stress. Indeed, lying is a highly prioritised need in cattle, and limited access to proper lying areas can have a negative effect on animal welfare (Ekesbo, 2011; Munksgaard et al., 2005). Artificial shelters should, therefore, be large enough to provide such lying areas for the entire group simultaneously.

According to Danish recommendations, a shelter should provide a minimum space of 4 $m^2$ per adult individual (> 500 kg) (Table 1; SEGES, 2016). However, these recommendations have not been investigated scientifically, and it remains unknown whether the recommended space is sufficient for all animals in a group to lie down simultaneously.

The objective of this experiment was to evaluate the effect of space allowance on shelter use. The prediction was that increased space allowance per individual would increase simultaneous use by all animals in a group. An additional objective was to investigate the effect of temperature, wind speed and precipitation on the use of artificial shelters in an area without access to protection by natural vegetation.

## 2. Materials and methods

### 2.1. Subjects

The data collection took place in a private Angus herd in Jutland, Denmark. A total of 35 animals were included. Of these, 9 were heifers,

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**Table 1**
Recommendations for cattle on minimum space allowance per individual in shelters for outdoor winter housing of cattle (SEGES, 2016).

| Body weight, kg | < 60 | 60–100 | 100–150 | 150–200 | 200–300 | 300–400 | 400–500 | > 500 |
|---|---|---|---|---|---|---|---|---|
| Minimum shelter area ($m^2$/individual) | 1.2 | 1.4 | 1.7 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 |

**Table 2**
Overview of animals in each group in each of the three periods.

| Group | Animals | | |
|---|---|---|---|
| | Period 1 | Period 2 | Period 3 |
| 1 | 3 cows, 1 bull, 1 calf | 3 cows, 1 bull, 1 calf | 3 cows, one bull, 1 calf |
| 2 | 5 heifers | 5 heifers | 5 heifers |
| 3 | 1 cow, 4 heifers, 1 calf | 1 cow, 4 heifers, 1 calf | 1 cow, 4 heifers, 1 calf |
| 4 | 3 cows | 3 cows | 3 cows, 1 calf |
| 5 | 3 cows | 3 cows, 1 calf | 3 cows, 1 calf |
| 6 | 3 cows | 4 cows | 3 cows, 1 calf |
| 7 | 3 cows | 3 cows, 1 calf | 3 cows, 2 calves |
| 8 | 4 cows | 3 cows | 4 cows |
| 9 | 3 cows | 3 cows | 3 cows, 2 calves |

2 were calves, 1 was bull and 23 were cows. Furthermore, an additional seven calves were born during the experimental period. The animals were divided into nine groups (Table 2). Due to practical circumstances at the private farm, the bull had to be included into one of the groups. Each group had access to a fenced paddock with a squared shelter (5 × 10 m) with an open long side. The shelter was constructed of metal with metal roof and open, triangular gables in both ends (Fig. 1a). The shelter was bedded with barley straw. Hay silage was provided as feed in a trough within the paddock, and water was available ad libitum. The nine paddocks were located on two fields separated by a track with three paddocks on the east field and six on the west field (Fig. 1b). The paddocks were separated by an electric fence, and all access to vegetation was barred, so the only possible shelter was provided by the artificial shelters. The animals were separated into groups and had access to the shelters 14 days before the experimental period. The experiment was conducted during the winter 2016/2017 and complied with EU and Danish Ministry of Justice legislation concerning animal experimentation.

### 2.2. Experimental design

Experimental treatments were based on Danish recommendations (SEGES, 2016) on shelter space for beef cattle (Table 1). Three experimental treatments were tested: 1) 100% of the recommended $m^2$/individual (**T100%**), 2) 150% of the recommended $m^2$/individual (**T150%**) and 3) 200% of the recommended $m^2$/individual (**T200%**). The study was designed as a 3 × 3 crossover design, randomly

**Table 3**
Distribution of the nine experimental groups (1–9) in a 3 × 3 crossover design. The groups were randomly selected into each category. Treatments were based on 100%, 150% and 200% of the recommended space availability in shelters (See Table 1).

| | Treatment | | |
|---|---|---|---|
| | T100% | T150% | T200% |
| Period 1 | 2, 4, 6 | 1, 5, 9 | 3, 7, 8 |
| Period 2 | 3, 7, 8 | 2, 4, 6 | 1, 5, 9 |
| Period 3 | 1, 5, 9 | 3, 7, 8 | 2, 4, 6 |

subjecting all nine groups to all three treatments (Table 3). The experimental period (January 2017–March 2017) consisted of three treatment periods, each consisting of an adaption period (approx. 10 days) followed by a 16 days registration period. During the adaption period, the group had access to the space available in the following treatment to habituate them to the new space allowance and minimize any potential order effects. For all groups, the available space per group was calculated as the sum of $m^2$/individual based on Table 1. For example, in T100%, cows had 4 $m^2$/individual, heifers had 3 $m^2$/individual and calves 1.2 $m^2$/individual (see Table 1). The number of individuals in the groups varied between the treatment periods as a few groups required regrouping and due to calving (Table 2). These changes occurred outside the registration periods and the space available in the shelter was always adjusted to fit the space requirements based on group composition (Table 1). The only exception was when a cow calved within a treatment period. In this case, the space availability was unadjusted to avoid disturbance of the cow and calf. Space availability in the shelters was adjusted using movable, galvanized fences, which allowed shielding part of the shelter. The depth of the shelter was constantly 5 m, while the width of the opening varied between treatments, but was never less than 2.5 m.

### 2.3. Recordings

The use of the shelters was recorded by infrared trail cameras (1 camera/shelter, Black IR Trail Camera, ScoutGuard, USA) taking a picture every 15 min. From these pictures, the use of the shelters was estimated by recording of the number of animals inside the shelter and their position (lying/standing) on each picture. Since some pictures were lost due to camera/flash failure (see results), the following

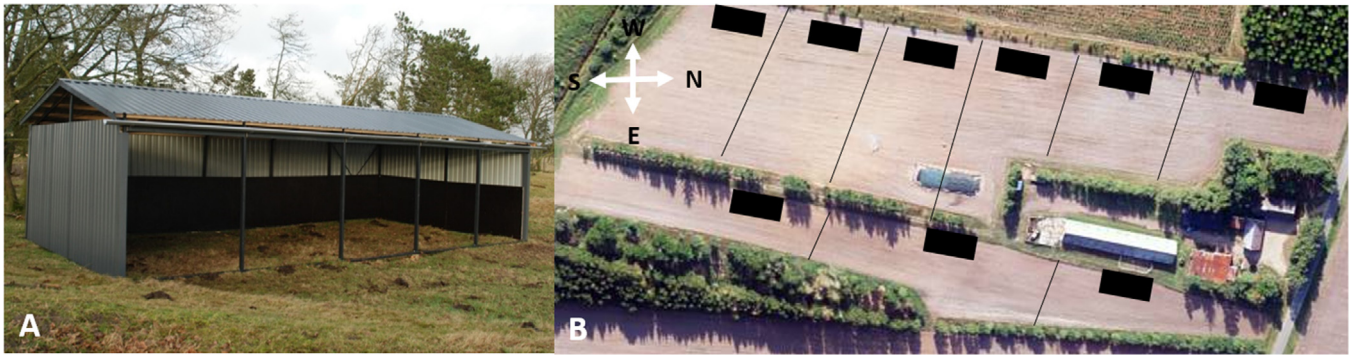


**Fig. 1.** a) Shelter design. b) Overview of the nine paddocks with shelters (black rectangles), placed with the opening towards the east/southeast.