Research report

Differences in lying positions, postures, angles between familiar and unfamiliar cows and in different types of weather in a pasture-based dairy herd in Uruguay

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1. Abstract

Lying is one the most important behaviours of the dairy cow and, therefore, an essential element in cow welfare. Lying behaviour can be affected by various factors, including social structures in the herd, housing system and weather. Cows are gregarious animals, live in groups with complex relationships and with familiar and unfamiliar cows. Lying areas in housing systems influence the way cows can perform their lying behaviour. When outside, cows tend to lie less and in different postures in bad weather. The aim of the present study was to determine if there is a difference in lying behaviour between familiar or unfamiliar cows which lie in pairs together on pasture. Lying position, posture and angle, and the type of weather have been recorded and analysed. This study was conducted in a pasture-based dairy herd of 180 cows in Uruguay. The study was divided into two phases. In phase 1, all cows that were lying together in pairs were recorded. In phase 2, all pairs of cows lying together were recorded and in addition their lying position, posture and angle were recorded. Also the type of weather was recorded. For analysis, all the pairs of cows from phase 2 were then divided into two groups. The pairs of cows which had been lying in a pair together in phase 1 as well, and therefore had shown preferential lying together at least twice, were seen as familiar cows and therefore labelled as the ''match'' group. The pairs of cows which had not been lying together in a pair in phase 1, were seen as unfamiliar cows and, therefore, labelled in the ''no match'' group in phase 2.

There were no significant differences in lying position, posture and angle between familiar (match) and unfamiliar (no match) cows. Cows were lying in position head - back 62,7% and 61,7%, in posture head up - head up 82,7% and 84,9% and in an angle between 136° and 180° in 40,0 and 43,4% in the match and no match group respectively. No significant differences were found in lying behaviour and type of weather (lying time was not recorded). An association between lying position and angle, and an association between posture and angle was found in all the observed pairs of cows, the ''no match'' group and the ''match'' group. Cows were lying in position head-back and an angle between 136° and 180°, and in posture head up-head up and an angle between 136° and 180° degrees, significantly more than in other combinations of lying positions, postures and angles. Although no differences in lying behaviour between familiar and unfamiliar cows was found, these data show a discrepancy between the lying behaviour of dairy cows on pasture and the observed lying behaviour in different housing systems. The ability to show natural lying behaviour may improve dairy cow welfare and, therefore, the results of this study could be used in future design of new housing systems.

2. Introduction

Lying is one of the most important behaviours of the dairy cow. Cows preferably lie down 10 to 13 hours a day (Fregonesi & Leaver, 2002; Phillips, 2007; Tucker *et al*., 2009). However, in different types of housing systems, the total lying time is between 8 and 15 hours a day (Endres & Barberg, 2007; Fregonesi & Leaver, 2002; Jensen *et al.*, 2005; Olmos *et al*., 2009; Tucker *et al*., 2009). If cows are deprived of lying, they become highly motivated to achieve these minimal amount of hours (Jensen *et al*., 2005). The need for a cow to lie down may be greater than the need for other basic needs, such as eating and drinking. Cows which were deprived of lying for three hours, choose to lie down before choosing other basic needs (Metz, 1985). Munksgaard *et al.* (2005) found when cows have limited time with free access to eating, lying and social contact, the proportion of time used for lying was increased, while the proportion of eating and social behaviour remained the same. These studies demonstrate the importance of lying behaviour to dairy cows and therefore lying time can be an indicator for animal welfare that can be monitored automatically (Crump *et al*., 2019). However, diseased or lame cows also show an increased lying time, so this should be taken into an account when considering lying behaviour (Ito *et al*., 2010).

Lying behaviour can be affected by various factors, including social structures, housing system and weather (Tullo *et al.,* 2019). Cows are known to have a strong social structure within the herd (Gutmann *et al*., 2014). This is based on a matriarchal group, where aggressive or dominance behaviour is particularly seen during the early determination of the hierarchy in the herd. The dominance relationships between the cows are very stable and can be persisting for years. This behaviour indicates that there are preferential relationships in the herd between certain cows. Affinities between cows include spatial proximity, reduced aggressive behaviour, more positive interactions and tolerance in competitive situations (Bouissou, 1974; Reinhardt, 1981, as cited in Bouissou *et al*. 2001). When looking at lying behaviour, Sambraus (1976) reported that cows do not lie down next to another cow at random and, therefore, cows choose their lying partner, often a familiar cow. Ewbank (1967) concluded that twin calves which were observed lying together did so because of their mutual rearing period, rather than genetical factors. Unrelated calves which were reared together demonstrated the same behaviour. Cows which grow up together and cows which share their last dry period together, have closer relationships than other cows within a herd. They have repeated encounters with specific other cows in the barn, while encountering 20% of the other herd members only once in a few days (Gutmann *et al*., 2014; Gygax *et al*., 2010). Likewise, at pasture, cows tend to choose to be near a familiar cow rather than an unfamiliar cow of the herd when grazing and lying down (Patison *et al*., 2010; Reinhardt *et al*., 1978; Takeda *et al*., 2000). Resting in near proximity of another cow is considered to be a relaxing situation and may therefore be only reserved for specific other cows (Gutmann *et al*., 2014). These studies show that the relationships and proximities of these cows are individual choices and non-random, and that cows have familiar and unfamiliar herd mates.

Lying behaviour is furthermore affected by type of housing. There are many different types of housing in the world. It has been reported that lying time, lying bouts, and lying frequencies of dairy cows can vary considerably in different types of housing (Charlton & Rutter, 2017). For example, in cubicle housing, lying times of 8,7 – 13,2 hours have been reported (Endres & Barberg, 2007), while in a loose straw yard cows were lying down for 12,3 – 14,1 hours a day (Fregonesi and Leaver, 2002). On pasture, on the other hand, uniparous and multiparous cows spend 10,8 – 11,5 hours lying down (Phillips & Rind, 2001) and pregnant heifers spend on average 9,5 hours a day on lying (Singh *et al*., 1994, as cited by Arnott *et al.,* 2016). The hours spend lying down on pasture are less than in indoor

housing, probably because the amount of time spent grazing and walking is higher on pasture than in indoor housing (Broom & Fraser, 2007; Charlton *et al*., 2013). Besides that, lying bouts are longer on pasture than indoors (Crump *et al.,* 2019; Olmos *et al.*, 2009), indicating the cows were more comfortable and less restless (Crump *et al.*, 2019). Furthermore, access to pasture reduces the incidence of lameness and mastitis in comparation with indoor housing (Fregonesi & Leaver, 2001; Haskell *et al.*, 2006). When considering the preference of cows for different type of housing, cows have a small to high preference for pasture. At daytime, cows had a partial preference for indoor housing or spend the same amount of time indoors and on pasture (Charlton *et al*., 2013; Crump *et al*., 2019; Falk *et al*., 2012; Legrand *et al*., 2009). However, at night cows had a strong preference for pasture, probably due to the heat stress they experience during the day and by a desire for a comfortable lying area (Charlton *et al*., 2013; West, 2003). Furthermore, in a study investigating the motivation of cows by pushing a weighted gate to access pasture, cows worked as hard to access pasture as they did to access fresh feed. In the evening hours they worked even harder. Interestingly, the authors suggested that the motivation to access pasture was not driven by hunger, as there was fresh feed inside the barn, but by the motivation to be outside per se and to be able to act on different behaviour outside, such as grazing and lying (Von Keyserlingk *et al*., 2017).

In general, pasture can offer spacious and comfortable places to lie down for dairy cows. This allows the cow to lie down in different postures and positions at the time and place the cow desires. Four lying postures have been suggested by Krohn & Munksgaard (1993). The most common posture is head up, followed by head back, head on the ground and flat on the side. On pasture, cows may lie down more in stretched postures or on their side, which is not possible in most types of housing systems, for example in cubicle housing (Krohn & Munksgaard, 1993; Van Erp-Van der Kooij *et al*., 2019). It has been reported that cows spend more time lying with their heads resting on the ground and with their head back when they are on pasture than in tie-stall barns (Ketelaar-de Lauwere *et al*., 1999; Krohn & Munksgaard, 1993). These postures are related to deep sleep (Ruckenbush, 1972). According to Ruckebusch (1972) cows have 10 to 12 periods of 4 to 5 minutes of deep sleep per day. In order to be able to achieve this sleep, the neck muscles of the cow need to be supported and the head needs to rest against the flank or on the ground (Ruckebusch, 1974).

In the Netherlands, almost all dairy cattle are kept in cubicle barns, partly or throughout the whole year (van der Peet *et al.*, 2018) In these housing systems cows don't have as much space as on pasture. In the barns, the cows have individual cubicles to lie down, mostly with some kind of bedding. The cubicles are separated by dividers, thus preventing cows to walk on the resting area and defecate there. Cows can lie down next to each other, in one direction with their heads in the same direction. It depends on the farm how many cubicles are next to each other and how they are divided in the house, so depending on the design, the cows can lie down in a particular position, posture and angle in such a house and therefore this affects the lying behaviour (Ouweltjes *et al*., 2003; Van Erp-Van der Kooij *et al*., 2019).

Furthermore, the type of weather affects the lying behaviour of cows on pasture. Cows spent significantly more time outdoors during summer (17,2 hours) than during winter (4,8 hours) (Krohn *et al*., 1992). Also the time spend outdoors decreases when rainfall increases (Ketelaar-de Lauwere *et al*, 1999). When exposed to experimentally induced wet and windy weather, cows spend only four hours a day lying down on pasture. Also it was reported that cows in these conditions had different lying postures; less time was spent on lying back with their head or with their head on the ground (Tucker *et al.*, 2007).

So, on pasture, where there is, in essence, unlimited space, cows can choose with whom and how they lie next to each other. Because cows do have preferential relationships within the herd,

interesting parameters are their lying positions, postures and angles in pairs together, and it is interesting if these parameters differ between familiar or unfamiliar cows and in different types of weather. Familiar cows show closer space proximity than unfamiliar cows (Bouissou *et al.*, 2001), so the personal space between two familiar cows is probably smaller (Philips, 2007) and this can make the cows lie down in different positions, postures and angles together. Furthermore, the head and its position to the body plays an important role in the communication of the cow, for example in aggressive or submissive behaviour (Schloeth, 1958, as cited in Bouissou, 2001). Lying next to a familiar neighbour can help in resting undisturbedly (Gygax *et al.*, 2010), while lying close with the head next to an unfamiliar cow could be challenging in this manner. This could change the way familiar or unfamiliar cows lie in pairs next to each other. In addition, a certain position, posture or angle could contribute to the relationship a pair of cows have, to maintain and/or strengthen their bond, as is known during allogrooming and grazing (Phillips, 2007). As unfamiliar cows have no bond, this could mean they position themselves differently than if this had been a familiar cow. It is, therefore, expected that there will be a difference in lying positions, postures and angles between familiar and unfamiliar cows when lying in pairs on pasture.

Lying positions of pairs of cows in familiar or unfamiliar pairs have not been studied before. When the lying positions of pairs of familiar and unfamiliar cows on pasture are investigated, basic knowledge can be obtained about the preferential lying positions between pairs of cows. In cubicle housing systems, cows are forced to lie down next to another cow in a certain direction, with limited options for the position, and it may be possible that cows do not prefer this position. On pasture, different positions can be chosen and it is important to know in which position they lie together if they have a choice. In this regard, the angle in which cows are lying together with familiar and unfamiliar cows is also an important parameter. Cows are forced to lie in a specific angle with their neighbours in a cubicle housing system, but on pasture they can choose in which angle they want to lie. As no previous study could be found about the angles between lying pairs of cows, this parameter would be interesting to study as well. In addition, studies involving different postures have been previously done (Ketelaar-de Lauwere *et* al., 1999; Krohn & Munksgaard, 1993; Van Erp-Van der Kooij *et al*., 2019), but these studies haven't considered the differences in postures of lying pairs of cows on pasture. When lying in pairs, the familiar cow can control the surroundings, as cows are predated animals, and the other cow can lie down in another posture, relax her neck and for example may have a few minutes of deep sleep in a different posture (Philips, 2007; Ruckenbush, 1972).

If there is a difference in lying behaviour between familiar and unfamiliar pairs of cows in these three parameters, this information could be used to determine if this preferred behaviour is possible in a cubicle housing system. When this lying behaviour is impossible in a cubicle housing system, this could be an argument to change the housing system and, thereby, maybe, enhance dairy cow welfare.

3. Aim of the study

If lying behaviour is affected by housing system, weather, social behaviour and the relationships which cows have within the herd, it is interesting to see how familiar cows are lying together on pasture compared to unfamiliar cows lying together. On pasture, there are no restrictions regarding the amount of space or the angle in which cows can lie down. As cows have preferential partners during feeding, grazing and lying, the assumption can be made that familiar cows may lie in different positions, postures and angles than unfamiliar cows do. It is expected that familiar cows lie more often with their head together than unfamiliar cows, and that the angle between familiar lying cows will be smaller than for unfamiliar cows. Furthermore, it is expected that familiar cows lie more often in postures whereby their head is not held upwards, for example the head in the flank or on the ground.

In different weather conditions, it is expected that the pairs of cows lie in a head - back position when the weather is rainy and/or windy, because cows will lie with their backs towards the rain and/or wind. Because of that, the angle is expected to be between 135° and 180° degrees in rainy or windy weather. Also it is expected that the cows will lie in a posture with their head up, due to the conditions of the grass in bad weather (Tucker *et al*., 2007).

Difference in lying behaviour among familiar or unfamiliar cows on pasture could be used to question our current view on the cubicle housing system and the way these barns are designed. It may be that familiar and unfamiliar cows lie differently together and in different positions, postures and angles than possible in cubicle housing and therefore could be an argument to change the current housing systems.

The aim of this study is to detect whether there are differences in lying position, posture and angle between familiar and unfamiliar cows, when they lie in pairs, and to detect whether there are differences in lying position, posture and angle in different types of weather in a pasture dairy herd in Uruguay.

4. Material and methods

4.1. Location and animals

Data were collected at the Campo Experimental Numero 2 of the Facultad de Veterinaria, Universidad de la Republica in Libertad, Uruguay, from the 1st of April until the 12th of May, 2014. The cows were grouped in one herd of approximately 180 cows of different breeds, the majority Holstein Friesians, and were kept on pasture 24 hours a day, all year round. The herd was moved to a different meadow every two or three days and the cows were milked twice a day in a milking parlour, around 5:00 a.m. and 5:00 p.m..

4.2. Data collection

The data collection was divided into two phases. Lasting one week, phase 1 was used to register all pairs of two cows lying together. If the cows were lying less than one cow body length away, it was determined that they were a pair. If the cows were lying further than one cow body length away, they were considered not lying together or alone. In addition, phase 1 was used to test and to get familiar with the ethogram, which would be used in phase 2. The time of day was registered when most cows were lying down to be able to be on time in phase 2. Furthermore, phase 1 was used to get used to the different pastures surrounding the milking parlour.

The next four weeks of the data collection were used for phase 2. During phase 2, the ethogram made and tested in phase 1 was used to register the lying position, the postures and the angles of pairs of cows lying together (for definitions used see Table 1). Furthermore, it was registered if the pairs of cows had been lying together in phase 1 or had not been lying together in phase 1.

4.3.Observations

During the data collection of five weeks, cows were observed for four to six hours a day, between approximately 8:00 and 11:00 a.m. and 12:00 and 15:00 p.m.. The observations were done, when most cows were lying down, called a lying period. Two lying periods a day were observed. The observations were mostly from Monday till Friday and sometimes on Saturday or Sunday. One observer did the data collection. Observed time differed every day, depending on how much time the cows were lying down in one lying period.

The cows were observed from a distance between 50 and 70 meters approximately, to prevent that the presence of the observer affected the cows and their behaviour. The data collection was performed when most of the cows were lying down, using binoculars. Between each lying period, all the cows had to be standing, in order to prevent registering the same pair of cows twice. The cows were registered with their individual ear tags.

4.4. Ethogram

In the ethogram used in phase 2 the following data have been collected of all pairs of cows; lying position, posture, angle and in general the type of weather of the days of observations (see Table 1). To make statistical analysis of the observations possible after the data collection, the lying position of the pairs and postures of the cows were recorded using a coding system in the ethogram.

Table 1. **Descriptive list of observed categories, used in the ethogram**

Observed categories	Description
Lying position	
Head - head	The pair of cows is lying with their heads towards each other.
Head - back	One of the cows in the pair is lying with her head to the backside of the other cow.
Back - back	The pair of cows is lying with their backs towards each other.
Postures	
Head up	The cow is lying on her sternum and her head is held up.
Head back	The cow is lying on her sternum and her head is turned towards the side of her body.
Head on ground	The cow is lying on her sternum and the head rests on the ground with a stretched neck.
Flat on side	The cow is lying flat on her side and her head is on the ground.
Angle (degrees °)	
0 – 45	The pair of cows lie together in an angle between 0 and 45 degrees.
46 – 90	The pair of cows lie together in an angle between 46 and 90 degrees.
91 – 135	The pair of cows lie together in an angle between 91 and 135 degrees.
136 – 180	The pair of cows lie together in an angle between 136 and 180 degrees.
Weather	
Sunny	There were no clouds and the sun was shining all day.
Cloudy	There were clouds in the air and the sun was not shining all day
Sunny/cloudy	There were partial clouds in the air, causing the sun to shine sometimes.
Cloudy/rainy	There were clouds in the air and it would rain light to moderate different periods of the day.

4.4.1. Lying position

Three lying positions of the pairs of cows were recorded. If cows laid with their head towards each other, this was registered as 'head - head'. If one cow laid with her head towards the back of the other cow, this was registered as 'head - back'. If the cows laid with their backs towards each other, it was called 'back - back'. In the ethogram 'head - head', 'head - back' and 'back - back were recorded as 1, 2, and 3 respectively.

4.4.2. Postures

The postures of the pairs of cows laying together was recorded. There are four different postures of the cow; head up, head back, head on the ground and flat on the ground, as shown in Figure 1. (Krohn & Munksgaard, 1993). 'Head up' was defined as the cow is lying on her sternum, with her head raised high. 'Head back' was defined as when the cow is lying on her sternum, and her head is turned towards her flank. 'Head on the ground' was defined as the cow is lying with a stretched neck and her head is lying on the ground in line with her body. And 'flat on ground' was defined as the cow lying flat on her side, with her head on the ground. Nine possible combinations of the postures were possible in a pair of cows. These combination were recorded as head up – head up (1), head up – head back (2), head up – head on ground (3), head back – head on ground (4), head back – head back (5), head on ground – head on ground (6), head up – flat on side (7), head back – flat on side (8) and head on ground – flat on side (9).

Figure 1. Four different postures of the cow: head up, head back, head on the ground and flat on the ground (Van Eerdenburg, 2020).

4.4.3. Angle

The smallest angle between the pairs of cows was recorded. The angle of both cows was taken from the craniocaudal line in between the shoulders, as the head of the cow varies is direction all the time and cannot be used to measure the angle. Four different angles were registered, between 0° – 45°, 46° – 90°, 91° and 135° and 136° and 180°. These angles were noted in the ethogram, as well with the coding system 1 - 4 respectively.

4.4.4. Weather

The weather was registered every day in phase 2. The types of weather in the autumn of Uruguay were called; sunny, cloudy, sunny/cloudy or cloudy/rainy.

4.5 Analysis and statistics

After phase 2, the data were used to create two groups; the 'match' group and the 'no match' group. Group 'match' consisted of cows which were lying together in phase 2 and had been lying together in phase 1 as well. Therefore, these pairs were registered as 'familiar' cows, as these cows choose to lie next to the same cow at least twice during the study. Group 'no match' consisted of cows lying together in phase 2, which had not been lying together in phase 1 and, therefore, were considered 'unfamiliar' cows. These outcomes were used to determine if there are differences in lying position, posture and angle between familiar (match) or unfamiliar cows (no match) and if there were differences in different types of weather. Furthermore, correlation between the three variables were analysed for all the pairs, the match group and no match group. Cows which did not have any match in phase 1, were excluded from the results.

Statistical analyses have been done using Microsoft Excel 2016 and SPSS Statistics 25 for Windows, using Chi Square Test and Fisher Exact Test.

5. Results

Out of 1130 pairs of cows observed during phase 2, data of 589 pairs were used. Cows that did not have any match in phase 1, were excluded from the data. Of these 589 pairs in phase 2, 75 pairs of cows were a 'match' and 514 pairs of cows were 'no match. Furthermore, it was observed that during the recorded lying periods, not one period all the cows of the herd were lying at the same time.

5.1.Lying position

Three lying positions for the pairs of cows have been mentioned; head - head, head - back and back - back. No significant difference was found between the match group and no match group in lying positions for the pairs of cows (P=0,6092). The majority of pairs of cows were lying in the position head - back, 62,7% and 61,7% respectively. In the match group, 20% of the pairs were lying in position head - head and 17,3% of the pairs were lying in position back - back. In the no match group 24,8% of the pairs were lying in position head - head and 13,5% in back - back position (See Table 2).

Table 2. **Percentages (%) of pairs of cows in lying position head - head, head - back and back - back in the match group and the no match group.**

	Head – Head	Head – Back	Back – Back
Match	20	62,7	17,3
No Match	24,8	61,7	13,5

5.2. Posture

Of the nine possible combinations of postures, five were observed: head up - head up, head up - head back, head up - head on ground, head back - head on ground and head back - head back. The other four were not observed and, therefore, have been kept out of the results. No significant difference between the match group and the no match group was found (P=0,7581). The observations show that 82,7% and 84,9% of the pairs of cows in the match and the no match group were lying head up - head up respectively. Head up - head back was observed 14,7% and 12,9% of the time and only a few pairs of cows were observed in the other three postures (See Table 3). No cows were lying together head up - head on ground in the match group and only 0.7% in the no match group were observed in this posture.

Table 3 **Percentages (%) of pairs of cows in postures head - head up (1), head up - head back (2), head up - head on ground (3), head back - head on ground (4) and head back - head back (5) in the match group and the no match group.**

	1.	2.	3.	4.	5.
Match	82,7	14,7	0	1,3	1,3
No match	84,9	12,9	0,7	0,1	1,4

5.3. Angle

5.3.1. Match and no match group

The pairs of cows were lying in different angles next to each other, divided in four groups; 0-45°, 46-90°, 91-135° and 136-180°. No significant difference was found between the match group and the no match group (P=0,4994). The majority of the pairs of cows were lying in an angle between 135° - 180°, 40,0% and 43,4% respectively (See Table 4).

Table 4. **Percentages (%) of pairs of cows in the four groups of angles observed in the match group and no match group.**

	0°-45°	46°-90°	91°-135°	136°-180°
Match	18,7	21,3	20,0	40,0
No match	13,4	27,6	15,6	43,4

5.3.2. Exact angles of all paired cows

Most of the cows (38,6%) were lying in an angle of 180°, or to say straight behind each other. Of the other angles, 25,3% were lying in an angle of 90°, 13,3% in an angle of 135° and 8,8% in an angle of 45°. 14,1% of the pairs were lying in a different angle than mentioned before (See Figure 2).

Figure 2. Percentages (%) of exact angles of all pairs of cows observed.
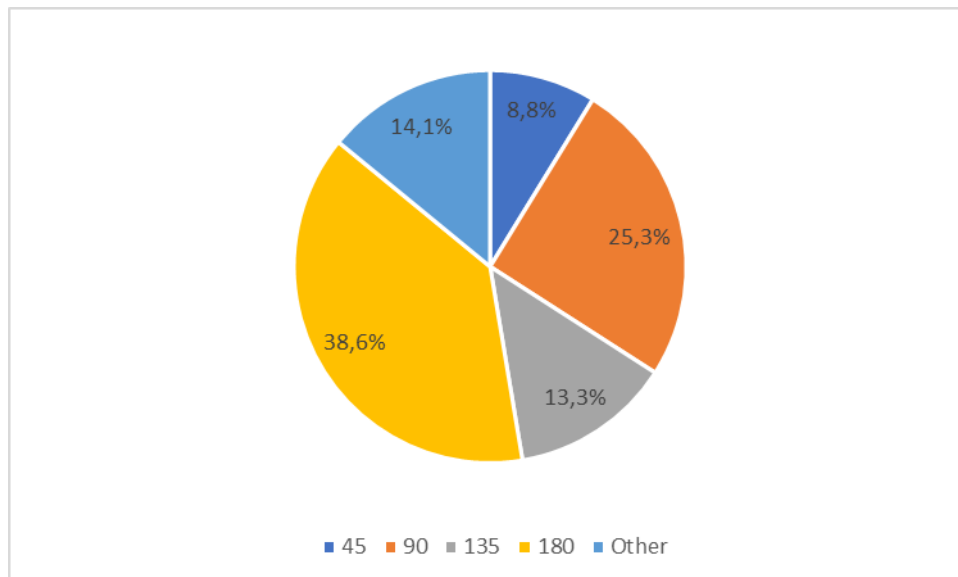
5.4. Weather

During phase 2, in April and May (autumn) in Uruguay, four types of weather have been registered; sunny, cloudy, sunny/cloudy and cloudy/rainy. Lying position, posture and angle have been compared on these different days in order to see if there was a difference in lying positions, postures and angles with different types of weather for all observed pairs of cows.

5.4.1. Lying position

No significant differences in lying position in different types of weather have been found (P=0,1922), (See Table 4). The majority of cows were lying head - back in the four different types of weather registered. Although not significant, it can be noticed that in sunny weather, more cows were lying back - back than in the other weather types cloudy, sunny/cloudy and cloudy/rainy (See Table 5).

Table 5. **Percentages (%) of type of weather and lying positions of all pairs of cows observed.**

	Lying positions		
Weather type	Head - Head	Head - Back	Back - Back
Sunny	28,3	51,3	20,5
Cloudy	27,1	62,8	10,1
Sunny/cloudy	20,4	66,9	10,1
Cloudy/rainy	21,3	64,9	13,8.

5.4.2. Posture

When looked at the postures of the pairs of cows in different types of weather, there is no significant difference (P=0,5482). Most of the pairs of cows were lying head up - head up, followed by head up - head back. Very few pairs of cows were lying in different postures. Interestingly, not one cow showed posture head on ground, when the weather type was cloudy or cloudy/rainy. This posture was only seen when the weather type was sunny or sunny cloudy. In weather type cloudy/rainy, only the postures head up - head up and head up - head back were observed (See Table 6).

Table 6. **Percentages (%) of types of weather and postures head - head up (1), head up - head back (2), head up - head on ground (3), head back - head on ground (4) and head back - head back (5) for all pairs of cows observed.**

	Postures				
Weather type	1.	2.	3.	4.	5.
Sunny	80	17,3	1,9	0,4	0,4
Cloudy	89,7	9,3	0	0	1
Sunny/cloudy	85,7	11,7	1,5	0,2	2
Cloudy/rainy	85,6	14,4	0	0	0

5.4.3. Angle
No significant differences were found between the types of weather and angle (P=0,3913). The majority of the pairs of cows were lying in an angle between 135° - 180° in all four weather types. In cloudy weather less pairs of cows were lying in an angle between 46° - 90° and were lying more in an angle between 91° - 135° in comparison with the other types of weather (See Table 7).

Table 7. **Percentages (%) of types of weather and angles of all pairs of cows observed.**

	Angle			
Weather type	0°-45°	46°-90°	91°-135°	136°-180°
Sunny	13,2	33,2	13,1	40,5
Cloudy	13,2	16,4	21,3	49
Sunny/cloudy	14,4	25,5	16,7	43,4
Cloudy/rainy	11,8	30,4	15,4	42,3

5.5. Association between lying position and postures
No significance was found between lying position and posture for all pairs of cows (P=0,677), the match group (P=0,331) or the no match group (p=0,410) with the Fisher's Exact test (See Table 8, 9 and 10). Although not significant, the majority of all the pairs of cows were lying in the position head - back, with a head up - head up posture (51,6%). So, in total more than half of the observations were in this combination. When looked at all the pairs of the cows which were lying in posture head up - head up, 60,9% were lying in the head - back position, 24,7% in the head - head position and 14,3% in the back - back position. The position back - back and posture head up - head on ground was not observed during phase 2.

Table 8. Observed frequencies and percentages of lying positions and postures head - head up (1), head up - head back (2), head up - head on ground (3), head back - head on ground (4) and head back - head back (5) of all the observed pairs of cows.

			Postures					
			1.	2.	3.	4.	5.	Total
Lying position	Head - head	Count	186	27	1	0	3	217
		% of Total	20,9%	3,0%	0,1%	0,0%	0,3%	24,4%
	Head - back	Count	459	78	5	1	6	549
		% of Total	51,6%	8,8%	0,6%	0,1%	0,7%	61,8%
	Back - back	Count	108	12	0	1	2	123
		% of Total	12,1%	1,3%	0,0%	0,1%	0,2%	13,8%
	Total	Count	753	117	6	2	11	889
		% of Total	84,7%	13,2%	0,7%	0,2%	1,2%	100,0%

In the match group and no match group it was observed that the cows were lying 53,3% and 51,5% in position head - back and posture head up - head up respectively (See Table 9 and 10). Posture head up - head on ground was not seen in the match group.

Table 9. Observed frequencies and percentages of lying positions and postures head - head up (1), head up - head back (2), head up - head on ground (3), head back - head on ground (4) and head back - head back (5) of the match group.

			Postures					
			1.	2.	3.	4.	5.	Total
Lying position	Head - head	Count	10	4	0	0	1	15
		% of Total	13,3%	5,3%	0,0%	0,0%	1,3%	20,0%
	Head - back	Count	40	6	0	1	0	47
		% of Total	53,3%	8,0%	0,0%	1,3%	0,0%	62,7%
	Back - back	Count	12	1	0	0	0	13
		% of Total	16,0%	1,3%	0,0%	0,0%	0,0%	17,3%
	Total	Count	62	11	0	1	1	75
		% of Total	82,7%	14,7%	0,0%	1,3%	1,3%	100,0%

Table 10. Observed frequencies and percentages of lying positions and postures head - head up (1), head up - head back (2), head up - head on ground (3), head back - head on ground (4) and head back - head back (5) of the no match group.

			Postures					
			1.	2.	3.	4.	5.	Total
Lying position	Head - head	Count	176	22	1	0	3	202
		% of Total	21,6%	2,7%	0,1%	0,0%	0,4%	24,8%
	Head - back	Count	419	72	5	0	6	502
		% of Total	51,5%	8,8%	0,6%	0,0%	0,7%	61,7%
	Back - back	Count	96	11	0	1	2	110
		% of Total	11,8%	1,4%	0,0%	0,1%	0,2%	13,5%
	Total	Count	691	105	6	1	11	814
		% of Total	84,9%	12,9%	0,7%	0,1%	1,4%	100,0%

5.6. Association between lying position and angle

There was an association between lying position and angle, when considering all the pairs of phase 2 (p=0,000), the match group (p=0,0013) and the no match group (p=0,000) with the Chi Square Test (See Tables 10, 11 and 12). The higher P-value for the match group is probably due to the limited number of observations of that group. Almost one third of all the pairs of cows (32,6%), were lying together in lying position head - back and in an angle between 136° - 180°. When considering only the position head - back of all the pairs of cows, 52,8% of the pairs were lying in an angle between 136° and 180°, 24,6% of the pairs were lying in an angle of 46° and 90°, 18,0% of the pairs of cows were lying in an angle between 91° - 135° and only 4,7% of the pairs were in angle between 0° - 45° (See Table 10).

Table 11. Observed frequencies and percentages of the combinations of lying position and angles of 0° - 45° (1), 46° - 90° (2), 91° - 135° (3) and 136° - 180° (4) of all the observed pairs of cows.

			Angle				
			1.	2.	3.	4.	Total
Lying position	Head - head	Count	81	57	21	58	217
		% of Total	9,1%	6,4%	2,4%	6,5%	24,4%
	Head - back	Count	26	135	98	290	549
		% of Total	2,9%	15,2%	11,0%	32,6%	61,8%
	Back - back	Count	16	49	23	35	123
		% of Total	1,8%	5,5%	2,6%	3,9%	13,8%
	Total	Count	123	241	142	383	889
		% of Total	13,8%	27,1%	16,0%	43,1%	100,0%

In the match group and no match group, 32,0% and 32,7% of the pairs of cows were lying in the position head - back and an angle between 136° - 180° respectively. Of the position head - back in the match group, 51,0% of the pairs of cows were lying in an angle between 136° and 180°, 20,7% in an angle between 46° - 90° and 91° - 135° and only 6,8% in an angle between 0° and 45° (see Table 11). In the no match group, 53% of the pairs of cows which were lying in the position head - back, were lying in an angle between 136° - 180°, 25,0% of the pairs were lying in an angle between 45° - 90°, and in an angle between 91° - 135° and 0° - 45° the pairs of cows were lying 17,5% and 4,5% respectively (see Table 12). So, of the pairs of cows in the position head - back, more than half of the pairs was lying in an angle between 136° and 180°.

Table 12. Observed frequencies and percentages of the combinations of lying position and angles of 0° - 45° (1), 46° - 90° (2), 91° - 135° (3) and 136° - 180° (4) of the match group.

			Angle				
			1.	2.	3.	4.	Total
Lying Position	Head - head	Count	7	3	2	3	15
		% of Total	9,3%	4,0%	2,7%	4,0%	20,0%
	Head - back	Count	3	10	10	24	47
		% of Total	4,0%	13,3%	13,3%	32,0%	62,7%
	Back - back	Count	4	3	3	3	13
		% of Total	5,3%	4,0%	4,0%	4,0%	17,3%
	Total	Count	14	16	15	30	75
		% of Total	18,7%	21,3%	20,0%	40,0%	100,0%

Table 13. Observed frequencies and percentages of the combinations of lying position and angles of 0° - 45° (1), 46° - 90° (2), 91° - 135° (3) and 136° - 180° (4) of the no match group.

			Angle				
			1.	2.	3.	4.	Total
Lying position	Head - head	Count	74	54	19	55	202
		% of Total	9,1%	6,6%	2,3%	6,8%	24,8%
	Head - back	Count	23	125	88	266	502
		% of Total	2,8%	15,4%	10,8%	32,7%	61,7%
	Back - back	Count	12	46	20	32	110
		% of Total	1,5%	5,7%	2,5%	3,9%	13,5%
	Total	Count	109	225	127	353	814
		% of Total	13,4%	27,6%	15,6%	43,4%	100,0%

5.7. Association between posture and angle

An association was found between posture and angle (p=0,008) for all the pairs of cows and in the no match group (p=0,009) with the Fisher Exact Test. In the match group, no association between posture and angle was found (p=0,508), possibly due to the limited number of observations. As shown in Table 13, the pairs of cows in posture head up - head up and in an angle between 136° - 180° were the most observed (34,1%). When looked at the most observed posture, head up - head up, 40,3% of the pairs of cows were lying in an angle between 136° - 180°, 28,8% of the pairs of cows were lying in an angle between 46° - 90°. An angle of 0° and 45° and 91° - 135° was observed in 14,5% and 16,4% of the time in combination with posture head up - head up respectively.

Table 14. Observed frequencies and percentages of the combinations of posture and angles of 0° - 45° (1), 46° - 90° (2), 91° - 135° (3) and 136° - 180° (4) from all the observed pairs of cows.

			Angle				
			1.	2.	3.	4.	Total
Posture	1.	Count	109	217	124	303	753
		% of Total	12,3%	24,4%	13,9%	34,1%	84,7%
	2.	Count	11	22	17	66	116
		% of Total	1,2%	2,5%	1,9%	7,4%	13,0%
	3.	Count	0	2	0	4	6
		% of Total	0,0%	0,2%	0,0%	0,4%	0,7%
	4.	Count	1	0	0	1	2
		% of Total	0,1%	0,0%	0,0%	0,1%	0,2%
	5.	Count	2	0	1	9	12
		% of Total	0,2%	0,0%	0,1%	1,0%	1,3%
	Total	Count	123	241	142	383	889
		% of Total	13,8%	27,1%	16,0%	43,1%	100,0%

In the match group not one pair of cows was lying in posture head up - head on ground, so this posture was excluded in Table 14. In the match group and the no match group, when considering the posture head up - head up, 35,4% and 40,6% of the pairs of cows were lying in an angle between 136° - 180° respectively. In the match group, the posture head up - head up was observed in 22,6% in an angle between 46° - 90° and 91° - 135° and 19,3% in an angle between 0° - 45°. In the no match group these were 29,3% in an angle between 46° - 90° degrees, 15,9% in an angle between 91° - 135° and 14% in an angle between 0° - 45° (See Table 14).

Table 15. Observed frequencies and percentages of the combinations of posture and angles of 0° - 45° (1), 46° - 90° (2), 91° - 135° (3) and 136° - 180° (4) of the match group.

			Angle				
			1.	2.	3.	4.	Total
Posture	1.	Count	12	14	14	22	62
		% of Total	16,0%	18,7%	18,7%	29,3%	82,7%
	2.	Count	1	2	1	7	11
		% of Total	1,3%	2,7%	1,3%	9,3%	14,7%
	4.	Count	0	0	0	1	1
		% of Total	0,0%	0,0%	0,0%	1,3%	1,3%
	5.	Count	1	0	0	0	1
		% of Total	1,3%	0,0%	0,0%	0,0%	1,3%
Total		Count	14	16	15	30	75
		% of Total	18,7%	21,3%	20,0%	40,0%	100,0%

Table 16. Observed frequencies and percentages of the combinations of posture and angles of 0° - 45° (1), 46° - 90° (2), 91° - 135° (3) and 136° - 180° (4) of the no match group.

			Angle				
			1.	2.	3.	4.	Total
Posture	1.	Count	97	203	110	281	691
		% of Total	11,9%	24,9%	13,5%	34,5%	84,9%
	2.	Count	10	20	16	59	105
		% of Total	1,2%	2,5%	2,0%	7,2%	12,9%
	3.	Count	0	2	0	4	6
		% of Total	0,0%	0,2%	0,0%	0,5%	0,7%
	4.	Count	1	0	0	0	1
		% of Total	0,1%	0,0%	0,0%	0,0%	0,1%
	5.	Count	1	0	1	9	11
		% of Total	0,1%	0,0%	0,1%	1,1%	1,4%
Total		Count	109	225	127	353	814
		% of Total	13,4%	27,6%	15,6%	43,4%	100,0%

6. Discussion

In this study, there were no differences found in lying positions, postures, angles or differences in lying behaviour with different types of weather between familiar and unfamiliar cows in a pasture-based dairy herd. Observed lying positions, postures and angles between pairs of cows are relevant when cows are lying down next to each other. Cows choose to lie down and stand at the feed bunk next to a specific cow in a non-random manner (Sambraus, 1976; Val-Laillet *et al*., 2009). This is due the relationship of the cows within the herd. In the present study, differences were expected regarding the way familiar and unfamiliar cows were lying together in pairs. However, this was not observed. As familiar cows have closer space proximity than unfamiliar cows and their head is an important part in the communication of the cow, it was expected that cows would lie down in position head – head more often than unfamiliar cows. In this regard it was also expected that the angle between a pair of familiar cows would be smaller than of an unfamiliar pair of cows. Furthermore, it was expected that familiar pairs of cows would lie more often in different postures than head up together, as the familiar cow could be vigilant. Most of the previous studies have been done indoors (Gutmann *et al*., 2014; Gygax *et al*., 2010; Val-Laillet *et al*., 2009), and cows are known to behave differently when they are on pasture (Krohn & Munksgaard, 1993). In addition, it is possible that the study design was not ideal for this study. The first week of the study was used to observe which cows were lying together. This was then used to refer to cows as "familiar" or ''unfamiliar''. Also cows which were lying aside an unfamiliar cow, were recorded as an familiar cow. This observation period may be too short to be able to interpret these complex relationships on lying behaviour, based only on this week of observation. However, in other studies animals were observed for 2,5 days (McLennan, 2013) or even one day (Gygax *et al*., 2010) to determine the level of familiarity. On the other hand, these studies did use focal animals with a selected number of cows being observed within the herd. This was not done in the present study, in which all cows were observed. Since the herd consisted of approximately 180 cows, this may be a group too big to observe thoroughly for familiar relationships. Instead of observing all the cows when lying down in pairs, a number of cows could have been observed for all affiliative behaviour during the day, for example when grazing or walking. On the other hand, with that way of observing, not all the cows in the herd would have been observed and social relationships within the entire herd might have been missed. It could also mean that cows lie next to a preferred cow, but that the way they lie next to this other cow is less relevant for cows, regarding to position, posture and angle and, therefore, no differences were observed in the results between familiar and unfamiliar cows in lying positions, postures and angles. No explanation was found in the present study. Future research could differentiate between familiar and unfamiliar pairs of cows in a different study design and determine their lying behaviour in pairs of cows. Moreover, cows on pasture tend to lie down the majority of time (Legrand *et al*., 2009; Falk *et al*., 2012). In this present study, it was impossible to observe the pairs of cows during the night, because of the lack of light. However, observing the herd during the night could increase the knowledge of their lying behaviour in pairs. This present study analysed the differences in lying positions, postures and angles between pairs of cows. It did not include the analysis of which specific pairs of cows were next to each other, which was beyond the scope of this study. In future research this could be included, so the understanding of the relationship between (specific) pairs of cows can be enhanced.

In the present study, an association was observed between lying position and angle, when considering all the matches in phase 2, but also in the match and the no match group. Almost one third of all cows were lying in a position head - back and an angle between 136° and 180°. When considering the position head - back only, more than half of these cows were lying in an angle

between 136° and 180°. Cows live necessarily in a herd to reduce the risk of predation and have an excellent eyesight (Doyle & Moran, 2015). Cows have a 330° vision (Doyle & Moran, 2015), so the position head - back may be a sign of trust between two cows, given that the second cow can see less of the surroundings than the first cow because the first cow limits her view. On the other hand, the second cow can see more behind the two cows, as her range of sight goes beyond the sight of the first cow. Also, it can be a way of getting out of the wind and/or rain by lying behind another cow, as cows may lie in a position to minimize the amount of body area exposed to wind and rain (Tucker et al., 2007). Furthermore, there is evidence that cows align their body axis in a north-south direction, due to magnetic fields on earth (Begall et al., 2008). In this way, the angle between 136° and 180° makes sure the body axes are all aligned in this direction. However, this evidence has been contradicted by other studies (Hert *et al*., 2011). There was also an association between posture and angle within all the pairs observed in phase two and the no match group. More than one third (34,1% for all the pairs and 34,5% for the no match group) of the cows were lying in the posture head up - head up and in an angle between 136° and 180°. This combination may be favourable for the cow, as both cows can monitor the surroundings by this posture, as with the lying position mentioned before.

Although there were no significant differences in the lying position, postures and angles between familiar and unfamiliar cows, the results are useful regarding the way we view the use of cubicle housing systems and the welfare of dairy cows. In the present study, lying positions head - head, head - back and back - back were recorded. Position head - back was the most observed position, with 62,7% and 61,7% of the pairs of cows in this lying position in the match and no match group respectively. In a cubicle housing system it is simply impossible to lie down in this preferred position. If there is one single row of cubicles in the barn, the cows can only lie down in proximity of another cow in a cubicle next to them. If the cubicles are designed in double rows, the cows can lie with their heads towards each other as well. This means that position head - head is the only possible position in a cubicle housing system if there are double rows. In the present study, 20% and 24,7% in the match and not match group respectively were lying in this position.

The observed pairs of cows were lying 82,7% and 84,9% in posture combination head up - head up in the match and no match group respectively. Although there are no other studies comparing the postures of cows lying in pairs to the author's knowledge, it has been reported in previous studies that over 80% of the cows were lying in a head up position (Krohn & Munksgaard,1993; Endres & Barberg, 2006). Nevertheless, other postures were also observed in this study. For example, posture head up - head back was observed 14,7% and 12,9% in the match and no match respectively. Time spent with the head back, head on the ground or flat on the side is longer for cows on pasture than for cows in tie-stall barns (Ketelaar-de Lauwere *et al*., 1999; Krohn & Munksgaard, 1993). This difference was also observed when comparing cows on pasture and cows in a cubicle housing system (Van Erp-Van der Kooij *et al*., 2019). This indicates that the housing system influences the posture which a cow assumes and, moreover, it implies that the choice of certain postures is limited or restricted in cubicle housing systems and tie-stall barns (Ketelaar-de Lauwere *et al*., 1999; Krohn & Munksgaard, 1993; Van Erp-Van der Kooij *et al*., 2019). Furthermore, the other postures, head back and head on ground, are in close relationship with deep sleep. According to Ruckebusch (1972) cows have 10 to 12 periods of 4 to 5 minutes of deep sleep per day. In order to be able to achieve this sleep, the neck muscles of the cow need to be supported and the head needs to rest against the flank or on the ground (Ruckebusch, 1974). Krohn & Munksgaard (1993) concluded that the reduced time of lying in the postures head - back, head on ground or flat on side indicates that tie-stall systems had more influence on resting of the head than for example the quality of the lying place for these cows. Although these postures were observed much less than the posture head up - head up, this does not

mean that these postures are not important to cows. In the present study, posture flat on the side was not observed, but this posture is only seen a few minutes a day (Krohn & Munksgaard, 1993) and, therefore, might have been missed during the observations. Posture head up - head back and head back - head back were seen multiple times.

In the present study 40,0% and 43,4% of the pairs of cows were lying in an angle between 136° and 180° in the match and no match group respectively. As mentioned above, this may be due to the aligning to the magnetic fields (Begall *et al*., 2008) or a favourable angle for cows lying together as a gregarious and predated animal. In the cubicle housing system, it is impossible to lie down in this angle due to the design of the cubicles. The other angles were less observed, but the distribution of the different angles between all the pairs of cows in the present study, showed that cows do prefer to lie down in different angles, instead of the required angle between neighbouring cows in the rows of cubicles. In the five weeks of observation done in the present study, it was noticed that cows almost never lie down in such an angle that equals the way cows have to lie down in the cubicles.

The weather had no significant influence on the lying positions, postures and angles, but did show some interesting results. In sunny weather, it was observed that more cows were lying in position back - back than in the other weather types. Furthermore, the data showed that not one cow was lying with their head on the ground when the weather type was cloudy or cloudy/rainy. In weather type cloudy/rainy only the postures head up - head up and head up - head back were observed. During rainfall, cows tend to change their behaviour (Ketelaar-de Lauwere *et al*., 1999). Cows lie down less time when exposed to rain and/or wind (Schütz *et al*., 2010; Webster *et al*., 2008) and lie down in different postures to minimise the amount of body area on the ground during rainfall (Tucker *et al*., 2007). Furthermore, in the present study only the angle between the cows was recorded, but not the angle towards the direction of the wind and/or rain. In future research, this may be taken into an account when assessing lying behaviour in different types of weather.

When assessing the welfare of the dairy cow, the importance of the relationships within a herd cannot be underestimated. Cows do have preferential herd mates, whom they choose to be in close proximity with. In this study, no differences in lying behaviour regarding lying position, postures and angles were determined, yet the results give a clear discrepancy between natural lying behaviour on pasture and the way dairy cows are held in the widely used housing system with rows of cubicles. Showing natural lying behaviour enhances the welfare of the dairy cows, and is, therefore, an essential key for the design of housing systems for dairy cattle nowadays and in the future.

7. Conclusion

This study found no significant differences in lying positions, postures and angles between familiar and unfamiliar cows in a dairy herd in Uruguay. After analysing the different lying positions, the pairs of cows showed a preference for lying in position head - back, with 62,7% and 61,7% of the match and no match group respectively. Considering the different posture combinations, a clear preference for posture head up - head up was observed, with 82,7% and 84,9% of the pairs of cows lying in this posture in the match and no math group respectively. An angle between 136° and 180° was found to be the preferable angle, with 40,0% of the match group and 43,4% of the no match group lying in this angle. No explanation was found, and future research to the different lying positions, postures and angles of lying pairs of cows could be done to enhance the knowledge about lying behaviour. Furthermore, it could include the analysis of which specific cows are next to each other, to enhance the understanding of the relationship between these specific pairs of cows. In addition, no significant differences in lying positions, postures and angles were found in different types of weather and this was probably due to the different types of weather, rather than the relationship between the cows. Associations between lying position and angle, and posture and angle were found. The pairs of cows clearly had an preference for lying in position head - back in an angle of 136° and 180° degrees and in posture head up - head up and an angle of 136° and 180° degrees. Furthermore, the results of the present study clearly show a discrepancy between the natural lying behaviours on pasture and observed lying behaviour of cows in different housing systems. Different lying positions, postures and angles observed in this study, are impossible to show in a cubicle housing system. The ability to show natural lying behaviour may improve dairy cow welfare and, therefore, this study could be used in future designs of new housing systems for the dairy cow, where dairy cow welfare is just as important as good health, production and practical design.

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