University of Natural Resources and Life Sciences (BOKU), Vienna/Austria
Department of Sustainable Agricultural Systems
Division of Livestock Sciences

CHILLED OR BORED? INACTIVITY IN CATTLE

Master Thesis
by
Freija Maulbetsch, BSc.

Supervised by:
MSc. Ph.D. Dr.med.vet. Sara Hintze

Univ.Prof. Dr.med.vet. Christoph Winckler

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Abstract

Animals kept in barren environments often show increased levels of inactivity and first studies indicate that inactive behaviour may reflect boredom or depression-like states. However, knowledge of what inactivity looks like in different species is scarce and methods to precisely describe and analyse inactive behaviour are thus needed. To this end, we first developed an Inactivity Ethogram for fattening cattle. The ethogram encompasses information on positions of different body parts, including the whole body (standing, lying), head, ears, eyes and tail. We then applied this ethogram to Austrian Fleckvieh heifers from three different types of husbandry systems: "intensive" (fully slatted floor), "semi-intensive" (straw-bedded lying area), and "extensive" (pasture) systems and we visited three farms per husbandry system on two days each. During each visit, the behaviour of 16 animals was continuously recorded live for 15 minutes.

Descriptive analysis showed that the time heifers spent inactive increased with increasing intensity of the husbandry system. When inactive, animals were lying twice as long as they were standing; lying laterally was rare. In all husbandry systems, the animals' heads were in an upward position for approximately 75 % of the observation time. Heifers kept on pasture showed low ears, a potential sign of relaxation, for longer than heifers kept on intensive or semi-intensive farms. The most prevalent combination of positions on intensive and semi-intensive farms was lying with two legs under the body, head up, ears backwards, eyes open and tail hanging whereas on pasture it was lying with two legs under the body, head up, ears low, eyes closed and tail hanging. Our study provides first insight into inactive behaviour of cattle across different husbandry systems. The Inactivity Ethogram may serve as a methodological tool for further research on the association between certain forms of inactivity and both negative and positive affective states.

Zusammenfassung

Inaktivität ist häufig bei Tieren in restriktiven Haltungsformen zu beobachten und wird in ersten Studien als ein Ausdruck von Langweile oder Depression gedeutet. Wissen darüber, wie Inaktivität bei verschiedenen Tierarten aussieht, ist rar. Daher haben wir ein Inaktivitäts-Ethogramm für Mastrinder entwickelt. Dieses Ethogramm umfasst Informationen zu Körperhaltungen, Kopf-, Ohr-, und Schwanzpositionen sowie darüber, ob die Augen geschlossen oder geöffnet sind. Wir haben das Ethogramm bei Färsen in „intensiven" (Vollspaltenboden), „semi-intensiven" (Liegefläche mit Stroheinstreu) und „extensiven" (Weide) Haltungssystemen angewendet. Pro Haltungssystem

wurden drei Betriebe an zwei verschiedenen Tagen besucht und bei jedem Besuch wurde das Verhalten von 16 Tieren 15 Minuten lang kontinuierlich aufgezeichnet.

Die deskriptive Auswertung zeigt, dass mit steigender Intensität des Haltungssystems die Dauer des inaktiven Verhaltens zunahm. Wenn die Tiere inaktiv waren, verbrachten sie doppelt so viel Zeit im Liegen wie im Stehen; laterales Liegen wurde nur selten beobachtet. 75 % der Beobachtungszeit hatten die Tiere ihren Kopf in einer erhobenen Position. Hängende Ohren, ein potentielles Zeichen von Entspannung, wurden bei Färsen auf der Weide mehr beobachtet als bei Färsen von intensiven und semi-intensiven Betrieben. Die am häufigsten beobachtete Kombination von Positionen auf intensiven und semi-intensiven Betrieben war das Liegen mit erhobenem Kopf, nach hinten gerichteten Ohren, geöffneten Augen und hängendem Schwanz, während auf der Weide diese Kombination, jedoch mit hängenden Ohren und geschlossenen Augen, am häufigsten auftrat. Diese Studie gibt einen ersten Einblick in das inaktive Verhalten von Rindern in verschiedenen Haltungssystemen. Das Inaktivitäts-Ethogramm bildet die Grundlage für zukünftige Forschungen im Zusammenhang mit Inaktivität und positiven (z.B. Entspannung) bzw. negativen (z.B. Langeweile, Depressionen) affektiven Zuständen bei Rindern.

AFFIDAVIT

I hereby declare that I am the sole author of this work. No assistance other than that which is permitted has been used. Ideas and quotes taken directly or indirectly from other sources are identified as such. This written work has not yet been submitted in any part.

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Date, Signature

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Table of content

~ I dedicate this work to all animals ~

1. Introduction

This thesis is divided into two parts. The first part is a literature review on how to assess emotions, high arousal and low arousal states and studies on inactivity in animals. The second part describes the experiment that was carried out to investigate inactive behaviour of cattle in three different husbandry systems.

In part 1, animal welfare is defined by highlighting three approaches: biological functions, feelings and naturalness. The challenges to assess animal emotions who are not able to express themselves verbally are described and the indirect access to animal emotions through cognitive, physiological and behavioural measures is discussed. The state of research in low arousal states is described and some important studies on inactivity are presented.

Part 2 describes our development of an Inactivity Ethogram and its application to heifers across different husbandry systems. After giving a brief introduction to the topic, the experimental design and the descriptive analysis are described. At the end of part 2, the results of the study are described and discussed comparing them to existing literature.

2. Part I: Literature review

2.1. Defining animal welfare

In the last 30 years the ideas about what animal welfare represents have evolved through a change in the view the society has on what are ethically acceptable and unacceptable ways of treating animals. Already 1964 the English animal advocate Ruth Harrison questioned in her book *Animal Machines* "How far have we the right to take our domination of the animal world? Have we the right to rob them of all pleasure in life simply to make more money more quickly out of their carcasses?" (Harrison, 1964, 37). Furthermore the recruitment of both scientists (Fraser, 2008; Mellor and Bayvel, 2008; Green and Mellor, 2011) and ethicists (Sandøe and Christiansen, 2008) into the animal welfare arena (Fraser, 2008; Mellor and Bayvel, 2008; Sandøe and Christiansen, 2008; Green and Mellor, 2011) brought forward the understanding of animal welfare.

Fraser (2003) proposes three main approaches towards defining animal welfare, focusing on either

1. natural-living based definitions emphasising the **naturalness** of the housing conditions,

Rollin (1993) stated, that nurturing and fulfilment of the animals' nature should be taken into account when it comes to animal welfare. This also includes the social needs of the animals.

Most domesticated species are social (i.e., live in groups), but due to the different kinds of social organization and life history, the importance of individualized bonds differs from species to species (Hennessy et al., 2009; Raussi et al., 2010; Clark et al., 2011). Cattle, for example, have clear rankings, prefer a certain distance to their conspecifics, etc. (Sambraus, 1978).

2. feelings-based definitions trying to identify the **feelings** experienced by an animal,

Duncan (2005) takes the view that even when pain and stress is absent, there is no guarantee that the animals do not suffer, because they can also suffer mentally when pain and stress are not present.

3. biological-functioning based definitions studying the **biological functioning** of an animal.

McGlone (1993) suggested that animals are only in a poor state of welfare when their physiological systems are disturbed to the point that reproduction or survival are impaired.

In the following I will take a closer look on the emotional states.

2.2. Approach to assess animal emotions

Emotions in humans are defined as complex patterns of change that include physiological arousal, feelings, cognitive processes and behaviours. Emotions occur in response to a situation that an individual perceives as personally meaningful. Examples of emotions are, for example, happiness, sadness, anger, fear, surprise, disgust (Konecny and Leitner, 2006).

In the research from Paul and Mendl (2018) about how to define the word “emotion” in non-human species they found, beside others, this definition of emotions: “An emotion is a multicomponent response (subjective, physiological, neural, cognitive) to the presentation of a stimulus or event. It is always valenced (i.e. either positive or negative; occasionally both)…it can be intense or mild; long lasting or brief…”(Paul and Mendl, 2018, 2).

Mendl et al. (2010) characterized emotions by two dimensions: their arousal (intensity of activation) and their valence (negative or positive). For example, the states of elation and contentment are both positively valanced, but elation involves a higher degree of arousal than contentment (Mendl et al., 2010). Negative low arousal states (e.g. depression, sadness) are associated with low expectation of positive events and may favour low activity and conservation of energy in conditions with a lack of resources (Nesse, 2000).

Mendl et al. (2010) differentiate between two forms of affective states, short-term emotions and long-term mood. Emotions are event-oriented (object-oriented) and usually appear only briefly. They arise when a rewarding or punishing event is expected or experienced (Mendl et al., 2010). In humans, the occurrence of emotions does not only depend on the response to certain stimuli or events. While emotions are stimulus specific, moods are not and usually last longer than emotions. They include longer term states such as "sadness" or "happiness" as well as more extreme forms such as chronic anxiety or depression or mania (Mendl et al., 2010).

Many scientist do not feel comfortable when the word “emotion” is used in connection with animals, because it can imply anthropomorphic assumptions about how animals feel (Paul et al., 2005). This uncertainty regarding the word “emotion” results from the fact that emotions of animals are difficult to assess (Paul et al., 2005). In humans, the subjective, conscious experience of emotions can be assessed using interview techniques (like standardised questionnaires used in psychology), but we cannot use these techniques to find out what animals feel (Boissy et al., 2007a). Therefore it is not possible to get an access to the conscious experience of animal emotions (Mendl et al., 2010) and thus we do not know if animals experiences emotions comparable to humans (Boissy et al., 2007b). But it is likely that animals feel as humans do, because behaviour, structure, and brain chemistry are similar (Boissy et al., 2007b).

Paul and Mendl (2018) acknowledge, that emotions as we humans understand them, is something unique, reserved for our species and that the animals' emotions might be different from those of humans. This could be due to the way the neural system processes the expectation or experience of punishments or rewards, specialised for the particular niche an animal occupies. However, independent from the question to what extent emotions in humans and animals differ, it is important to notice that due to the lack of language in animals, we can not directly assess the animals' emotions, but we can only indirectly capture them using cognitive approaches, physiological measurements and behavioural indicators.

2.3. Indirect approach to assess animal emotions through: cognition, physiology and behaviour

Mendl et al. (2010) discuss the effects of emotions on the behavioural, cognitive and physiological responses of animals. Since behavioural, physiological and cognitive changes form important parts of what we call an emotion, it is necessary to discuss what such changes mean, which I will do in the following paragraphs.

2.3.1. Cognitive approaches to assess animal emotion

While the relationship between emotions and cognition has received little attention in animal studies, it has been much researched in human psychology (Boissy et al., 2007b). In humans, cognitive processes are often closely involved in the production and output of emotional states. It is therefore of interest to what degree such processes are also involved in the emotional states of animals (Paul et al., 2005). Boissy et al. (2007b) stress the usefulness of cognitive science for research on emotions in animals and thus for animal welfare.

The study from Spruijt et al. (2001) shows that measures of cognitive processes, for example anticipation, can provide information about animal emotion. That is because emotions, such as pleasure, result into the release of specific signals in the brain, on which the animal responds accordingly with approach or avoidance (Spruijt et al., 2001).

2.3.2. Physiological measurements to assess animal emotion

Another indirect approach to the emotions of an animal is through physiological measurements. Paul et al. (2005) discuss in their paper different physiological measures like measures of

HPA (hypothalamic-pituitary-adrenal) function, HRV (heart-rate variability), changes in sympathetic and autonomic function (for example alterations in heart rate, blood pressure, skin conductance and skin temperature), and other measures of neuroendocrine activity, such as levels of prolactin, vasopressin and opioid peptides.

From physiological data conclusions can be drawn on emotions. However, interpretation of physiological measures regarding emotional states is not always simple. Some situations which are likely to induce different emotions may arouse the same physiological responses. For example, cortisol levels may rise both during sexual activity and in fearful situations (Toates, 1995; Broom and Johnson, 1993; Rushen, 1986, 1991). To improve the interpretation of emotional states in animals it could help to combine the measure of multiple physiological indicators with observations of behaviour (Broom and Johnson, 1993)**.**

2.3.3. Behavioural approaches to assess animal emotion

Behaviour can be an attainable, indirect measure of animal emotion (Fureix and Meagher, 2015), because behaviour is influenced by the emotional state of the animal (De Oliveira and Keeling, 2018). Additionally, behaviour is what animals do to control and change their environment and it provides information about the needs and preferences of animals (Appleby et al., 2018).

For example, body positions can be an external indicator of internal states of the animals (De Oliveira and Keeling, 2018). Studies looking at the body positions and/or facial expressions of farm animals as indicators of their emotions included sheep (Boissy et al., 2011; Reefmann et al., 2009; Guesgen et al., 2016), goats (Briefer et al., 2015), pigs (Reimert et al., 2012) and cattle (Proctor and Carder, 2014; Gleerup et al., 2015). Observations of specific parts of the body showed considerable variations among species. The same tail or ear positions appear to be associated with opposing emotional states in different species (De Oliveira and Keeling, 2018). For example, in the study from Reefmann et al. (2009), the tail of the sheep was held up more often in negative than in positive situations as opposed to the study with goats (Briefer et al., 2015) where goats spent more time with the tail up in positive situations. Furthermore, in the study from Reimert et al. (2012) pigs had their tails in a low position more often than in negative than in positive situations. Concerning the ear positions, Reimert et al. (2012) observed in their study that in pigs backward orienting ears are associated with negative situations, while Reefmann et al. (2009) linked them to positive experiences in sheep.

Spontaneous behaviour like freezing, attacking, consumptive and exploratory behaviours should also be noted, since spontaneous behaviour may indicate the presence of object-directed (event-focused) emotions (Paul et al., 2005) as opposed to a free-floating mood. Other relevant forms of spontaneous behaviour are vocal or facial expressions (Paul et al., 2005), like ear position changes, as mentioned above, or eye white exposure which can be an indicator of frustration in cattle (Sandem et al., 2002).

When studying the relationship between behaviour and emotional states it is important to be sure to consider the context in which the behaviour occurs (Sandem et al., 2002). For example, the lying position could vary depending on the surface of the lying area (e.g. concrete floors vs. soft mats) (Tuyttens et al., 2008). To get more reliable indicators it may be of benefit to use behaviours which occur consistently in a variety of contexts (with similar affective valence) and which do not appear in oppositely valenced situations (Paul et al., 2005).

Taken together, we can get an indirect access to the feelings of the animals through cognitive, physiological and behavioural parameters, which might help us to improve animal welfare. Let's see what research on animal welfare has primarily focused on so far.

2.4. Much research on high arousal states

In the past, animal welfare research has mainly focused on avoiding high arousal states of suffering, including pain and stress (Paul et al., 2005; Yeates and Main, 2008). Different methods to assess pain and other forms of suffering have been developed (Boissy et al., 2007b). An important approach in the study of stress and welfare is the measuring of the HPA (hypothalamic-pituitary-adrenal) axis activity (Mormède et al., 2007). Vigilance can be used as a measure of fear in dairy cows (Welp et al., 2004) and changes in the ear position of lambs can provide information whether the animals experience pain (Guesgen et al., 2016). Gleerup et al. (2015) developed on this basis a pain scale for use in dairy cattle under production conditions including the following behavioural signs of pain: 1) attention towards surroundings, 2) head positions, 3) ears positions, 4) facial expressions, 5) the response to approach and 6) back positions.

2.5. Less attention on low arousal states

Much less attention has been devoted to the field of low arousal states going along with low levels of activity (Fureix and Meagher, 2015), for example sunbathing, rumination etc. Let’s have a closer look at this low arousal states.

2.5.1. What is it? It could be boredom, depression, etc.

Many types of animal husbandry inevitably lead to a restriction of the behavioural repertoire of animals because they are not in their natural environment. In the wild, for example, animals do not wait for food to be given to them, but spend a lot of time searching for food. In a monotonous environment, animals usually do not have the possibility to search for suitable stimuli, but there is a lack of adequate stimuli (Wemelsfelder, 1984). Could boredom be caused by the "waiting" for stimuli? Of course, animals also have rest periods, so it would be important to know when an animal just relaxes and when it waits until finally a stimulus comes from outside. Sambraus (1978) for example intensively worked on investigating the behaviour of animals and in this context described the resting behaviour of cattle. He created a good foundation for the different facets of cattle behaviour, but his research does not include the question if the observed resting behaviour means "waiting" or a state of mere relaxation. Both "waiting" and relaxation have in common, that they are likely to be dominated by inactive behaviour and therefore it is important to take a closer look at inactivity in farm animals. The main question is: what does inactive behaviour indicate? To get closer to an answer, it is important to identify forms of inactivity which might indicate good or poor welfare. According to Meagher et al. (2013) this may be possible by e.g. investigating indicators of location and position.

However, inactivity is difficult to interpret with respect to animals' affective states because some forms of low activity can reflect chronic fear (e.g. hiding), or potentially apathy or depression-like states, whereas others might reflect positive states (as relaxation) (Meagher, 2011).

2.5.2. A few studies on inactivity

There are already some studies which deal with inactivity in animals. Alloy and Seligman (1979) state that inactivity may be caused by two emotional states: total equilibrium, when everything is at or close to optimum, or learned helplessness, if the subject has the experience that there is no possibility to escape the negative environment. The latter emotional states results in an inactive, depression-like chronic stress state that is often accompanied by permanently increased levels of the stress hormone cortisol (Boissy et al., 2007b).

Inactivity is often noticed in situations where the welfare of animals is supposed to be poor (Fureix and Meagher, 2015). For instance, buffalo cows housed in high stocking density environments spend more time inactive than cows with large outdoor access and grazing opportunities (Tripaldi et al., 2004). Not being inactive enough may also indicate or cause poor welfare (Fureix and Meagher, 2015), for example when organisms consistently have to cope with external challenges or when they are sleep deprived (Ferrara and De Gennaro, 2001).

The question whether animals are even able to feel bored, we humans can only vaguely approach. As a first step we will look at how boredom is defined in humans. According to Burn (2017, 5) boredom in humans is defined as follows: "Boredom is an unpleasant emotion including motivation to experience almost anything different or more arousing than currently possible". Chronic boredom in humans is related with repetitive behaviour, sensation-seeking, vandalism, gambling, apathy, depression, cognitive deficit (Burn, 2017). With the knowledge that higher organisms actively stay away from a monotonous environment (Heron, 1957), we can conclude that for animals boredom is an adverse state and thus associated with stress (Wemelsfelder, 1984), as it is the case in humans (Thackray, 1980).

In some studies, certain body positions, like dog sitting in sows (Fraser, 1975; Vestergaard, 1984) and hunched positions in rabbits (Gunn and Morton, 1995) were associated with specific negative affective states like boredom and lethargy. But what is really a reliable indicator for animal boredom? Boredom can operationally be defined as a negative state caused by under-stimulation, therefore boredom should increase the interest in all kind of stimuli (Meagher and Mason, 2012). The study from Meagher and Mason (2012) proved the hypothesis that mink experience more boredom in non-enriched cages than in enriched cages since minks in non-enriched cages showed increased exploration of novel stimuli. This result shows that boredom can be assessed empirically in non-human animals and can be reduced by environmental enrichment (Meagher and Mason, 2012).

Inactivity may appear only as a by-product of the methods used to assess activity levels (Fureix and Meagher, 2015). Behavioural studies rarely focus on inactivity and in many cases inactivity is regarded as a basic state instead of a “true behaviour” (Lima et al., 2005; Levitis et al., 2009).

Therefore, and because there are only a few studies about the potentially relevant topic of inactivity in animals, it is necessary to do further research on inactivity. Prior to data collection, ethograms with precise descriptions (e.g. postural descriptions, environmental and social context of behaviour) of any specific form(s) of inactivity should be developed (Fureix and Meagher, 2015).

Meagher et al. (2013) did a study with minks, in which they identified specific subtypes of inactivity, which may indicate poor welfare, by comparing the animals’ behaviour in enriched and non-enriched conditions. Such research needs to be done for every species, accounting for different ways to express affective states in different species (Meagher, 2011). A detailed knowledge of all the behaviour characteristics of a certain species can help to get a better idea of what the behaviour of an animal could “mean” in terms of animal welfare (Appleby et al., 2018). If we have a detailed ethogram of inactive behaviour, we can deduce which behaviour is natural, thus also to be seen in free-living animals, and which behaviour results from the influence of animal husbandry conditions, perhaps even reflecting boredom.

3. Part II: Experimental Paper

3.1. Introduction

In the past, animal welfare research has mainly focused on avoiding high arousal states of suffering, including pain and stress (Yeates and Main, 2008). Little attention has been devoted to the field of low arousal states going along with low levels of activity (Fureix and Meagher, 2015). However, captive animals are often described as inactive (e.g. Gunn and Morton, 1995; O'Connell and Beattie, 1999; Zanella et al., 1996), and high levels of inactivity have been discussed as a potential welfare problem (Fureix and Meagher, 2015). Inactive behaviour can, for example, lead to potential welfare consequences like obesity and can have negative impacts on fertility.

Besides these potential effects on health and reproduction, inactivity has also been discussed to have detrimental effects on the affective states of animals (Fureix and Meagher, 2015). However, inactivity is difficult to interpret with respect to animals' affective states because some forms of low activity can reflect chronic fear (e.g. hiding), and potentially apathy or depression-like states, whereas others might reflect positive states (e.g. relaxation) (Meagher, 2011). These examples demonstrate that inactivity is not a homogenous state: There are various forms, expressed in different contexts, and each is probably related with different affective states (Fureix and Meagher, 2015). Moreover, behavioural studies rarely focus on inactivity and in many cases inactivity is regarded as a basic state instead of a "true behaviour" (e.g. Lima et al., 2005; Levitis et al., 2009). Additionally, inactivity often appears only as a by-product of the methods used to assess activity levels (Fureix and Meagher, 2015).

Unfortunately, a uniform definition of inactivity is lacking. In most studies, animals are defined as inactive if they are standing or lying, often with the condition that the eyes have to be open (Beattie et al., 2000; Meagher and Mason, 2012). Other studies differentiate between standing or lying actively or idle (e.g. Webb et al., 2017). To our knowledge, the only study in which further forms (besides standing and lying) of inactivity were defined is the study by Meagher et al. (2013) in which three different lying positions of mink were recorded.

To fill this gap, we developed an Inactivity Ethogram for fattening and rearing cattle, an often intensively kept species, with a description of different forms of inactive behaviour, including detailed information on the animal's body position including facial expressions and on the context in which the behaviour is shown. We applied this Inactivity Ethogram to Austrian Fleckvieh heifers to explore the duration of the different inactive behaviours, the co-occurrence of the different positions and the context in which they appear across different husbandry systems. This Inactivity Ethogram may form the basis for further studies investigating the relationship between different forms of inactive behaviour and farm animal welfare.

3.1.1. Aims of the thesis

The aims of the thesis are

a) to develop an Inactivity Ethogram for cattle, which includes the identification and a detailed description of different forms of inactive behaviour.
b) to apply the developed Inactivity Ethogram in order to explore the duration of different inactive behaviours, the co-occurrence of the different positions and the context in which they appear across different housing systems ranging from highly intensive to extensive systems.

3.2. Animals, material and methods

3.2.1. Development of the Inactivity Ethogram

To develop and refine the Inactivity Ethogram, first a detailed literature research was carried out; literature about inactivity and behaviour of cattle was studied. Then, already existing video clips of fattening cattle in intensive husbandry systems were used and, finally, four pilot farms in Austria (representing the three husbandry systems (see Housing), plus one to test the recording software INTERACT®) were visited to observe behavioural situations to be added with their descriptions to the ethogram and to explore the feasibility of using it for continuous live observation. In addition, information on the context of the behaviour, including the distance to the nearest conspecific, external influences etc., were added (Table 4). In addition to the positions defined for inactive cattle (Table 2), some categories of active behaviour were also included in our ethogram, e.g. walking, feeding, to capture the “whole picture” and not only the inactive behaviour (Table 3). Furthermore, we worked out a definition for being inactive during our pilot visits. An animal was defined as inactive when it fulfilled two requirements. First, it had to either stand or lie. Certain movements of different parts of the body are allowed to still characterise the animals as being inactive. Second, inactivity must be shown for a minimum of 30 seconds to start focal animal observations. Because the animals can be active and inactive while they are standing and lying, we made a list were all certain movements are classified as active or inactive (Table 1). For movements which could be classified as both active and inactive, e.g. ear movements, we made a classification which movements are still recorded as the animal being inactive and which movements are recorded as active. Repetitive movements, i.e. movements that are repeated more than two times in a row (consecutively), were recorded as the animal being active (Table 1).

Table 1. Behavioural elements classifying the animal as being inactive or active

	Movements that classify the animal as being inactive	**Movements that classify the animal as being active**
Body	Maximum two steps forward or backward	Scratching self with one foot more than twice
	Singe movement of one leg, including a kick after flies	Scratching self on barn equipment or other objects
	Lying down or standing up without further movements	Licking self more than twice
	Stretching while standing or lying	Sniffing an object or conspecific
	Skin twitching	
	Urinating or defecating	
	Any tail movements	
Head	Head shaking (while standing or lying)	Flehming
	Snapping after flies by quickly throwing the head towards one side of the body	
	Ear movements	
	Eye blinks	

	Yawning	
	Coughing	
	Sneezing	
Interactions with a conspecific	Being licked without obvious reaction	Licking a conspecific
	Being nibbled without obvious reaction	Nibbling on a conspecific
	Being mounted	Mounting a conspecific
	Receiving a head butt without obvious reaction	Head butting
	Being displaced and being inactive thereafter	Displacing a conspecific

Table 2. Inactivity Ethogram

Category	Behaviour	Description	Literature
Body position	Standing	Three or four claws on the ground, trunk does not touch the ground, no forward movement	
	Lying	Trunk touches the ground	
	Out of sight	The exact body position cannot be defined by the experimenter	
Lying	Lying chest-prone both front legs under body	Chest-prone position, both front legs are bent at the carpal joint and placed under the body	Sambraus (1971)
	Lying chest-prone one front leg under body	Chest-prone position, one front leg is bent at the carpal joint and placed under the body, the other front leg is stretched	Haley et al. (2000)
	Lying chest-prone both front legs stretched	Chest-prone position, both front legs are stretched	
	Lying laterally	Lateral position, either the right or the left side of the trunk are on the ground, legs not under the body	Haley et al. (2000)
	Out of sight	The exact lying position cannot be defined by the experimenter	
Head position	Head up	While standing: head at a height of between the carpal joint and head and back being in a horizontal line; between “head down” and “head raised” While lying: all positions in which the mouth does not touch the ground, the head is not placed on the own body or on a conspecific/an object	
	Head down	While standing: head at a height of between touching the ground and the carpal joint While lying: mouth or other part of the head touches the ground	Haley et al. (2000)
	Head raised	Head held above the imaginary horizontal line between the back and the rump	De Oliveira and Keeling (2018)
	Head leaned against conspecific	Forehead of focal animal touches body of conspecific	
	Head on conspecific/object	Chin or jowl of the focal animal in direct contact with a conspecific or object, e.g. a fence	Fisher et al. (1997)

	Head on own body	While lying: Head placed on the own body	
	Out of sight	The exact head position while standing cannot be defined by the experimenter	
Ear position	Forwards	The both ears are in or in front of the frontal plane	Boissy et al. (2011)
	Backwards	The both ears are behind the frontal plane	Boissy et al. (2011)
	Low ears	Both ears hanging to the sides, the tip of the ear pointing down (the tip of the ear is not the highest point of the ear)	Gleerup et al. (2015)
	Asymmetrical	Both ears are in two distinct positions relative to the frontal plane, i.e. one ear forwards and one ear backwards	Boissy et al. (2011)
	Out of sight	The exact ear position cannot be defined by the experimenter	
Eyes	Eyes open	Upper and lower eyelid are not in contact, part of the eyeballs is visible	
	Eyes closed	Upper and lower eyelid are in contact, eyeballs invisible	
	Out of sight	The experimenter cannot define whether the eyes are open or closed	
Tail	Tail on hindquarters	Tail hangs straight downwards, minimal soft movements of the lower end of the tail are accepted as the tail still being hanging	Albright and Arave (1997)
	Tail in motion (tail flinch)	Tail moves from one side to the other, the tip exceeds the height of the focal animal's knees	
	Out of sight	The experimenter cannot define whether the tail hangs or moves	
Sounds	Humming	Deep vocal sound with mouth closed	
Alertness		Indirect measure if a) the head is raised, and b) the ears point forward	
Rumination	Yes/no	Starts with regurgitation, repetitive, uniform chewing, 45-60 chewing movements in one direction	
	Out of sight	The experimenter cannot define whether the focal is ruminating or not	

Table 3. Activity Ethogram

Category	Behaviour	Description	Literature
Movement	Walking	Moving forward or backward for at least three steps, at least three feet touch the ground at any time	
	Trotting	A two-beat diagonal gait where the diagonal pairs of legs move forward at the same time with a moment of suspension between each beat	
	Playing	Galloping, hopping, running, bucking, kicking, head-shaking, turning, leaping, jumping, frontal pushing	Jensen et al. (1998)
Oral behaviour	Eating/Drinking	Taking food with the tongue plus chewing movements/ Lowering the mouth into the water, while keeping the nostrils above the water. Sucking water into the mouth can be seen but does not have to be seen	
	Tongue rolling	Repetitive undeviating rolling of the tongue, either inside or outside the open mouth	Albright and Arave (1997)
	Other oral behaviour	Tongue to nose, bar in the mouth, drink urine, licking the ano-genital region of a conspecific, etc.	Raussi et al. (2005)
Comfort behaviour	Comfort behaviour	Scratching with foot, rubbing against equipment (e.g. brush) or trees, scratching with horns, self-licking, always repetitively	Huber et al. (2008)
Interactions	Social licking	Tongue in contact with the body surface (except ano-genital region, udder, teats or claws) of the recipient, repeated up and down head movements for at least 3 consecutive times	Gutmann et al. (2015)
	Being displaced	Moving away (independent of the direction) for more than two steps as a result of being but, pushed, rubbed, threatened or approached by a conspecific	Gutmann et al. (2015)
	Mock fighting	Focal animal and conspecific gently pushing each other head-to-head, non-agonistic behaviour	Reinhardt et al. (1986)
	Other interactions	Focal animal interacts with a conspecific, including e.g. budding, displacing, rubbing, mounting, scratching itself on a conspecific	
Sounds	Mooing	Vocal sound, with mouth open	

Table 4. Information on the context

Information	**Category**	**Description**
Location	In stable/pen	All four claws are inside, head can be inside or outside (door or window)
	On pasture	All four claws are on pasture
Location inside*	In lying area	At least two claws in the lying area, head within this area
	In area of activity	At least two claws in the area of activity, head within this area
	In feeding area (intensive & semi-intensive)	If the whole head (including the ear plane) is through the feeding fence
	In feeding area	At least two claws in the feeding area, head within this area
Floor type*	On slatted floor	At least two claws are on slatted floor, head within this area
	On solid floor	At least two claws are on solid floor, head within this area
Location outside	In shelter	All four claws are in the shelter, head can be inside or outside
	Under a tree	At least head and neck are under the tree
Rain/sun	In the rain	One part of the cattle (no matter which) is in the rain
	In the sun	One part of the cattle (no matter which) is in the sun
Distance to closest conspecific	Body contact	One cattle touch a conspecific with any part of the body (no matter which)
	Within individual distance	Up to 1.5 cow lengths to the nearest conspecific (but no body contact)
	Outside individual distance	More than 1.5 cow lengths and less than 10 cow lengths to the nearest conspecific
	Far away	More than 10 cow lengths to the nearest conspecific
External influences	People	
	Dogs	
Lameness	Lame animal	If the focal animal is observed as being lame, this will be recorded

***: not recorded in the present study, but may be included in future studies**

3.2.2. Experimental design

Data collection started in April 2018 when the grazing period for the animals in extensive systems had started and ended at the beginning of August.

Three different husbandry systems with three farms per husbandry system were included. Each farm was visited twice on two different days. On each farm one visit started in the morning (around 9:30 AM) and the other one around midday. So, data were recorded on every farm between 9:30 AM and 06:00 PM (both visits together). It was thus possible to cover a large part of the day.

The order of farm visits was counterbalanced across husbandry systems and day times (Table 5).

Table 5. Order of the farm visits balanced across husbandry systems and day times

Category	**First visit**	**Second visit**
Intensive		
Farm 1	2. Visit A (18.4.)	9. Visit M (16.5.)
Farm 2	4. Visit A (24.4.)	13. Visit M (28.5.)
Farm 3	7. Visit M (6.5.)	14. Visit A (4.6.)
Semi-intensive		
Farm 1	1. Visit M (16.4.)	8. Visit A (08.5.)
Farm 2	3. Visit M (22.4.)	11. Visit A (20.5.)
Farm 3	6. Visit A (2.5.)	12. Visit M (24.5.)
Extensive		
Farm 1	5. Visit M (30.4.)	15. Visit A (11.6.)
Farm 2	10. Visit M (18.5.)	16. Visit A (18.6.)
Farm 3	17. Visit A (24.7.)	18. Visit M (6.8.)

M=morning (observations started around 9:30 AM)

A=afternoon (observations started around midday)

The visits were scheduled using rules:

- No visits on farms with the same husbandry systems following each other directly,

- No more than two morning and afternoon visits following each other directly

In some cases, the schedule had to be adapted to unforeseen events, like thunderstorms, that made it impossible to visit extensive farms. In such cases the visit needed to be postponed. In addition, there were problems with the data collection at the extensive Farm 3 during both visits, so both visits were repeated.

Each farm visit included two observation periods of two hours each (four hours in total). One focal animal per group of heifers was continuously observed for 15 minutes, summing up to 16 focal animal observations per farm visit. Because there were always less than 16 groups, i.e. pens, the groups from which the focal animal was chosen were used repeatedly, but always making sure a different animal was chosen. On extensive farms (pasture) there was always only one group of heifers, so that all focal animals were taken from this group.

The criteria for choosing focal animals was that the animal was identified as being inactive (according to the definition of inactivity above) before the start of the observation. Moreover, focal animals were selected based on predefined rules: In the first group, the furthermost animal in the right rear quadrant of the pen was chosen. In the second group, the animal in the left front quadrant closest to the observer was chosen. In the third group, the furthermost animal in the left rear quadrant of the pen was chosen and in the fourth group the animal in the right front quadrant closest to the observer was chosen. If there were more than four groups, this order was repeated again, but instead of choosing the animal for example on the right side, the animal next to this animal was chosen (swerving towards the middle of the pen), always avoiding choosing the same animal for a second time. These rules were in general also used on pasture, but as described above there was only one group of heifers during each visit.

3.2.2.1. Animals

In this study 288 observations (18 x 16 focal heifers) of 15 minutes each were carried out. It is not possible to determine the exact number of observed individuals because it could be that on the second visit some animals were chosen that had been chosen on the first visit as well. The animals studied belonged to the breeds Austrian Fleckvieh and Fleckvieh crossbreed. Heifers were kept for fattening or for rearing (five farms with fattening heifers, four with rearing heifers). The age of the heifers ranged between 8 and 27 months for rearing and between 8 and 20 months for fattening heifers. All heifers weighted at least 300 kg (information based on estimations by the farmers). Some heifers had horns and some were dehorned and on one farm, some heifers wore bells.

Among the animals observed, 16 animals (17.18 %), were pregnant (up to six months of pregnancy).

3.2.2.2. Housing

The study was carried out in three different types of husbandry systems ("intensive", "semi-intensive", and "extensive") (Figure 1 and Table 6) on nine farms in Upper and Lower Austria.

Figure 1. Pictures of the three husbandry systems. Intensive: pens with fully-slatted floor. Semi-intensive: pens with straw-bedded lying area. Pasture: pasture

Table 6. Description of the different husbandry systems

	Intensive	**Semi-intensive**	**Extensive**
Pasture	No	No	Yes
Outdoor access	No	No	n.a.
Floor type	Fully slatted floor	deep-littered lying area and slatted or solid floor in feeding area	grass/soil
Bedding	No	Yes	n.a.
Number of animals per group	5 – 11	5 – 14	9 – 31
Space allowance per animal	2.9 m² (2.2 – 4.2 m²)	3.9 m² (2.9 – 5.5 m²)	~ 1250 m² (250 – 3800 m²)

Intensive husbandry system

In the intensive husbandry system, animals were kept on fully-slatted floor pens without bedding and without access to an outdoor area or pasture. Space allowance was ranged from 2.2 m² to 4.2 m² with the number of animals per pen ranging between 5 and 11 animals (Table 6). In all pens, except at one farm, a fixed brush for the animals was provided.

All animals had ad libitum access to water, which was provided through cup drinkers.
Feeding times were usually in the early morning and in the evening. Once a day the fodder (total mixed ration), which was out of the reach of the heifers, was manually pushed up. On the observation days, the farmers only pushed up the fodder in the breaks between recording sessions.
The temperature inside the stable ranged from 15 °C to 25 °C. During the observations the weather outside was mostly sunny and warm (details see Table 7).

Semi-intensive husbandry system

In the semi-intensive systems, the pens comprised a straw-bedded lying area and a fully-slatted or solid concrete floor activity area. The number of animals per pen was 5 to 14; the space allowance per animal ranged from 2.9 m^2 to 5.5 m^2 (Table 6). There was no outdoor run.
All animals had ad libitum access to water which was provided through cup drinkers.
Feeding times were usually in the early morning and in the evening. Once a day the fodder (total mixed ration), which was out of the reach of the heifers, was manually pushed up. On the observation days, the farmers only pushed up the fodder in the breaks between recording sessions.
In all pens a fixed brush for the animals was attached to the wall.
The temperature (see Table 7) inside the stable ranged from 16.6 °C to 21.2 °C. During the observations the weather outside was mostly sunny and warm (details see Table 7).

Extensive husbandry system

On pasture, the space allowance ranged from 250 to 3800 m^2 per animal with group sizes from 9 to 31 animals (Table 6). The animals were on pasture since the beginning/middle of April. On two farms the heifers were 24 hours on pasture and on one farm they spent the night in a stable and were on pasture during the day (8 AM to 6 PM).
On pasture they also had access to water through cup drinkers or through a water tank, except on one farm at one visit, during which the animals had no access to water while on pasture.
Animals with daytime pasture were fed (total mixed ration) inside in the mornings and evenings.
On one farm, where the animals spent day and night on pasture, the animals got some concentrates in the morning and in the evening.
The temperature on the pasture ranged from 19.6 °C to 39 °C. During the observations the weather was mostly sunny and sometimes windy (details see Table 7). On one farm, where the animals spent day and night on pasture, on one visit, the animals had a shelter in which water and straw were provided. Otherwise only on one further farm they had access to shade through many fruit trees.

Table 7. Overview of the temperature and weather conditions at the different farm visits

		1. Farm visits		2. Farm visits	
Husbandry systems	**Farm**	**Temperature**	**Weather**	**Temperature**	**Weather**
Intensive	Farm 1	25 °C	Sunny, warm	15 °C	Cold, rain
	Farm 2	18 °C	Cloudy, warm	24.9 °C	Sunny, hot
	Farm 3	16.5 °C	Sunny, coolly	24.3 °C	Sunny, hot
Semi-intensive	Farm 1	16.6 °C	Cloudy, partly sunny	20 °C	Sunny, humid
	Farm 2	18 °C	Sunny, warm	21.2 °C	Sunny, warm
	Farm 3	1. stable 19.5 °C, 2. stable 20 °C	Sunny, warm	1. stable 20 °C, 2. stable 21 °C	Sunny, cloudy
Extensive	Farm 1	26 °C	Sunny, partly cloudy, light wind	35 °C	Sunny, hot
	Farm 2	19.6 °C	Sunny, cold, windy	28 °C	Sunny, very stormy
	Farm 3	39 °C	Sunny	29 °C	Sunny, windy

3.2.3. Data collection

The behaviour of the animals was recorded live using Mangold INTERACT® (light version 17.1.11.0) on an Acer Iconia W510 tablet. Codes for all categories of the ethograms and all information on the context were deposited in INTERACT®. In addition to the live observation, each focal animal and the animals around the focal animal were recorded on video using a Panasonic HDC-SD99 camcorder for the indoor visits and a JVC GZ-R410BEU camcorder for the outdoor visits. The video clips were analysed in a complementary study of the institute to determine the inactivity level at pen/group level.

At the beginning of visits, air temperature was measured with a Hygrometer PCE-555 and the weather condition was recorded. The size of the pens, number of animals per pen, age of the animals, their breed, feeding times and stage of pregnancy were recorded. Farmers on the extensive farms were interviewed about how many hours per day and how many days per season the animals spent on the same pasture.

The data collection took place with the observer standing on a ladder (feet approximately 80 cm above the ground), to provide an optimum view on the animals. On each farm the same point of view on the animals was provided. At the start of each observation the number of the pen, the focal animal and the starting time of the recording was noted in a book, which was used through all observations. Each focal animal was chosen with the help of the definition of inactivity and the

predefined rules for choosing a focal animal (details see experimental design above). After choosing the animal, the recording was started on the tablet. Every behaviour, position, information on the context was recorded by tapping on the respective code in INTERACT® on the tablet.
Animals were observed for 15 minutes each. Observations shifted from one pen to the other. After two hours of recording a break of 30 minutes was made. After the break another block of two hours of recordings followed. After every visit, all the material used in the observations, like ladder, shoes etc., was washed and disinfected back at the university.
Lighting conditions were not recorded in all husbandry systems. Sounds that suddenly appeared and visibly affected the animals were recorded using the code "external influences" in INTERACT®.

3.2.4. Data preparation and descriptive analysis

Data sets from the observations were exported from Mangold INTERACT® in two different formats. First, the total duration the animals spent inactive, the duration for each position while being inactive and the duration for all active behaviours was exported for each animal (n=288). The exported data were corrected by expressing it as percentage of total observation time of each animal and, depending on the outcome variable, for the total time the animal was inactive and active, respectively.
Total inactivity was calculated as the time an animal spent standing inactively plus the time it spent lying inactively. Eye closure and tail position were potentially slightly overestimated since only eyes closed, but not eyes open or, respectively, tail in motion, but not tail hanging were recorded. The duration for eyes open was thus calculated as follows: eyes open = total duration of inactivity minus duration of eyes closed, minus duration of eyes out of sight. The duration for tail hanging was calculated as follows: tail hanging = total duration of inactivity minus tail in motion, minus tail out of sight.
The average percentage time each position was recorded for is depicted for each husbandry system by pie charts. Moreover, the average percentage time the animals spent inactive and active, the time the animals spent lying during morning and afternoon visits and the average percentage time the focal heifers spent in direct body contact, within or outside the individual distance or far away from her closest conspecific across all the three husbandry systems are also pictured by pie charts.
Second, for the analysis of position combinations, data of all inactive positions were extracted per second, so we got one-second interval samples. Only combinations that included complete information of the body position, head position, ear position, eye closure and tail position were included. Incomplete recordings were samples with "out of sight" in one or more positions, which

means that the respective body part(s) of the focal animal could not be clearly defined in the moment of recordings. The duration for each position combination, which included complete information of the body position (standing and lying, including information on the lying positions), head position, ears position, eyes closure and tail position, was calculated across all husbandry systems and per husbandry system. The ten combinations that were observed for the longest across all husbandry systems and for each of the three husbandry systems were identified and are presented in a table.

3.3. Results

All results are based on 15-minute observations from 288 heifers (18 farm visits x 16 focal animals). The observation time per farm visit was on average four hours, thus eight hours per farm. The total observation time per husbandry system was consequently 24 hours.

3.3.1. Duration of being inactive

The average time the heifers spent inactive per 15-minute observation across all husbandry systems was 10:49 ± 4:54 minutes (mean ± standard deviation) and the average time they spent active was correspondingly 3:56 ± 4:43 minutes. The percentage of observed time the heifers spent inactive increased from pasture (57 % ± 39 %) to the semi-intensive (75 % ± 27 %) to the intensive husbandry systems (86 % ± 21 %; Figure 2).

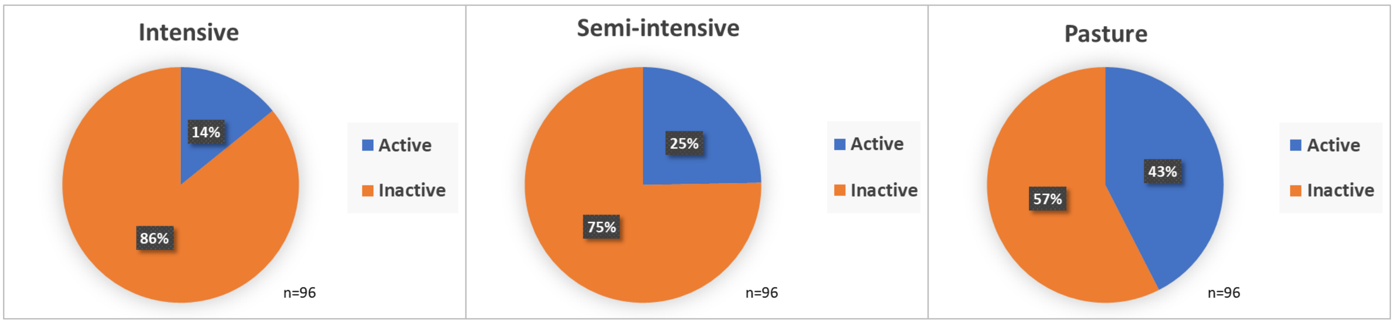

Figure 2. Average percentage of time the animals spent inactive and active across the three different husbandry systems

3.3.2. Duration of standing and lying while being inactive

When inactive, heifers on pasture spent more time standing than lying (58 % ± 45 % versus 42 % ± 45 %), while inactive heifers in the intensive and semi-intensive husbandry systems spent more time lying than standing (intensive: 57 % ± 47 % versus 43 % ± 47 %; semi-intensive husbandry system: 53 % ± 47 % versus 47 % ± 47 %; Figure 3).

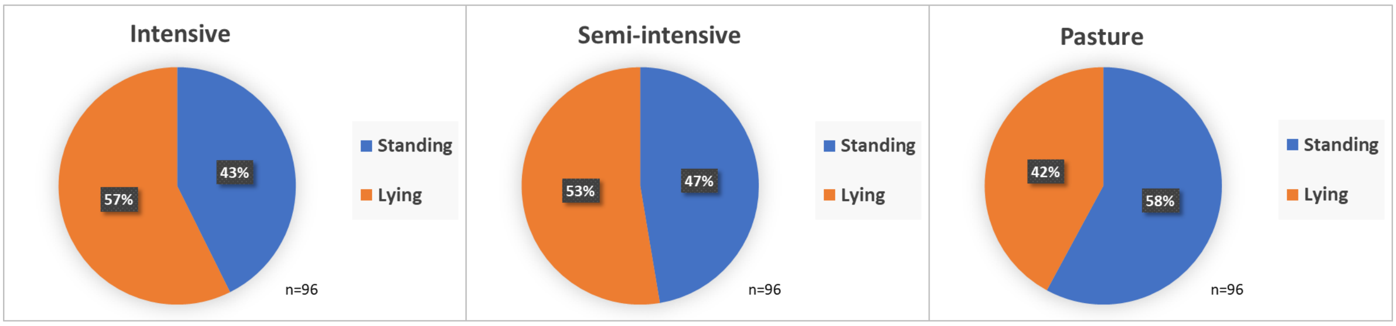

Figure 3. Average percentage of time the animals spent standing and lying across the three different husbandry systems

3.3.3. Duration of lying during morning and afternoon visits

Heifers in all husbandry systems spent more time lying inactively during the morning visits than during the afternoon visits (morning: 54-69 % ± 46 % vs. afternoon: 31-46 % ± 47 %) with reference to the total time they were lying inactively. On pasture, the heifers spent more than twice as long lying during the morning visits than during the afternoon visits (69 % ± 45 % vs. 31 % ± 40 %) (Figure 4).

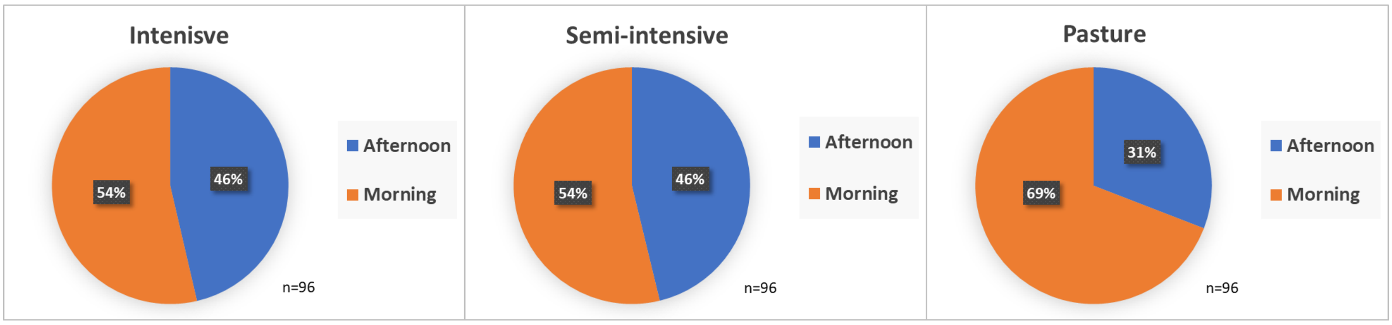

Figure 4. Relative distribution of time the animals spent lying inactively across the three different husbandry systems during morning and afternoon visits

3.3.4. Duration of the different lying positions while being inactive

Lying in chest-prone position with both front legs under the body was most prevalent across all husbandry systems (91 % ± 21 % in semi-intensive husbandry systems; 88 % ± 28 % on pasture; 82 % ± 30 % in intensive husbandry systems; Figure 5). Lying in chest-prone position with only one front leg under the body and the other front leg stretched was the second most common lying position in all husbandry systems, but was shown much less than when both front legs were under the body and mainly in intensive husbandry systems (14 % ± 27 %) and on pasture (11 % ± 25 %), but even less in semi-intensive husbandry systems (5 % ± 14 %; Figure 5). Lying in a lateral position with either the right or the left side of the trunk on the ground, was observed only rarely, for 1 % of the observation time on intensive (± 4 %) and pasture farms (± 9 %) and for only 0.2 % (± 2 %) in semi-intensive husbandry systems (Figure 5).

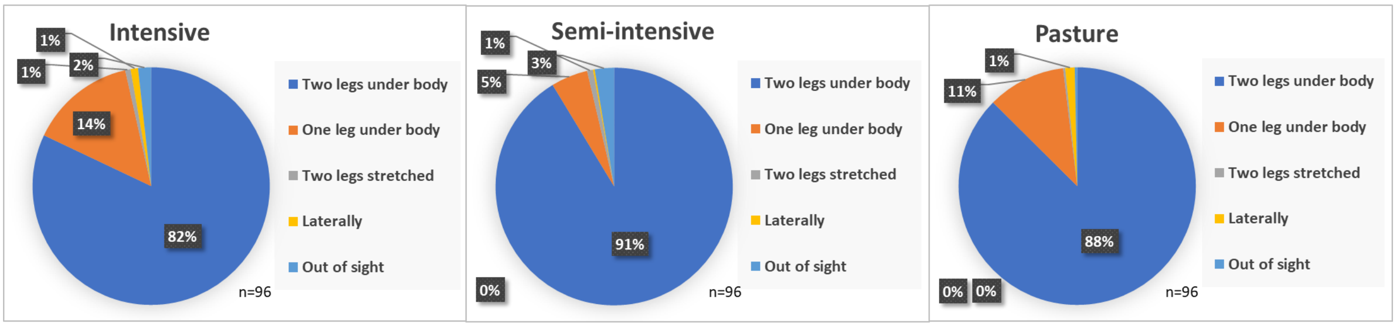

Figure 5. Average percentage of time the animals showed different lying positions across the three different husbandry systems

3.3.5. Duration of the different head positions while being inactive

In all husbandry systems, the animals' heads were held up for 80-89 % of the time the animals were inactive and this position was thus the most commonly recorded head position. The duration for which the head was held up did not differ greatly between the three husbandry systems (89 % ± 17 % on pasture; 85 % ± 20 % in intensive husbandry systems; 80 % ± 22 % in semi-intensive husbandry systems; Figure 6). Taking all other head positions together, they were shown for less than a quarter of the observation time across all husbandry systems.

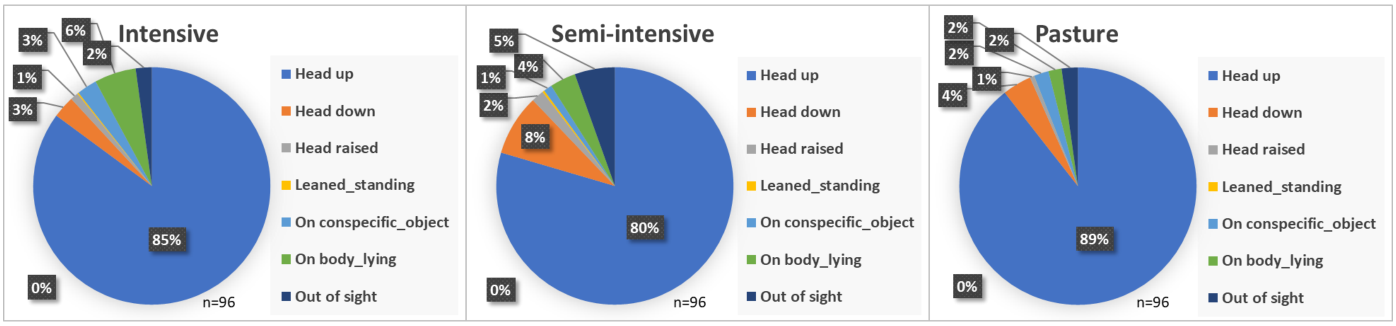

Figure 6. Average percentage of time the animals showed different head positions across the three different husbandry systems

3.3.6. Duration of the different ear positions while being inactive

Ears backwards, defined as both ears being behind the frontal plane, was the most common ear position in intensive (48 % ± 27 %) and semi-intensive husbandry systems (44 % ± 28 %; Figure 7).
Ears forwards, defined as, both ears are in or in front of the frontal plane, was the most shown ear position on pasture farms (39 % ± 31 %) and the second most shown position in intensive (33 % ± 27 %) and semi-intensive husbandry systems (37 % ± 29 %; Figure 7).
Ears asymmetrical, when the two ears are in two distinct positions relative to the frontal plane, was shown most prevalently in intensive (13 % ± 14 %), less in semi-intensive (10 % ± 12 %) and the least on pasture (4 % ± 12 %) farms (Figure 7). In contrast, heifers kept on pasture showed low ears, defined as both ears hanging to the sides, the tip of the ear pointing down, for longer (15 % ± 27 %) than heifers kept in semi-intensive (4 % ± 12 %) or intensive (2 % ± 8 %) husbandry systems (Figure 7).

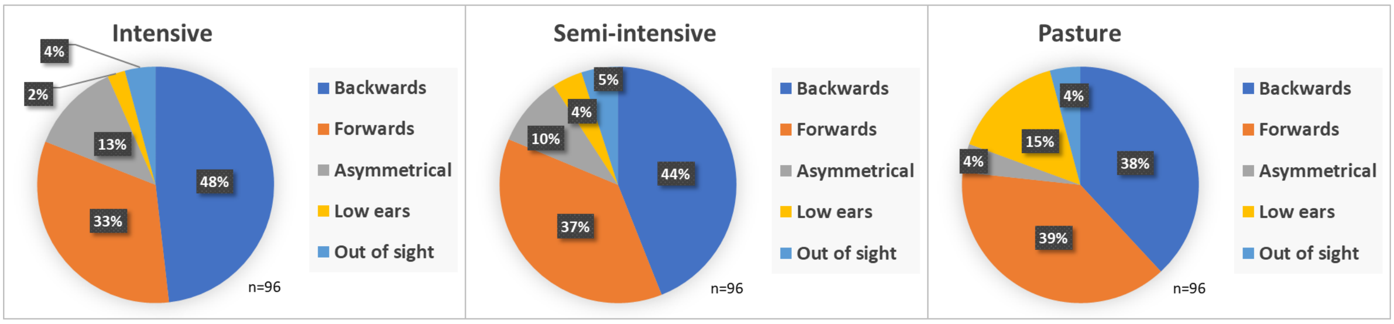

Figure 7. Average percentage of time the animals showed different ear positions across the three different husbandry systems

3.3.7. Duration of the eyes being open or closed while being inactive

Across all husbandry systems, the heifers' eyes were open for more than half of the observation time. Closed eyes were mostly recorded on pasture farms (34 % ± 93 %) compared to semi-intensive (12 % ± 23 %) and intensive husbandry systems (9 % ± 16 %; Figure 8).

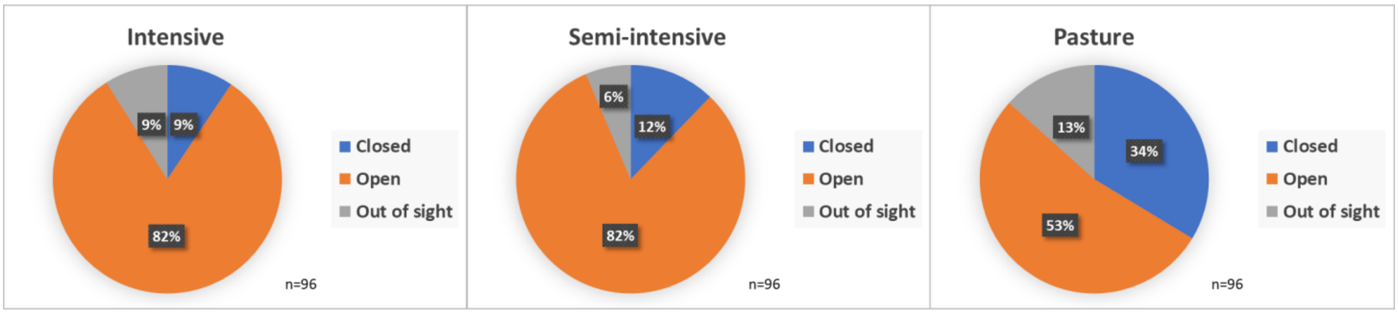

Figure 8. Average percentage of time the animals showed different eye positions across the three different husbandry systems

3.3.8. Duration of the tail hanging or moving while being inactive

The tail of the heifers was mainly in a hanging position across all three husbandry systems (99.9 % ± 0.90 % in intensive husbandry systems; 99.9 % ± 0.2 % in semi-intensive husbandry systems; 85 % ± 27 % on pasture). Tail in motion was almost exclusively recorded on pasture (13 % ± 25 %; Figure 9).

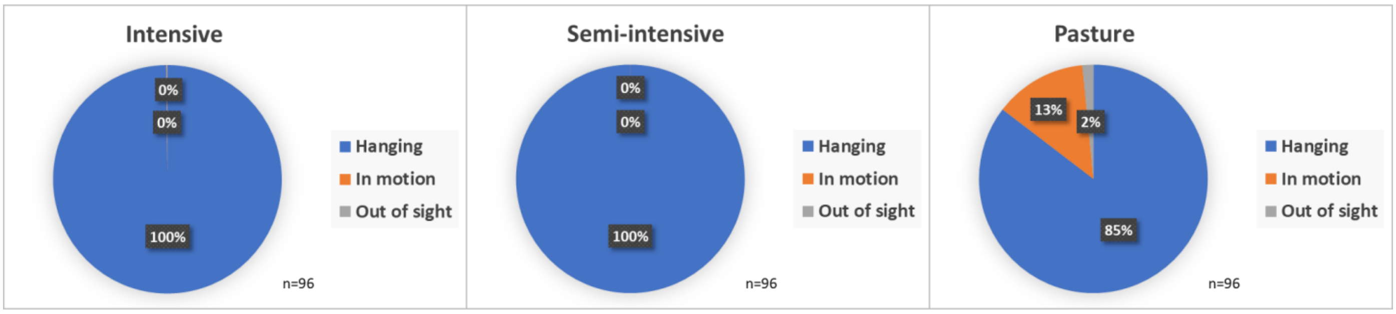

Figure 9. Average percentage of time the animals showed different tail positions across the three different husbandry systems

3.3.9. Distance to the closest conspecific while being inactive

Across all husbandry systems, the closest conspecific was within the individual distance of the focal animal for the longest time, (57 % ± 41 % in intensive husbandry systems; 66 % ± 38 % in semi-intensive husbandry systems; 69 % ± 39 % on pasture; Figure 10) followed by direct body contact in intensive (43 % ± 41 %) and semi-intensive husbandry systems (34 % ± 37 %; Figure 10). On pasture, however, focal animals spent more time outside the individual distance of their nearest conspecific than in direct body contact (19 % ± 35 % versus 12 % ± 27 %; Figure 10).

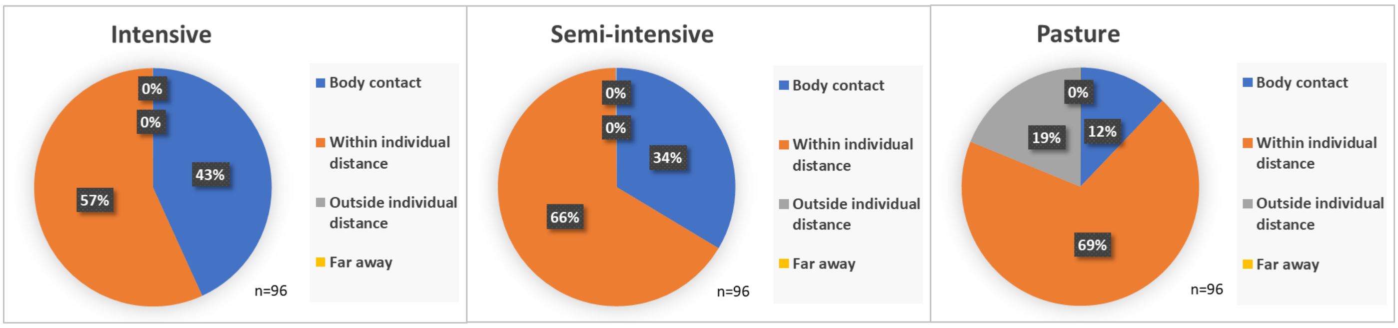

Figure 10. Average percentage of time the focal heifers spent in direct body contact, within or outside the individual distance or far away from her closest conspecific across all the three husbandry systems

3.3.10. Simultaneous occurrence of different combinations of positions

We analysed the simultaneous occurrence of different combinations of standing/lying, head, ear, eyes and tail positions within and across the three husbandry systems (Table 8). In total, we observed 118 combinations including combinations with "out of sight" (i.e. the exact position could not be clearly defined during the live observations). Excluding all combination with at least one "out of sight" component, 104 combinations were left. From these combinations, 67 were observed on intensive, 56 on semi-intensive and 69 on pasture farms.

The combination lying with both front legs under the body, head up, ears backwards, eyes open and tail hanging was the most prevalent combination in intensive and semi-intensive husbandry systems (intensive: 25.8 %; semi: 22.7 %; pasture: 7.7 %). This combination was observed for 20.1 % of the total time animals were observed inactive across all three husbandry systems (Table 8). On pasture, the combination lying with both front legs under body, head up, low ears, eyes closed and tail hanging was most prevalent (17.4 %). The share of this combination was 6.6 % of the total duration of observation of all combinations (Table 8).

The prevalence of combinations varied between the three farms within a husbandry system. In intensive husbandry systems, recordings of the most prevalent combination (lying with both front legs under the body, head up, ears backwards, eyes open and tail hanging) ranged between 7.0 % to 10.2 % based on the total duration of observation of all combinations in the intensive husbandry systems (15.0 hours). The combination in semi-intensive husbandry systems that was observed for the longest (lying with both front legs under the body, head up, ears backwards, eyes open and tail hanging) ranged between 6.5 % to 8.4 % of the observation time based on the total duration of all combinations of the semi-intensive husbandry systems (11.8 hours).

For the most prevalent combination on pasture, lying with both front legs under body, head up, low ears, eyes closed and tail hanging, the percentage duration ranged between 0.0 % and 10.9 % for the three farms based on the total duration of observation of all combinations of the extensive husbandry systems (9.5 hours).

When looking at the 10 most common combinations across all husbandry systems, standing occurred only in combination with eyes open, but not with eyes closed (Table 8).

Table 8. Duration as well as percentage out of total time spent inactive of the ten combinations of positions observed for the longest across all husbandry systems and for each of the three husbandry systems

Ranking of the prevalence	**Standing/Lying positions**	**Head positions**	**Ear positions**	**Eye closure**	**Tail positions**	**hh:mm:ss**	**% of total time**
All husbandry systems							
1	Lying two legs under body	Head up	Ears backwards	Eyes open	Tail hanging	7:16:34	20.1%
2	Standing	Head up	Ears forwards	Eyes open	Tail hanging	4:21:44	12.0%
3	Lying two legs under body	Head up	Ears backwards	Eyes closed	Tail hanging	3:42:45	10.2%
4	Lying two legs under body	Head up	Ears forwards	Eyes open	Tail hanging	3:38:22	10.0%
5	Standing	Head up	Ears backwards	Eyes open	Tail hanging	3:06:28	8.6%
6	Lying two legs under body	Head up	Low ears	Eyes closed	Tail hanging	2:24:11	6.6%
7	Lying two legs under body	Head up	Ears asymmetrical	Eyes open	Tail hanging	1:17:34	3.6%
8	Lying two legs under body	Head up	Ears forwards	Eyes closed	Tail hanging	0:58:05	2.7%
9	Lying one leg under body	Head up	Ears backwards	Eyes open	Tail hanging	0:54:55	2.5%
10	Standing	Head up	Ears asymmetrical	Eyes open	Tail hanging	0:54:43	2.5%
Intensive							% of intensive
1	Lying two legs under body	Head up	Ears backwards	Eyes open	Tail hanging	3:51:30	25.8%
2	Standing	Head up	Ears forwards	Eyes open	Tail hanging	2:02:35	13.7%
5	Standing	Head up	Ears backwards	Eyes open	Tail hanging	1:56:52	13.0%
4	Lying two legs	Head up	Ears forwards	Eyes open	Tail hanging	1:27:16	9.7%

	under body						
3	Lying two legs under body	Head up	Ears backwards	Eyes closed	Tail hanging	0:58:21	6.5%
7	Lying two legs under body	Head up	Ears asymmetrical	Eyes open	Tail hanging	0:47:10	5.3%
9	Lying one leg under body	Head up	Ears backwards	Eyes open	Tail hanging	0:38:16	4.3%
10	Standing	Head up	Ears asymmetrical	Eyes open	Tail hanging	0:35:07	3.9%
	Lying one leg under body	Head up	Ears asymmetrical	Eyes open	Tail hanging	0:14:15	1.6%
	Lying two legs under body	Head up	Ears asymmetrical	Eyes closed	Tail hanging	0:13:35	1.5%
Semi-intensive							% of semi
1	Lying two legs under body	Head up	Ears backwards	Eyes open	Tail hanging	2:41:13	22.7%
2	Standing	Head up	Ears forwards	Eyes open	Tail hanging	1:39:36	14.0%
4	Lying two legs under body	Head up	Ears forwards	Eyes open	Tail hanging	1:33:23	13.1%
3	Lying two legs under body	Head up	Ears backwards	Eyes closed	Tail hanging	1:20:13	11.3%
5	Standing	Head up	Ears backwards	Eyes open	Tail hanging	0:45:59	6.5%
6	Lying two legs under body	Head up	Low ears	Eyes closed	Tail hanging	0:34:14	4.8%
7	Lying two legs under body	Head up	Ears asymmetrical	Eyes open	Tail hanging	0:27:19	3.8%
8	Lying two legs under body	Head up	Ears forwards	Eyes closed	Tail hanging	0:22:40	3.2%
	Lying two legs under body	Head up	Ears asymmetrical	Eyes closed	Tail hanging	0:18:10	2.6%
10	Standing	Head up	Ears asymmetrical	Eyes open	Tail hanging	0:18:01	2.5%

Pasture							% of pasture
6	Lying two legs under body	Head up	Low ears	Eyes closed	Tail hanging	1:38:55	17.4%
3	Lying two legs under body	Head up	Ears backwards	Eyes closed	Tail hanging	1:24:11	14.9%
	Standing	Head up	Ears forwards	Eyes open	Tail in motion	0:52:25	9.2%
1	Lying two legs under body	Head up	Ears backwards	Eyes open	Tail hanging	0:43:51	7.7%
2	Standing	Head up	Ears forwards	Eyes open	Tail hanging	0:39:33	7.0%
4	Lying two legs under body	Head up	Ears forwards	Eyes open	Tail hanging	0:37:43	6.7%
	Standing	Head up	Ears backwards	Eyes open	Tail in motion	0:32:24	5.7%
5	Standing	Head up	Ears backwards	Eyes open	Tail hanging	0:23:37	4.2%
8	Lying two legs under body	Head up	Ears forwards	Eyes closed	Tail hanging	0:23:35	4.2%
	Lying one leg under body	Head up	Ears backwards	Eyes closed	Tail hanging	0:15:48	2.8%

Only combinations without any “out of sight” were considered. “Lying two legs under body”: Lying with both front legs tucked under the body. “Lying one leg under body”: Lying with one front leg tucked under the body.

3.4. Discussion

The aims of the present study were to develop an Inactivity Ethogram for cattle and to apply this ethogram to explore the duration of different positions while being inactive across different husbandry systems. The ethogram was developed including different positions of the whole body, the head, the ears, the closure of the eyes and the tail. Descriptive inspection of the data revealed the most common behaviours across husbandry systems. For example, regardless of the husbandry systems lying with both front legs under the body was most prevalent. Differences between husbandry systems considering some of the behaviour categories were found, which will be discussed below.

3.4.1. Discussion of the methods

3.4.1.1. Limitations and challenges regarding the methods

Austrian farms fattening their heifers on pasture are rare. Thus, we could not choose among pasture farms and had to include farms in the sample with replacement heifers instead heifers raised for beef. This meant that in one of the three pasture farms we observed some pregnant animals (in early stages of pregnancy). Moreover, due to the small number of animals on one pasture farm (n = 9), we did not have 16 different focal animals but had to observe seven animals twice during each of the two farm visits.

Ideally, we would have had 16 pens in intensive and semi-intensive husbandry systems avoiding repeated observations of the same pen and securing independent observations. It would also have been ideal to have 16 pastures to be able to choose focal animals from independent groups of animals. However, such conditions were not given in practice. In Austria, farms are relatively small, so that all animals are usually kept on one pasture.

In semi-intensive husbandry systems, the floor types were not similar. In one farm, pens were entirely straw bedded, one had fully-slatted floor in the front of the pen and straw bedding in the back and one solid concrete floor in the front and straw in the back. The behaviour of heifers on fully-slatted floor may differ from the behaviour shown on straw or on concrete floor. Differences in the behaviour, for example with regard to lying positions, became apparent when we compared intensive and semi-intensive farms. Unfortunately, we did not record the pen area in which the animals showed a certain behaviour. This could have helped in distinguishing the behaviour exhibited, for example, on slatted floors in intensive husbandry systems compared to the behaviour on slatted floors in semi-intensive husbandry systems. Still, lying areas were bedded with straw in all three semi-intensive farms.

Influence of the direct observation on the behaviour of the observed animals

The first time we entered the stable/pasture our presence was unfamiliar to the animals. This might have caused unrest. Therefore, we first spent time talking with the farmers inside the stable/on pasture and setting up our equipment before starting observations, so that the animals could get used to us and the equipment. Unrest could also occur for another reason - when our observation time got too close to the feeding times. Animals are used to their feeding times and may become restless when feeding is close. To avoid this, we scheduled the observations in accordance with feeding times, which we obtained from the farmers in advance.

Inter-observer reliability

For live observations, it is not possible to check for intra-observer reliability, but it is possible to check for inter-observer reliability. We did not formally test for inter-observer reliability, but with the help of videos from fattening cattle and on-site on four pilot farms, we trained the identification of the categories of the ethograms defined beforehand and compared the observations to make sure that Sara Hintze and I record the same position etc.

3.4.1.2. Suggestions for future studies

In this study, we described inactive behaviour across different husbandry systems. However, the present data does not allow associating positions of different body parts with positive or negative emotional states. To assess whether certain behaviours are truly indicative of the emotional state, future studies have to manipulate the emotions of the animals more specifically by e.g. keeping them in a very enriched husbandry system and in a very barren, low-stimulus environment, while controlling for other factors that may affect the animals' emotions. Moreover, to identify associations between certain positions and the emotional state, it would be possible to consider physiological measures such as the levels of stress hormones or heart rate variability parameters.

3.4.2. Discussion of the results

3.4.2.1. Discussion of the ethogram

In this study we developed the first Inactivity Ethogram for cattle. With its detailed descriptions of different positions, it provides a useful methodological tool for behavioural studies on inactivity and animal welfare. The detailed description of different body parts, like in our Inactivity Ethogram, is especially useful in the study of inactive behaviour associated with the study of emotional states (De Oliveira and Keeling, 2018). It may help, in conditions where the emotions of the animals are manipulated, to differentiate between positive (e.g. relaxation) and negative (e.g. depression) inactivity (as discussed above).

In our study, we applied the Inactivity Ethogram on Fleckvieh heifers. Adapting it to other cattle breeds, bulls and dairy cows needs further studies.

3.4.2.2. Inactive & active behaviour

The data was only evaluated graphically / descriptively, which means that differences are not necessarily statistically significant.

Across the compared husbandry systems, a variation of different inactive behavioural patterns could be observed. This may indicate that the differences of the husbandry systems have an influence on the animals. In this study, intensive systems with a lack of stimuli induced higher levels of inactivity (86 % = average percentage time the animals spent inactive within the observation time) than more extensive husbandry systems (75 % in semi-intensive husbandry systems and 57 % on pasture), in which the animals are faced with a wider range of stimuli. Also O'Connell and Beattie (2000) found in their study that pigs in barren environments showed inactive behaviour, like sitting, standing and lying with eyes open, for a greater duration than pigs in enriched environments. Furthermore, Bolhuis et al. (2006, 2005) noticed in their studies, in which they looked on the behavioural development of pigs in barren and substrate-enriched housing conditions, that the environment had a major influence on the behaviour of pigs - pigs housed in barren were less active than pigs in enriched housing environments. Fureix et al. (2016) found in studies with mice increased inactivity levels in mice kept in barren compared to mice kept in enriched conditions. Moreover, Meagher and Mason (2012) found that minks in non-enriched environments spent much more time lying still but awake than minks in enriched housing conditions.

Not only the lack of stimuli but also the lack of available space may lead to increased inactivity in intensive systems, but we cannot disentangle this effect, because the animals here were in entirely different husbandry systems, where apart from space also different floor types, stocking density etc. prevailed. On pasture farms, the animals were probably more active, compared to the other two husbandry systems, because they had the greatest freedom of movement and the water was further away than in intensive or semi-intensive husbandry systems.

Within the same husbandry system (data of three farms) there were variations regarding the time the heifers spent inactive and active. On one pasture farm, for example, heifers were more active (58 %, average percentage time) than on another farm (19 %). This may be due to a range of factors. For example, at the farm with the "most active" animals, there was no water provided on pasture, and on the farm with the "least active" animals some heifers were already pregnant. Also, the pastures had different sizes. However, due to the small sample size in terms of farms, no conclusions can be drawn on the actual effect of such factors on the (in)activity level.

3.4.2.3. Discussion of the different positions

Lying positions

Lying with both front legs under the body was the most prevalent lying position across all husbandry systems. Sambraus (1971) described rest on the sternum as the basic position in cattle. Thereby the front legs are often bent and pulled under or to the trunk. Haley et al. (2000) also found in their study lying with front exposed legs tucked as the most common position.

Laying laterally was seen less long but we made interesting observations. On intensive farms, the animals laid almost as long as on pasture (1 %) in a lateral position. This is interesting because one would expect that due to the higher stocking density the animals would have less space to lie laterally and therefore this position would occur less long. Do animals in intensive systems have pain in the joints, caused by the hard floor, and thus prefer to have less weight on their legs by lying laterally? A study by Elmore et al. (2015) investigated the effects of different flooring types on the behaviour, health, and welfare of finishing beef steers. Beef cattle, which were raised on fully slatted floors, showed increased joint swelling compared to cattle raised on fully slatted floors with rubber mats. However, even though we did not check the animals for joint swellings, we did not recognise swellings during our observations. Still, not only injuries such as lesions and swellings may affect the lying position but also mere discomfort from resting with protruding parts of the joints on hard surfaces.

According to Petru et al. (2009) lying with the belly exposed, like in a lateral position, is a vulnerable position and could therefore suggest relaxation, while lying belly down is likely to provide the fastest escape when the animal is awakened (Aristakesyan, 2009). Therefore, we can argue that cattle in intensive husbandry systems and on pasture were in a relaxed state. (Winckler, 2009) describes that this lying position occurs only sporadically and only for periods of a few minutes in cattle (cows: 15 min, heifers: 20 min) and is mostly observed on pasture or free lying areas.

Therefore, it is surprising that the heifers in semi-intensive husbandry systems, where the heifers had more space and a straw bedded lying area, spent less time (only 0.2 % compared to 1 %) in a lateral position than in intensive husbandry systems. This is against the interpretation that heifers in semi-intensive systems were in a more relaxed state than in intensive systems. However, the proportion of time spent in a lateral lying position was very low (1 %) and there was also variation between farms within a husbandry system.

Head positions

In this study we only differentiated between three head positions (head up, down & raised). In further studies it would be of advantage to include more categories of certain head positions, to get a more precise overview of the different head positions.

In this study head up was the most prevalent head position across all husbandry systems. There are hardly any studies discussing head positions in cattle, except for the study by De Oliveira and Keeling (2018) where they recorded ear, neck and tail positions in dairy cattle during feeding, brushing and queuing to identify connections between these positions and emotional valence. They found that during feeding (positively connoted activity) neck down (same as head down in our study), during queuing (negatively connoted) neck below the horizontal (same as head up) and during brushing (positively connoted) neck horizontal (same as head up) was the most common position. De Oliveira and Keeling (2018) underline the importance to do further research on neck positions and animal emotions. Due to the lack of studies on head positions, it is difficult to discuss the head positions, but there are already more studies for ear positions, so more can be discussed here.

Ear positions

Ears backwards

In our study ears backwards was the most common ear position in intensive (48 %, average percentage time the animals showed ears backwards) and semi-intensive (44 %) husbandry systems while it was the second most (38 %, 39 % ears forwards) in pasture systems. In studies with sheep and cattle, ears backwards has been associated with positive states (Reefmann et al., 2009; Proctor and Carder, 2014; Verbeek et al., 2012), whereas in studies with dogs, pigs and horses, ears backwards have been associated with negative situations (Heleski et al., 2009; Reimert et al., 2012; Tod et al., 2005). This shows that ear positions can have different meanings in different species. With our study, we cannot say if ears backwards indicate a positive or negative state in cattle.

Ears forwards

Ears forwards was the most shown ear position on pasture farms (39 %) and the second most shown position in intensive (33 %) and semi-intensive husbandry systems (37 %). In studies with dairy cattle (De Oliveira and Keeling, 2018) and sheep (Boissy et al., 2011; Reefmann et al., 2009) ears forwards was associated with negative situations. But whether ears forwards are indicative of positive or negative states in cattle cannot be answered with our data.

Ears asymmetrical

In the study by De Oliveira and Keeling (2018), where asymmetric ear positions in cattle were assessed for the first time, they found this ear position more frequently during brushing which could be associated with positive emotions. In studies with sheep, ears asymmetrical was associated with negative and sudden situations (Boissy et al., 2011; Reefmann et al., 2009), but also in situation which might be positive such as play (Chapagain et al., 2014)**.**

In our study, ears asymmetrical was shown most prevalent in intensive husbandry systems (13 %), less in semi-intensive (10 %) and the least on pasture farms (4 %).

With asymmetrical ear positions we did not distinguish between the left or the right ear pointing backwards or forwards. De Oliveira and Keeling (2018) looked at this differentiation in their study with dairy cows and found that in line with the concept of emotional lateralisation (Leliveld et al., 2013) right ear backwards might be connected with more positive situations than left ear backwards. The concept of emotional lateralisation assumes that negatively valenced states are processed predominantly by the right hemisphere, whereas positively valenced states are processed by the left hemisphere (Leliveld et al., 2013). In further studies it would be interesting to add the differentiation between left and right asymmetry to the Inactivity Ethogram.

Low ears

Low ears have been suggested as an indicator of positive emotional states (Boissy et al., 2011, Reefmann et al., 2009, Proctor and Carder, 2014) and were in our study mainly shown on pasture (15 % compared to 4 % in semi-intensive and 2 % in intensive husbandry systems). However, Gleerup et al., (2015) found that low ears may be a sign of pain. We do not have any indication that cattle on pasture were in pain and for this reason it might be more likely that they were in a more relaxed state than in pain.

Eyes

In our study closed eyes were mostly recorded on pasture farms (34 %) compared to semi-intensive (12 %) and intensive husbandry systems (9 %). Did heifers on pasture sleep more during our observations? This would be in line with findings that cattle on pasture have several rest and sleep periods during the day (Sambraus, 1971) while cattle in stables sleep mostly at night (Ternman et al., 2019). Our study also agrees with other studies showing that animals in enriched environments spend less time still with their eyes open than animals in barren environments (Fureix et al., 2016; Meagher and Mason, 2012).

Although eyes closed are considered as a sign of sleep in other studies, such as in the study from Fureix and Meagher (2015) with mice, and in the study from Meagher (2011) with mink, animals can also be awake with their eyes closed. We only know that sleep phases in cattle are characterized by closed eyes (Winckler, 2009), but closed eyes alone do not define sleep. Electroencephalographic (EEG) measurements together with electromyographic (EMG) signals have to be measured to determine if it is rest or sleep. Because of these circumstances, rest and sleep are often merged together in one category (Fureix and Meagher, 2015). However, it makes a difference in the interpretation of inactivity whether the animals are sleeping or resting with their eyes closed, because sleep is a subcategory of rest and has additional functions, which are still discussed (Siegel, 2009, 2008).

Tail

The tail is mostly hanging when cattle walk or graze. When they fend off flies, they usually raise the tail in about a 90° angle to the vertical line (Albright and Arave, 1997). Consequently, the fact that tail in motion was almost exclusively recorded on pasture might be explained by the flies.

Albright and Arave (1997) describe in their study that positions and movements of the tail can also be an indicator of the mood and activity of cattle. Studies in dogs (Quaranta et al., 2007), pigs (Reimert et al., 2012) and goats (Briefer et al., 2015) showed that tail in motion occurs generally in positively assessed situations. Another explanation for tails in motion mostly on pasture could therefore be that the heifers on pasture felt more comfortable than in the other husbandry systems. In further studies it would be of advantage to include more categories of certain tail positions, like in the study from De Oliveira and Keeling (2018), to get a more precise overview of the different tail positions.

3.4.3. Discussion of the information on the context

When space is unlimited, cattle keep a certain distance to their conspecifics, which is called individual distance (Winckler, 2009). Therefore, direct body contact occurred on pasture, compared to the other husbandry systems, for the shortest time (12 % on pasture compared to semi-intensive with 34 % and intensive husbandry systems with 43 %). Location of the nearest neighbour outside the individual distance (i.e. more than 1.5 cow lengths and less than 10 cow lengths to the nearest conspecific) occurred only on pasture, which can be explained by the relatively high stocking density and the comparably smaller size of the pens in the intensive and semi-intensive husbandry systems, which renders this distance between cattle almost impossible.

3.4.4. Discussion of the different combinations

Within the 10 most common combinations across all husbandry systems, standing occurred only in combination with eyes open, not with eyes closed. This is probably because cattle close their eyes mostly when they lie down and rest or sleep (Winckler, 2009). Furthermore, low ears occurred only in combination with eyes closed. This could be because low ears were observed mostly on pasture (15 % compared with 4 % in semi-intensive and 2 % in intensive husbandry systems), where the animals rested with low ears and closed eyes.

The more prevalent occurrence of closed eyes on pasture farms compared to the other two husbandry systems could be caused by the increased activity, resulting in more tired animals.

Lying with two legs under the body, head up, ears backwards, eyes open, tail hanging was the combination across all husbandry systems, which was observed for the longest. These findings are in line with the study from Haley et al. (2000) which looked at the activity and resting behaviour of dairy cows in two types of housing (tie-stalls on a concrete floor and large pens with a mattress flooring). In this study, during lying the most commonly observed position was front legs tucked (same as front legs under the body) and the head in an upright position (same as Head up). However, ears, eyes and tail positions were not recorded, limiting the comparability of that study with our result.

Our study provides first insight into the simultaneous occurrence of different body positions, head, ear and tail positions and the closure of the eyes in inactive cattle in different husbandry systems. However, conclusions about which positions and combinations could be positive or negative for animal welfare cannot be drawn from our data. It would be beneficial in further studies to look at the simultaneous occurrence of positions with respect to animal welfare to identify combinations that are specific to positive or negative welfare, respectively, and to thus be able to assess and potentially further improve the welfare of fattening cattle.

4. Conclusion

This study provided first insight into inactive behaviour of fattening and rearing cattle across different husbandry systems. The Inactivity Ethogram with its detailed description of different positions of the different body parts proved to be applicable during live observations. In the study of inactivity where overt behaviour is scarce, detailed observation of different parts of the body is desirable. Moreover, analysing co-occurring positions may help to get a more complete picture of the whole animal and to advance our understanding of what these positions mean for cattle welfare in the future. The Inactivity Ethogram may thus serve as a methodological tool for future research on the association between certain forms of inactivity and both negative and positive states, including boredom or depression-like states, and relaxation, respectively.

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6. List of figures and tables