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Use of exercise yard variants on seven dairy farms in Baden-Württemberg, Germany

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In dairy barns, there is a discrepancy between the objectives of animal welfare and environmental protection due to the larger proportion of emitting areas. One potential solution is the implementation of a structured exercise yard comprising elevated rubber mat cubicles without a roof and roofed feeding areas. This design permits the animals to engage in an array of behaviours, aligned with their species-appropriate needs, in the exercise yard while also curbing the emission-active areas. In the present study, the proportion of cows utilising the exercise yard was investigated by analysing wildlife camera images. Furthermore, the utilisation of the diverse functional areas of the structured exercise yards was examined on four farms. The use of the non-roofed elevated rubber mat cubicles by the cows was subjected to particular analysis on three farms with comparable barn and exercise yard designs. The average number of animals in a herd observed in the exercise yards between 8:00 and 16:00 was 14%. In the structured exercise yard variants, the animals were distributed relatively evenly across the functional areas, with the non-roofed elevated rubber mat cubicles being used for both lying and standing. However, significant discrepancies were observed between farms, even when the farm structures were similar. These findings underscore the necessity for further investigation into the optimal design of loose housing systems to effectively enhance the balance between animal welfare and environmental protection.

Keywords
Dairy cattle, animal behaviour, exercise yard

The provision of an exercise yard affords cows greater freedom of movement, while also enabling them to cope with a range of external climatic factors such as solar radiation, precipitation, wind and snow (Simon et al. 2018, Simon et al. 2020). In the summer months, cows demonstrate a clear preference for access to an outdoor pack (12 m^2 per cow, with a deformable surface) that provides sufficient shade. In contrast, during the winter season, they exhibit a preference for a dry and sheltered pack (Smid et al. 2019). Furthermore, as temperatures rise, cows spend a greater proportion of their time in shaded areas and exhibit a reduction in lying time on pasture (Schütz et al. 2010a). In summer, the animals spend over 50% of their time in the outdoor pack, whereas in winter this figure drops to only 5% (Smid et al. 2019). This observation is consistent with the findings of Fregonesi et al. (2007) and Chen et al. (2017), who reported that cows spend less time lying down on wet ground. To reduce the contact surface with the wet ground, cows alter their lying positions by pulling their limbs underneath them (Chen et al. 2017). The duration of lying times is shorter in conditions of precipitation and wind than in dry weather (Tucker et al. 2007, Webster et al. 2008, Schütz et al. 2010b). In the presence of precipitation, cows on pasture with access to weather protection exhibit reduced activity levels compared to those without such protection. The authors suggest that this may be due to using

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the shelter as a retreat for collective resting (Plesch and Wittmann 2013). A 1 °C increase in the maximum daily temperature in the cubicle barn is associated with a mean reduction in daily lying time of 10 minutes, while standing time is increased by the same amount (Heinicke et al. 2017).

As noted by Van Caenegem and Krötzl Messerli (1997), exercise yards are situated between two competing imperatives: the ethological necessity of year-round, extensive outdoor access and the imperative to limit the area available to the animals for economic and ecological reasons. A reasonable solution necessitates an understanding of the animals' genuine requirement for outdoor access and the factors that influence the utilisation of outdoor space. The study by Van Caenegem and Krötzl Messerli (1997) on an attached exercise yard for up to 34 animals, which lacked the provision of drinking troughs, troughs or brushes, and was devoid of structure, demonstrated that, on average, only 4% of the animals in a herd utilised the exercise yard at the same time. The orientation of the exercise yard has a significant impact on the intensity of utilisation. In the autumn and winter months, the runs are utilised to a greater extent when conditions are sunny, despite the smaller area per cow (3.6 m^2 vs. 9.2 and 15.1 m^2 respectively). The smaller area results in the exercise yard being used one-third less on average. Even in a large exercise yard of 15.1 m^2 per cow, there is minimal locomotion, with an average of only 100 metres covered per day (Van Caenegem and Krötzl Messerli 1997). The majority of time spent in the exercise yard is characterised by inactivity (47%) or rumination (39%). The mean duration of time spent in the exercise yard by cows is approximately one hour per day. The results of the studies conducted by Schrade et al. (2010) are comparable. The provision of basic feed in the exercise yard, or the installation of drinking troughs and brushes, has been observed to result in a notable increase in the time spent in the exercise yard (Van Caenegem and Krötzl Messerli 1997). The intensity of utilisation during the course of the day is also influenced by management practices. For example, only a small number of animals are observed in the exercise yard after milking in the conventional milking parlour and after feeding (Schrade et al., 2010). The mean percentage of the herd spending time in an attached exercise yard is 4 to 10%, while in an integrated exercise yard including the neighbouring cubicles, this figure rises to 32 to 35%. This discrepancy can be attributed to the functional use of the integrated exercise yard as a result of structural considerations (Schrade et al. 2010). Benz et al. (2024) observed the utilisation of the walking areas, the non-roofed elevated rubber mat cubicles and the feeding area on a structured exercise yard. Their findings indicated that the animals were distributed relatively evenly between these three areas.

Cubicles should be designed to provide the dairy cows with a comfortable and hygienic resting area (Von Keyserlingk et al. 2011) and should be sized to allow the cows to stand, lie down and rest without hindrance (Hoy et al. 2006). The use of cubicles provides the cows with protection from displacement (Richter 2006). The neck rail is a crucial control element of the cubicle (Dahlhoff et al. 2009) and is designed to prevent the cubicle from becoming soiled with manure (Bernardi et al. 2009). Fregonesi et al. (2009) observed that the standing behaviour with two or four legs in the cubicle was influenced by the positioning of the neck rail, which affected the cleanliness of the cubicle. The positioning of the neck rail has been demonstrated to influence the prevalence of standing with all four legs in the cubicle (Tucker et al. 2005). The risk of claw diseases is increased when cows only stand with their front legs in the cubicle (Somers et al. 2003, Bernardi et al. 2009, Galindo and Broom 2010). The presence of manure can result in damage to the skin, particularly in the inter-claw and bulb areas (Guhl 2009), as well as to the claw horn itself (Mülling and Budras 1998). This results in a reduction in the resistance of the horn. Therefore, standing on dirty and hard surfaces is generally detrimental to claw health. Regardless of claw health aspects, Schrade et al. (2010) argue for the regular cleaning of exercise yard surfaces in order to reduce ammonia emissions in a manner similar to that employed in the barn.

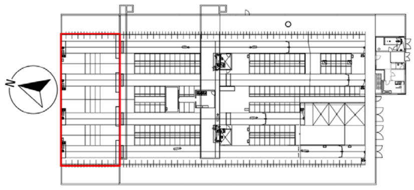
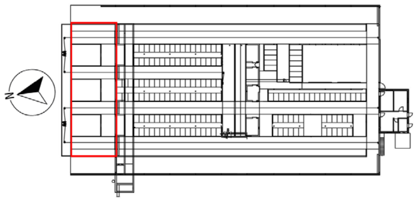
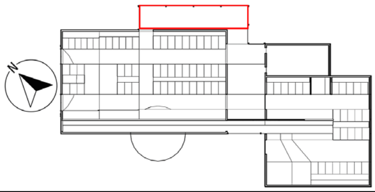
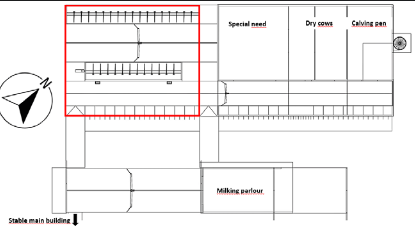
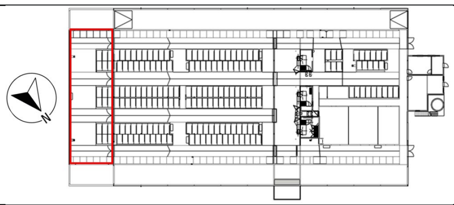
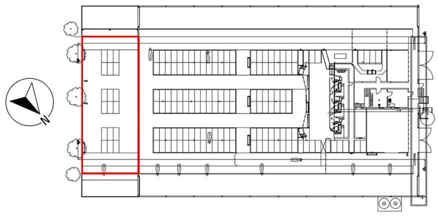
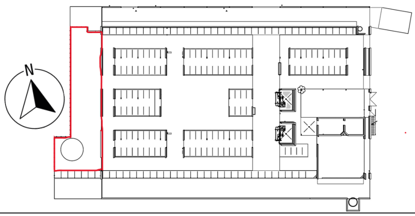
Material and methods

The study spanned the period from March 2021 to June 2022 and included seven dairy farms that had either newly constructed (5), converted (1) or extended (1) their cattle barns between 2019 and 2021. The dimensions were determined in accordance with the prevailing guidelines for agricultural investment support in Baden-Württemberg. This indicates that all farms exhibited an animal-to-lying space ratio of 1:1 and an animal-to-feeding space ratio of at least 1.2:1, with access to a constant supply of feed. All farms had implemented structural and technical measures to reduce ammonia emissions. These included elevated feed stalls with feeding place dividers, emission-reducing walking surfaces and adapted manure removal technology. At a minimum, the walking surfaces were covered with rubber mats in the feeding alleys.

The farms were coded according to the type of exercise yard (CEY = conventional exercise yard, SEY = structured exercise yard), the type of lying area (WS = woodchip area, RC = non-roofed elevated rubber mat cubicles, RM = rubber mats) and the cardinal direction of the location (cardinal directions N, E, S, W).

The exercise yards exhibited variability in terms of design and orientation. However, they were all attached to the stable building. Two of the farms had exercise yards oriented towards the north-east and south-east, while the remaining farms had exercise yards oriented towards the north-east, north-west and west. The exercise yards provided between 2.1 and 6.9 m^2 of space per cow with access to the yard. Four exercise yards were constructed with non-roofed elevated rubber mat cubicles and roofed feeding areas (with the exception of farm SEY_WC_N, where only half of the 26 feeding areas were roofed). One exercise yard was surfaced with rubber (CEY_RM_W), while another was covered with woodchip (CEY_WC_NE). In one exercise yard, the cows had access to three lying areas, each measuring 25 m^2, which were littered with woodchippings (farm SEY_WC_N). The non-roofed elevated rubber mat cubicles were installed in addition to the barn, with an existing animal-to-cubicle ratio of 1:1. Additionally, on one farm (SEY_RC_NW), roofed elevated rubber mat cubicles were present in the structured exercise yard, which were necessary for an animal/pen ratio of 1:1. The orientation of the exercise yard on this farm refers to the perspective of the existing dairy cattle barn and not to the extension with the special areas. In relation to the respective herd size, the structure offered was variable, resulting in a lack of standardised number of non-roofed elevated rubber mat cubicles or feeding places available per cow with access to the exercise yard (Table 1).

Table 1: Exercise yard designs and barn layouts of the seven farms, exercise yard marked in red, CEY=conventional exercise yard, SEY = structured exercise yard, WC=woodchip area, RC=non-roofed elevated rubber mat cubicles, RM=rubber mat; cardinal points N, E, S, W, exercise yard area is the non-roofed area, exercise yard area per cow refers to the number of animals with access to the exercise yard

Farm	Structural-technical design	Stable layout and orientation
SEY_RC_N	• New building • 420 m^2 exercise yard area • 6.3 m^2 exercise yard area/cow • 18 not roofed elevated rubber mat cubicles • 26 roofed elevated feedstalls • Drinking trough, brush	
SEY_WC_N	• New building • 292 m^2 exercise yard area • 2,4 m^2 exercise yard area/cow • Three 25 m^2-lying areas with woodchippings • 13 not roofed elevated feed stalls; 13 roofed elevated feedstalls • Drinking trough, brush	
CEY_WC_NE	• Converted building • 113 m^2 exercise yard area • 3,1 m^2 exercise yard area/cow • Lying area littered with woodchippings	
SEY_RC_NW	• Extended building • 434 m^2 exercise yard area • 3,9 m^2 exercise yard area/cow • 18 roofed elevated rubber mat cubicles, 13 not roofed elevated rubber mat cubicles • 31 roofed elevated feedstalls • Drinking trough, brush	
SEY_RC_SE	• New building • 295 m^2 exercise yard area • 2,1 m^2 exercise yard area/cow • 18 not roofed elevated rubber mat cubicles • 26 roofed elevated feedstalls • Drinking trough, brush	
SEY_RC_SE2	• New building • 370 m^2 exercise yard area • 2,7 m^2 exercise yard area/cow • 18 not roofed elevated rubber mat cubicles • 26 roofed elevated feedstalls • Drinking trough, brush	
CEY_RM_W	• New building • 265 m^2 exercise yard area • 2,4 m^2 exercise yard area/cow • Rubber mat flooring Not roofed feeding places without food presentation • Drinking trough	

Five of the farms milked with an automatic milking system (AMS). One farm offered its cows summer grazing, all others kept them indoors all year. All farms farmed conventionally. Different herd sizes, breeds and milk yields ranging from 7,900 to 11,200 kg milk per cow per year (milk test year 2021) were represented (Table 2).

Table 2: Study farms with key figures and structural and technical details of the barn (CEY = conventional exercise yard, SEY = structured exercise yard, WC = woodchip area, RC = non-roofed elevated rubber mat cubicles, RM = rubber mat; cardinal points N, E, S, W), exercise area per cow refers to areas that can actually be walked on without feedstalls and cubicles in the barn including exercise yard, proportion of rubber surface refers to this exercise area

Exercise yard characteristics	Milking system	Herd size	Animals with exercise yard access	Breeds[1)]	Annual milk yield In kg	Pasture	Floor version[2)]	Dung removal system	Walking area per cow In m^2	Proportion of rubber coating in %
SEY_RC_N	AMS	144	67	HF, FL	9,500	no	flat paved	scraper	11,8	87
SEY_WC_N	AMS	150	120	HF, FL	9,700	no	flat paved	scraper	5,2	80
CEY_WC_NE	Milking parlour	44	36	VW	7,900	yes	flat paved	scraper	7,1	64
SEY_RC_NW	Milking parlour	170	112	FL	9,500	no	flat paved	scraper	8,7	40
SEY_RC_SE	AMS	188	144	FL	11,200	no	flat paved	scraper	5,9	55
SEY_RC_SE2	AMS	163	136	HF, FL[1]	11,500	no	flat paved	scraper, manure collection robot	6,6	93
CEY_RM_W	AMS	128	111	HF	10,300	no	flat paved	manure collecting robot	9,4	100

1) HF = Holstein Friesian, FL = Fleckvieh, VW = Vorderwälder; also crossbred animals .
2) Feeding alley predominantly with elevated feedstalls.

Wildlife cameras from the manufacturers Dörr GmbH, Germany (SnapShot Limited 5.0s), Campark Electronics Co. LTD, China (T150) and Boly Media Communications Co., LTD, China (BG662-W4K) were used to observe the animals. The cameras were installed in such a way that the entire exercise yard was recorded. In case of the farms SEY_RC_SE and SEY_RC_N, two synchronised cameras were installed to ensure this. Observations were made exclusively during the day, always between 08:00 and 16:00. For the questions concerning the quantitative utilisation of the exercise yards on seven farms (I) and the distribution of the animals in the functional areas of the structured exercise yards on four farms (II) a recording interval of 30 minutes was chosen. Three different temperature ranges were defined as so-called "seasons", with the temperature at 14:00 for each observation day forming the basis for the assignment and not the respective date. If the temperature at 14:00 was > 20°C, the day was categorised as "summer"; if the temperature was between 8 and 20°C, the day was categorised as "transition", and if the temperature was < 8°C, it was categorised as "winter". The outside temperature was measured by the wildlife cameras, with the exception of the farm SEY_RC_SE, where a weather station (Vantage Pro2, Davis Instruments, Hayward, USA) was installed in the exercise yard. Five 8-hour days per season were observed. On three farms, images were not available for all seasons (SEY_WC_N, CEY_WC_NE, CEY_RM_W). The exercise yards were permanently available to the cows, with the exception of the farm CEY_WC_NE, where the cows could only use the exercise yard outside the grazing season in the afternoons from 12:00. A 4-hour day from 12:00 to 16:00 was therefore selected as the observation period on the CEY_WC_NE farm. This resulted in a total of 1,450 observations (Table 3), from which 8-h-day average values were formed.

To analyse the way in which the non-roofed elevated rubber mat cubicles were used in the similarly constructed structured exercise yards of three farms (III), image material with a recording interval of 5 minutes was available, which was recorded over 20 days between 8:00 and 16:00 (5820 observations in total). Only days were selected on which the temperature at 14:00 was between 8 and 20°C, i.e. within the “transition” season.

Table 3: Observation periods and number of observations per farm as data basis for analyses I, II and III

Farm	**SEY_RC_N**	**SEY_WC_N**	**CEY_WC_NE**	**SEY_RC_NW**	**SEY_RC_SE**	**SEY_RC_SE2**	**CEY_RM_W**
Analyses (I) and (II)[1]	Recording interval 30 minutes						
Survey period	1.3.2022 until 18.6.2022	23.5.2022 until 19.6.2022	31.10.2021 until 06.04.2022	16.3.2021 until 21.5.2022	26.3.2022 until 15.5.2022	26.2.2021 until 21.5.2022	31.10.2021 until 14.5.2022
Total number of observations	255	170	90	255	255	255	170
Number of observations in „summer“	85	85	0	85	85	85	85
Number of observations in „transition“	85	85	45	85	85	85	85
Number of observations in „winter“	85	0	45	85	85	85	0
Number of 8-hour days	15	10	10[2)]	15	15	15	10
Analysis (III)	Recording interval 5 minutes						
Survey period	13.5.2022 until 31.5.2022	-	-	-	15.10.2021 to 31.10.2021 and 1.5.2022 to 16.5.2022	3.5.2022 until 28.6.2022	-
Number of observations	1,940	-	-	-	1,940	1,940	-
Number of 8-hour days	20	-	-	-	20	20	-

[1)] Involved in (II) were SEY_RC_N, SEY_RC_SE_SEY_RC_SE2.
[2)] The exercise yard was only opened at 12:00 noon, so only 4-hour days were available here.

Due to the approach of categorising the seasons according to temperature rather than calendar, additional information on the maximum solar altitude, maximum solar altitude, maximum solar altitude and duration of daylight for the respective mean daylight period was also collected for the individual survey periods (Table 4).

Table 4: Overview of solar radiation conditions in the seasons categorised according to temperature ranges

		SEY_RC_N	SEY_WC_N	CEY_WC_NE	SEY_RC_NW	SEY_RC_SE	SEY_RC_SE2	CEY_RM_W
	Altitude (m.a.s.l.)	**540**	**685**	**777**	**705**	**580**	**563**	**684**
„Summer“	Start date	03.06.2022	04.06.2022		28.03.2022	10.05.2022	10.05.2022	10.05.2022
	Date End	18.06.2022	19.06.2022		14.05.2022	15.05.2022	21.05.2022	19.05.2022
	Number of days	15	15		47	5	11	9
	Middle date	10.06.2022	11.06.2022		20.04.2022	12.05.2022	15.05.2022	14.05.2022
	Maximum solar altitude	1:19 pm	1:25 pm		1:21 pm	1:21 pm	1:18 pm	1:17 pm
	Solar altitude	64,89°	62,71°		51,86°	59,63°	59,56°	60,72°
	Sun direction	179,70°	153,23°		161,57°	179,54°	179,89°	180,06°
	Daylight duration	16h	16h 3min		13h 59min	15h 7m	14h 59min	15h 8min
„Transition“	Start date	05.06.2022	23.05.2022	03.03.2022	30.10.2021	10.03.2022	30.12.2021	14.03.2022
	Date End	13.06.2022	29.05.2022	06.04.2022	18.02.2022	09.04.2022	20.04.2022	23.04.2022
	Number of days	8	6	34	111	30	111	40
	Middle date	09.06.2022	26.05.2022	20.03.2022	24.12.2021	25.03.2022	23.02.2022	03.04.2022
	Maximum solar altitude	1:19 pm	1:23 pm	12:35 pm	12:21 pm	12:31 pm	12:35 pm	1:24 pm
	Solar altitude	64,81°	62,80°	41,93°	18,13°	43,35°	32,15°	47,44°
	Sun direction	179,81°	179,85°	179,92°	179,82°	179,79°	179,96°	180,07°
	Daylight duration	15h 59min	15h 40min	12h 10min	8h 19min	12h 28min	10h 43min	12h 59min
„Winter“	Start date	01.03.2022		06.11.2021	18.01.2022	26.02.2022	25.11.2021	
	Date End	04.04.2022		21.12.2021	06.02.2022	05.04.2022	29.01.2022	
	Number of days	34		45	19	38	65	
	Middle date	18.03.2022		28.11.2021	27.01.2022	17.03.2022	27.12.2021	
	Maximum solar altitude	12:28 pm		12:16 pm	12:34 pm	12:33 pm	12:22 pm	
	Solar altitude	41,01°		20,64°	23,13°	40,19°	18,56°	
	Sun direction	179,95°		180,06°	179,79°	179,68°	182,91°	
	Daylight duration	12h 3min		8h 46min	9h16min	11h 59min	8h 23min	

Due to the practical conditions, this study provided descriptive data that was validated by simple statistical tests. The utilisation of the exercise yard (I) was calculated as the percentage of animals in the exercise yard of all animals with access to the exercise yard based on the 8 h daily averages. The utilisation of the functional areas (II) and the way in which non-roofed elevated rubber mat cubicles were used (III) were calculated proportionally based on the individual observations. The data were not normally distributed, which was tested using the Shapiro Wilk test. A non-parametric test was used for the pairwise comparisons (Wilcoxon test). For multiple pairwise comparisons, the Bonferroni error correction was performed to adjust the significance level. The distribution of frequencies was analysed with the chi-square test for ordinal data sets and with the binomial test for pairwise comparisons. The Kendall tau test was used to test for correlation. The statistical analyses were carried out using the R version 4.4.0 programme and the R Commander package. Significant was defined as $p < 0.05$ (*), very significant from $p < 0.01$ (**) and highly significant from $p < 0.001$ (***).

Results

Quantitative utilisation of exercise yards on seven farms (I)

The exercise yards on the seven farms were used by different proportions of the herd from 8:00 to 16:00 (Figure 1).

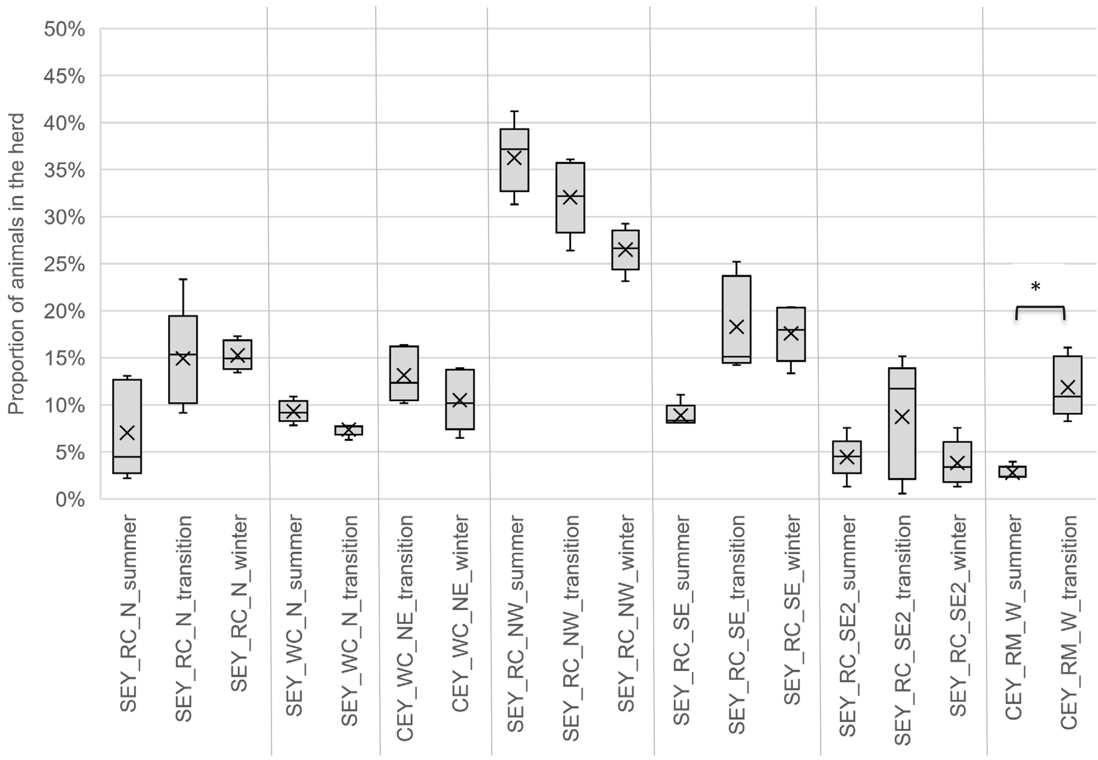


Figure 1: Proportion of animals in a herd in the exercise yards of seven farms, data basis seasons “winter”: < 8°C, “transition”: 8 to 20°C, “summer”: > 20°C, half-hourly observations between 8:00 and 16:00 over five days per season, a total of 1.501 individual observations, data from “summer” was missing for farm CEY_WC_NE (exercise yard not available during grazing), data from “winter” was missing for farms SEY_WC_N and CEY_RM_W

On average over all 8 h days, 13.9% (SD 12.3%, CV 88%, median 10.4%, min. 0.6%, max. 41.2%) of the animals in a herd were in the exercise yard at the same time. On the SEY_RC_N farm, in "winter" more animals were recorded in the exercise yard in the "winter", while the farms SEY_WC_N and SEY_RC_NW tended to have more animals in the "summer". On all other farms, the highest proportion of animals in the herd were in the exercise yard in the "transition" temperature range, with only farm CEY_RM_W showing a significant difference with regard to the seasons (binomial test, p-value = 0.035).

The mean proportion of animals in a herd in the exercise yard was highly significantly different between almost all farms. Only in three pair comparisons were there no differences (Table 5).

Table 5: Significant differences in pairwise mean comparisons of the proportion of animals in a herd in the exercise yard on seven farms, Wilcoxon test, significance level according to Bonferroni correction p-value < 0.008, significances are printed in bold type

Farm	SEY_RC_N	SEY_WC_N	CEY_WC_NE	SEY_RC_NW	SEY_RC_SE	SEY_RC_SE2	CEY_RM_W
SEY_RC_N	-	**<0,001**	0,012	**<0,001**	**<0,001**	**<0,001**	**0,004**
SEY_WC_N		-	**<0,001**	**<0,001**	**<0,001**	**<0,001**	**<0,001**
CEY_WC_NE			-	**<0,001**	**<0,001**	**0,005**	0,57
SEY_RC_NW				-	**<0,001**	**<0,001**	**<0,001**
SEY_RC_SE					-	**<0,001**	**<0,001**
SEY_RC_SE2						-	0,076

On average, the non-roofed exercise yard area was 3.3 m^2/cow (SD 1.4 m^2, VK 0.4). An evaluation of the available exercise yard area per cow and proportion of animals in a herd in the exercise yards in relation to the 8 h days, showed no differences between the seven farms (Kendall tau test, z = 0.61, tau = 0.19, p-value = 0.543).

Distribution of animals to the functional areas of the structured exercise yards of four farms (II)

On four farms, functional areas such as exercise yards, feeding areas and non-roofed elevated rubber mat cubicles were available in the exercise yards. On the SEY_RC_N farm, the mean proportion of animals in the exercise yard was 12.4% (SD 9.0%, median 10.4%), 31.6% (SD 13.4%, median 36.6%) on the SEY_RC_NW farm, 14.9% on the SEY_RC_SE farm (SD 7.4%, median 13.9%) and 5.7% (SD 6.7%, median 3.7%) on the SEY_RC_SE2 farm. Based on the proportions of animals in a herd on the free-range farms, the distribution of the animals to the individual functional areas: walking areas, feeding area, elevated rubber mat cubicles were analysed (Figure 2).

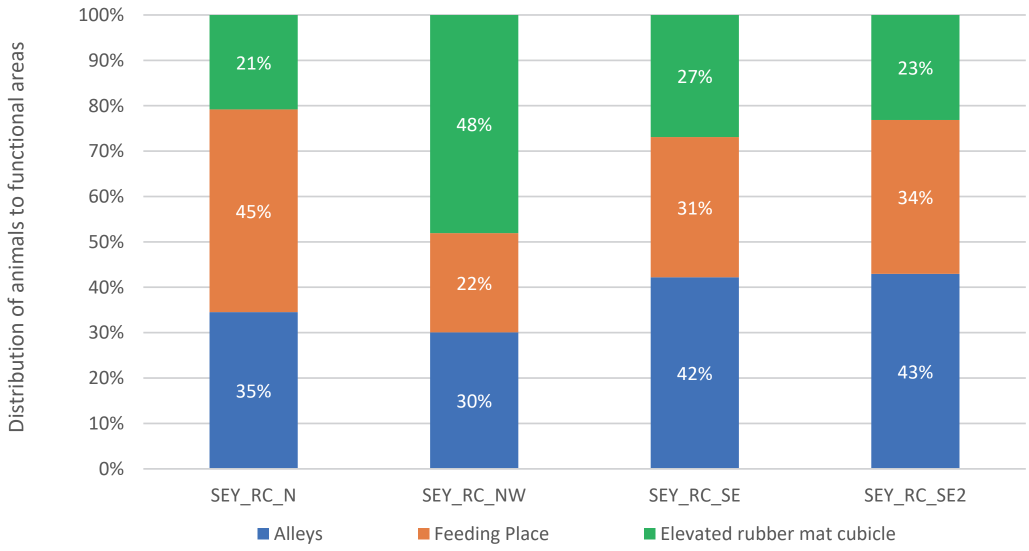


Figure 2: Distribution of the animals that were in the exercise yard in the functional areas walking area, feeding area and elevated rubber mat cubicles, data basis: four farms, half-hourly observations between 8:00 and 16:00 over five days per season, "winter": < 8 °C, "transition": 8 to 20 °C, "summer": > 20 °C, 15 days with a total of 255 observations per operation

The observed frequencies of animals on the walking area did not differ between the four farms (Chi-squared test, X-squared = 3.0133, df = 3, p-value = 0.390). In the area of feeding place utilisation, there were only significant differences between farm SEY_RC_N and farm SEY_RC_NW (binomial test, p-value = 0.007). There were significant differences between the farms with regard to animal stays in the non-roofed elevated rubber mat cubicles (chi-squared test, X-squared = 15.555, df = 3, p-value = 0.001), with farm SEY_RC_NW differed from farm SEY_RC_N (binomial test, p-value = 0.002), from farm SEY_RC_SE (binomial test, p = 0.020) and from farm SEY_RC_SE2 (binomial test, p-value = 0.004). While on the SEY_RC_NW farm, the cows spent almost half of their time in the exercise yard in the elevated rubber mat cubicles (non-roofed and roofed), in the other three farms only around a quarter of the cows spent time in the elevated rubber mat cubicles.

Distribution of animals to the functional areas of the exercise yards by season

The functional areas in the exercise yard were used in comparable proportions in the different seasons (Figure 3). The animals' utilisation of the exercise yard was 34% in the "summer" temperature range, 34% in the "transition" and 45% in the "winter" (chi-squared test, X-squared = 2.1416, df = 2, p-value = 0.343). In "summer", the proportion of feeding place utilisation was 41%, in "transition" 31% and in "winter" 22%, these differences were almost significant (Chi-squared test, X-squared = 5.766, df = 2, p-value = 0.056). The proportion of animals in the non-roofed elevated rubber mat cubicles was 25% in "summer", 34% in "transition" and 33% in "winter"; here too, the frequencies were not

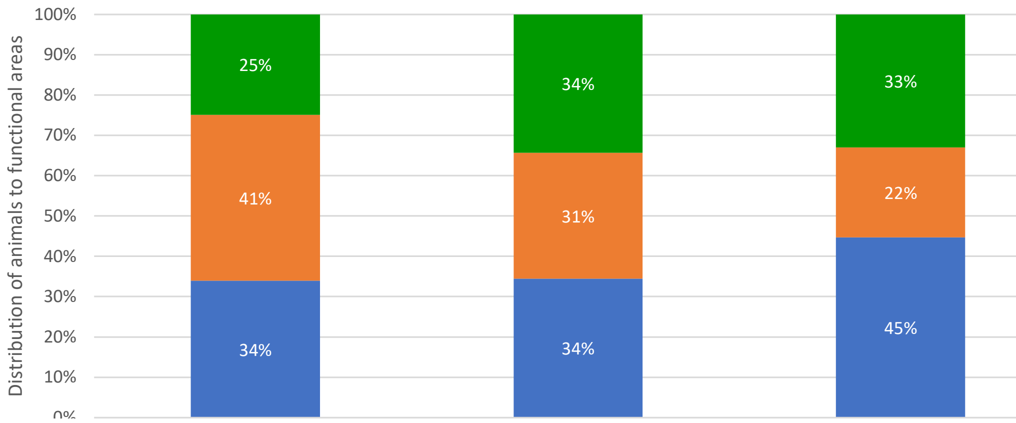


Figure 3: Frequency of functional area use in the exercise yard by season, data basis: four farms with SEY

Non-roofed elevated rubber mat cubicles utilisation on the structurally comparable structured exercise yards of three practical farms (III)

A further differentiation of non-roofed elevated rubber mat cubicles utilisation was investigated on analysed on three farms SEY_RC_N, SEY_RC_SE and SEY_RC_SE2. They were used with different frequencies for lying down (chi-squared test, X-squared = 58.908, df = 2, p-value < 0.001), for incomplete standing (chi-squared test, X-squared = 12.899, df = 2, p-value = 0.002) and for complete standing (chi-squared test, X-squared = 40.29, df = 2, p-value > 0.001) (Figure 4).

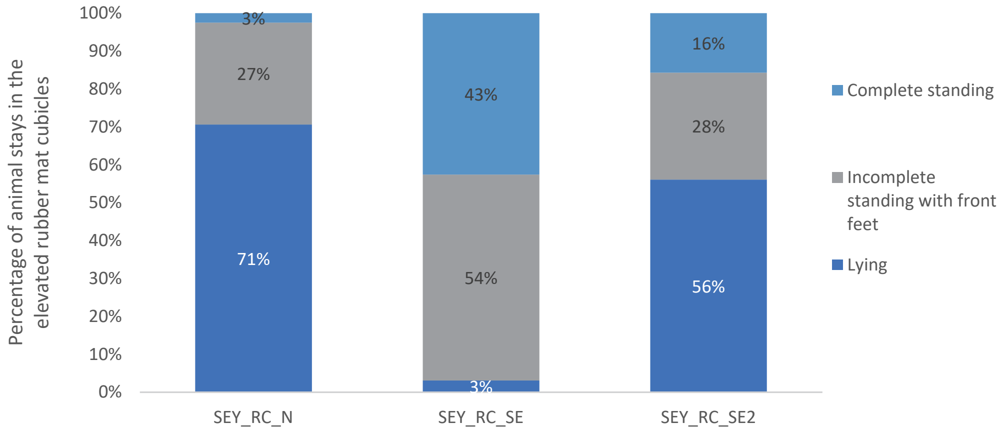


Figure 4: Non-roofed elevated rubber mat cubicles utilisation in the structured exercise yard of the farms SEY_RC_N, SEY_RC_SE and SEY_RC_SE2, Data basis: 10 observation days in each case, observations between 8:00 and 16:00 at 5-minute intervals, SEY_RC_N 655 observations, SEY_RC_SE 681 observations, SEY_RC_SE2 353 observations

On farm SEY_RC_N, the proportion of elevated rubber mat cubicles used for lying down was significantly higher at 71% was significantly higher than on farm SEY_RC_SE with 3% (binomial test, p-value < 0.001), the same was true for farm SEY_RC_SE2 with 56% (binomial test, p-value < 0.001). There were highly significant differences between the farms in terms of the proportion of complete standing in the elevated rubber mat cubicles. On farm SEY_RC_SE, the cows used the non-roofed elevated rubber mat cubicles for standing completely 43% more often than on farm SEY_RC_N with 3% (binomial test, p-value <0.001) and on farm SEY_RC_SE2 with 16% (binomial test, p-value = 0.004). There were also highly significant differences between the SEY_RC_SE (43%) and SEY_RC_SE2 (16%) farms (binomial test, p-value = 0.001). Incomplete standing with the front feet in the cubicles occurred very significantly more frequently on farm SEY_RC_SE (54%) than on farm SEY_RC_N (27%) (binomial test, p = 0.004) and on farm SEY_RC_SE2 (28%) (binomial test, p = 0.005). In the SEY_RC_N farm, the proportion of incomplete standing with the front feet in the cubicles at 27% was highly significantly higher than the proportion of complete standing at 3% (binomial test, n = 2, p > 0.001), while there were no differences within the other farms.

Discussion

On the farms studied, the use of the exercise yard (I) was on average 13.9% of the herd between 8:00 a.m. and 4:00 p.m. during the observation period, excluding the late afternoon and evening. Excluding farm SEY_RC_NW, which was a special case because it had additional covered cubicles in the exercise yard, the mean was 10.3%. In Swiss studies, animal residence rates of 4 to 10% of the herd have been reported for cultivated exercise yards (Van Caenegem and Krötzl Messerli 1997, Schrade et al. 2010). According to Van Caenegem and Krötzl Messerli (1997), the maximum use of exercise yards occurs between 9:00 and 16:00, but the results are not comparable as only one third of the day was observed in the present study, whereas Van Caenegem and Krötzl Messerli (1997) recorded 24 hours using an electronic animal monitoring system.

The percentage of animals in the exercise yard varied considerably among the investigated farms. Only in three pairwise comparisons were there no significant differences regarding the percentage of animals in the exercise yard. The significantly higher values of the farm SLH_HB_NW, on average 31.6% of the herd, are well in line with literature data, because due to the fact that a part of the covered cubicles was accessed from the , the structural implementation of the exercise yard corresponded more to the characteristics of an integrated exercise yard, for which Schrade et al. (2010) determined animal occupancy of between 32 and 36%.

Due to the data situation, the present study was unable to systematically examine the use of exercise yards facing in different directions under real-life conditions. Although two of the yards were southeast-facing, thus allowing comparability, they differed significantly from one another, with one yard hosting an average of 6% of the flocks and the other 15%. In the present study, neither the shading of the exercise yards nor precipitation were considered as known influencing factors (Tucker et al. 2007, Webster et al. 2008, Schütz et al. 2010a, Schütz et al. 2010b). Since only one farm showed a difference between the seasons in the individual farm analysis, it was assumed that the data did not allow a more in-depth analysis of the factors of compass direction and season. The categorisation of the seasons was not based on the date, but on the temperature at 2 p.m. on a particular day, since it was assumed that the influence of temperature in particular influences the use of the outlet. This approach took into account the fact that, within the calendar seasons, temperatures occur in winter, for example, that tend to correspond to the transitional season, and that days with typical summer temperatures occur in the transitional season. However, the method did not take into account that this resulted in significant differences in other possible influencing parameters, such as the height and direction of the sun (Tab. 4) and the resulting shading (Schütz et al. 2010a). Van Caenegem and Krötzl Messerli (1997) take shading of the outdoor area into account in their recommendations, as they found, for example, that the outdoor area is used more in autumn and winter when the sun is shining. Smid et al. (2019) also found that the animals used the outdoor area for longer in summer, but mainly for lying down at night. Therefore, other weather conditions and shading should be considered in addition to temperature when investigating the use of outdoor areas.

In the present study, no correlation was found between the size of the exercise yard and the proportion of animals in the exercise yard. The average exercise yard area offered per cow was 3.3 m^2/cow, less than the area offered in the Swiss study. Van Caenegem and Krötzl Messerli (1997) assume that the maximum number of animals decreases as the available area decreases. However, it was also found that the only time when the animals can use the exercise yard is when they are not lying down, eating or being milked. This may be at least partially mitigated by exercise yards with a structure with elevated rubber mat cubicles and feeding places, as this concept aims to enable the animals to carry out behaviours such as resting and feeding in the exercise yard as well.

The distribution of the animals to the functional areas in the structured exercise yards of the four practical farms (II) was 38% on the walking areas and one third each on feeding places and elevated rubber mat cubicles. However, it should be noted that the farm SEY_RC_NW was not comparable with the other three farms in terms of the structural and technical equipment of the exercise yard. In the exercise yard of this farm, there were both uncovered and covered cubicles. Only when the covered cubicles were included did each cow have a cubicle available (animal:cubicle ratio 1:1). This presumably had an effect not only on the more frequent use of this functional area, which accounted for almost half of the time spent in the exercise yard on the SEY_RC_NW farm, but also on the use of the exercise yard as a whole. Without taking this special case into account, the use of the functional area of the elevated rubber mat cubicles (then 24%) shifted in favour of the functional area of the feeding place (then 35%). These values fit well with the results obtained in a study over an entire year of investigation with the help of a tracking system at the SEY_RC_SE farm (Benz et al. 2024). In relation to the different temperature ranges, which were designated as the seasons ‘summer’, ‘transition’ and ‘winter’, there were no significant differences in the use of the three functional areas. However, the difference at the feeding place was close to the significance threshold, with a tendency for fewer animals to be counted in ‘winter’. The feeding places on the exercise yards were covered to protect the feed from the weather. In all the farms, there was a minimum of 1.2:1 animal:feeding place ratio in the barn with food available at all times. The structured exercise yards thus provided only a small proportion of the feeding places in the exercise yard, so that food intake mainly took place inside the barn. Furthermore, it was not known how regularly and in what quantities the farms provided food at the feeding places in the exercise yard. It was therefore not possible to evaluate the function and contribution of the feeding places to the feeding of the flock. A lower utilisation in ‘winter’ could also be due to the fact that less feed was provided at the outdoor feeding places during bad weather.

Due to the observation with the help of wildlife cameras in time intervals (both at 30 min (I and II) and at 5 min (III)), it was not possible to distinguish between walking and standing animals. Overall, however, it can be assumed that only short walking distances were covered during 30-43% of the time spent in the exercise yards. As already established by van Caenegem and Krötzl Messerli (1997) with a significantly higher area available, it can be assumed that walking activity in the exercise yard is low (< 100 m/cow and day). Van Caenegem and Krötzl Messerli (1997) report that the predominant behaviours of cows in the exercise yard are standing without noticeable activity (47%) and ruminating while standing (39%). The availability of space to satisfy the need for outdoor activity seems to be of secondary importance for the cows in the given exercise yard variants. In connection with the discussion about the conflict of objectives between environmental protection and animal welfare due to the additional emission-active areas in exercise yards, further studies on exercise yard utilisation should be carried out with the aim of finding an optimum with regard to the range of structures and functional areas. Up to now, exercise yards attached to the stable building have been at a disadvantage compared to integrated exercise yards with permanently installed stationary manure removal systems, as this resulted in additional or poorly mechanisable manure removal areas. This can now be compensated for with frontal attachment, structuring and continuation of the manure removal axes of the barn. The structuring of exercise yards with elevated rubber mat cubicles thus fulfils the requirement of Schrade et al. (2010) to frequently clean soiled exercise yard areas in the same way as stables in order to reduce ammonia emissions.

Three of the farms analysed were easily comparable in terms of structural and technical design (SEY_RC_N, SEY_RC_SE, SEY_RC_SE2), as they all had structured exercise yards with non-roofed elevated rubber mat cubicles and roofed feeding areas. On the basis of these three farms, the use of the non-roofed elevated rubber mat cubicles in the exercise yards for lying or standing (III) was analysed in more detail. There were major differences between the three farms in terms of how the cows utilised the non-roofed elevated rubber mat cubicles. On the SEY_RC_SE farm, the stalls were used almost exclusively for standing and only 3% for lying down, whereas on the other two farms, 56% (SEY_RC_SE2) and 71% (SEY_RC_N) of the stalls were used for lying down. Cubicles are also used for lying down in the stable used for standing , if the stall design allows this (Benz et al. 2020). A distinction was made between complete and incomplete standing when using the cubicles. On the SEY_RC_N farm, only 9% of the cows stood completely with all four limbs in the cubicle, whereas on the SEY_RC_SE farm, 44% of the cows stood completely in the cubicle, compared to 36% on the SEY_RC_SE2 farm. Complete standing in the cubicle is considered to be more claw-friendly, as the claws are in a clean environment during standing in an elevated cubicle (Bernardi et al. 2009, Mülling and Budras 1998). It can therefore be concluded that among the three farms on the SEY_RC_SE farm, although there was significantly less lying down in the cubicles in the exercise yard, the standing use of the cubicles was optimal, with all four limbs in the cubicle.

The study cannot reliably explain the different proportions of elevated rubber mat cubicles used for lying and standing. The non-roofed elevated rubber mat cubicles in the exercise yard are exposed to the weather and therefore have a wet surface when it rains, which is known to be avoided by cattle for lying down (Fregonesi et al. 2007, Reich et al. 2010, Chen et al. 2017). As no rainfall was recorded, it cannot be excluded that rainfall influenced the use of non-roofed elevated rubber mat cubicles. However, despite the basically similar design with a curved stabilisation tube and a flexible neck chain mounted at a low height of about 90 cm, there were also design differences between the three farms (Figure 5).

Farm SEY_RC_N Farm SEY_RC_SE Farm SEY_RC_SE2 (© B. Benz)

Figure 5: Box constructions on the three farms SEY_RC_N, SEY_RC_SE, SEY_RC_SE2

On the SEY_RC_SE farm, a tube was installed at a height of approx. 60 cm, whereas on the SEY_RC_SE2 and SEY_RC_N farms, a tube was present at a height of approx. 30 cm. A tube mounted at the head height of a lying cow could restrict the animals when lying down and standing up (head swing) and explain the low proportion of use of the elevated rubber mat cubicles for lying down. This hypothesis would need to be tested in further studies.

Conclusions

The study demonstrated that, on average, approximately 14% of the herd was present in the seven exercise yard variants examined between the hours of 8:00 and 16:00. It should be noted that important influencing factors such as shading and weather were not taken into account in this study, and therefore no conclusions can be drawn regarding the direction of the exercise yards. The space available in the present study had no influence on the proportion of animals in the exercise yards. In the structured exercise yards, the animals were distributed relatively evenly across the walking areas, feeding areas and elevated rubber mat cubicles. There was considerable variation in the use of the cubicles for lying or standing, with the farms also differing significantly in whether the cows were fully or partially standing in the cubicles.

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