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Rooting area and drinker affect dunging behaviour of organic pigs

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***Abstract* –** Hygiene is a common problem on outdoor runs of growing organic pigs. Manure and urine are mainly excreted outdoors and tend to spread all over the run. Reducing the soiled surface area may be beneficial to animal welfare, hygiene, ammonia emissions and labour, not only in organic but also in conventional systems. The objective was to reduce the soiled surface area in the pen and to make the outdoor run more attractive for pigs . Introduction of a rooting area and drinker in the outdoor run was tested in a 2x2 factorial design. In total 4 replicates were studied in a room with 2 rows of 4 pens containing 14 pigs each. More pigs went outdoors in pens with rooting area access than in pens without a rooting area (11.2 vs 8.5 %, P=0.003). This was due to more pigs entering the rooting area and an adjacent slatted floor. Addition of a drinker did not attract more pigs outdoors (P=0.53).
The rooting area improved the cleanliness of the whole pen (P<0.001). However, in some cases the rooting area was also used as a dunging area. The area around the additional outdoor drinker was cleaner, but on the whole pens were dirtier (P=0.011). Introduction of an outdoor drinker resulted in more indoor pen fouling, especially around the indoor drinker (P<0.001). An outdoor rooting area makes the outdoor run more attractive for pigs and reduces the dunging area. This study contributes to the knowledge base on how to reduce the dunging surface in pens for organic pigs.

Keywords: Pigs, behaviour, dunging, organic, rooting, drinking

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1. Introduction

All organic pigs should have access to an outdoor run (EU, 2008). Growing-finishing pigs from 85 up to 110 kg liveweight require an indoor area of 1.3 m² bedded with straw and an outdoor run of 1.0 m². This is approximately 2.5 times the space allowance for conventional pigs. In the Netherlands, organic sows should have access to pasture, but weaners and growing-finishing pigs have a bare, partly roofed, partly slatted concrete run. Environmental enrichment is mainly provided indoors. Commonly, the majority of excretory behaviour occurs on the outdoor run and the straw bedded indoor area remains clean and dry. Up to half of the concrete outdoor floor space may be slatted. Consequently, a proportion of the manure and urine will be excreted on the solid floor outside. This soiling of the outdoor run necessitates extra cleaning labour to maintain hygiene and ammonia emission standards.

Domesticated pigs under semi-natural conditions dung at least 5 to 15 m from their nests (Stolba and Wood-Gush, 1989). Under husbandry conditions Baxter (1984) states that pigs also prefer to move away from their selected lying area during excretion in order to find a colder, safer and secluded dunging location. Olsen et al. (2001) found that in pens with an outdoor run most dunging took place outside, away from the lying and roughage feeding area.

Halberg et al. (2010) demonstrated that organic pig production places a higher burden on the environment than conventional production in terms of mineral leaching and gaseous emissions . When excretory behaviour is restricted to a slatted area pen fouling and mineral losses are reduced. Scientific information concerning excretory behaviour on the outdoor run is limited, more information is available for conventional pigs kept indoors (Hacker et al, 1994; Fraser, 1985; Aarnink, 1996). Pen design, equipment and climate control may affect excretory behaviour (Pedersen et al., 2003). Further reductions in area used for excretion behaviour could eventually result in the development of a pig toilet for both organic and conventional systems. Since outdoor runs for pigs often lack any enrichment materials, fibres or other items (i.e. feeders or drinkers), additional provisions may enhance use outdoor runs, allowing species-specific behaviour like rooting, improving animal welfare and reducing pen fouling (Bracke et al., 2006; Van de Weerd and Day, 2009). Increasing outdoor activity will reduce the potential area used for excretion.

The objective of this study was 1) to reduce soiled surface area of organic pig pens and 2) to make outdoor runs more attractive for organic pigs, by including a rooting area and an additional outdoor drinker.

2. Material and Methods

The experiment was performed over a period of 1.5 years from September to March at the organic finishing unit of the research farm in Raalte (The Netherlands). In total 4 replicates were studied in a room with 2 rows of 4 pens containing 14 pigs each. Each pen had an indoor area with a 1.50 x 3.15 m kennel on one side, a feeder with 2 feeding places on the opposite side and a concrete outdoor area roofed for 75%. Water was available ad libitum indoors in a bowl (Egebjerg, DRIK-O-MAT® STANDARD) on the side partition above the slatted floor (Figure 1). Each pen was 4.57 m wide and 4.65 m deep indoors and 3.20 m deep outdoors. This provided an indoor area of 1.5 m² and 1.0 m² outdoor area for each pig. Each pen contained a 16 cm raised concrete slatted floor indoors that was 4.57 m wide and 1.60 m deep near the side wall and a 1.60 m deep slatted floor on the outer side of the outdoor run. All solid concrete floors had a slope of 1-2% towards the slatted floor. The pigs were fed a daily amount of approximately 0.5 kg of chopped (5-10 cm) straw per pen on the solid floor in the kennels. Pen partitions were solid to prevent neighbouring pens in different treatments affecting each other, except on the outdoor run.

The upper 2 m of the 3.5 m high side wall consisted of a fabric with 50% apertures and a manually operated wind-break curtain. An open ridge served as the main air outlet. An indoor kennel 1.75 deep and 3.00 m wide fronted with a transparent curtain provided the required microclimate for the pigs. No heating was provided in the finishing room.

The piglets (Large White x (Large White x Dutch Landrace)) entered the room at 25 kg (10-11 weeks) and were ready for slaughter at 110 kg (27 weeks). The animals were kept according to the EU regulations for organic pigs (EU, 2008). Each pen contained a mixture of both gilts and barrows.

Treatments

A 2x2 factorial experiment was designed to test the effect of an outdoor rooting area and a drinking bowl, resulting in 4 treatment combinations.

Rooting area **-** In half of the outdoor runs a rooting area was available (“root”) that was covered daily around 9 a.m. with a 10 cm layer of fresh chopped lucerne hay. Dirty material was removed on a daily basis if necessary. The rooting area (1.60x2.00 m) was placed in Area 2 (Figure 1), i.e. on the solid floor of the outdoor run with a 0.90 m high solid partition adjacent to the slatted floor with a low 0.26 m high barrier as entrance. In the remainder of the outdoor runs no rooting area (“noroot”) or materials were available.

Drinker **-** Half of the outdoor runs with and without rooting area were installed with an additional automatically filled frost free drinking bowl (Ritchie Thrifty King for Swine HG2) (“drink”). This was placed above the slatted floor in Area 4 (Figure 1). The remaining pens had no additional drinker available (“nodrink”).

Observations

A camera was installed 4 m high above the centre of the outdoor run in each pen to record still images every 15 minutes. The outdoor run was divided into 4 areas (Figure 1) and the presence of pigs in each of the four areas was counted using the images. This presence was only recorded in the outdoor part of the pen. A total of 27,648 images were collected: 4 replicates from 8 pens during 9 days for 24 hours every 15 minutes. Recordings were analysed from Mondays, Wednesdays and Fridays in weeks 4, 9 and 14 after the start of each replicate. The mean proportion of pigs occupying an area per pen per replicate was used as experimental unit.

Pen fouling was scored by visual assessment twice a week indicated as percentage wet and dirty surface on a scale with five 20%-classes from 0 (0-20% dirty) to 4 (80-100% dirty). Dry floor surface did not contribute to the dirty surface. Pen fouling of the rooting area was assessed when best visible in the morning prior to the daily cleaning and provision of fresh lucerne hay. Due to the fact that various amounts of excreta remain on top of solid and slatted floors a comparison of scores in different areas within a pen is impossible. A comparison of pen fouling scores was only possible between specific areas of pens in different treatments. Both the floors of the outdoor run and the indoor pen were divided in four areas resulting in 8 scores per pen per observation day (Figure 1). The mean proportion of the maximum fouling score per area per pen per replicate was used as experimental unit.

Analysis

The average number of pigs occupying an area was analysed depending on the number of pigs in the pen. Influence of the treatment factors (Rooting area and Drinker) on the average number of pigs occupying an area was examined with a logistic regression model for the proportion of animals in the area. This model comprised a main effect of replicate, main effect and interaction for Rooting area and Drinker, i.e.

$$\ln\left(\frac{\pi}{1-\pi}\right) = c + replicate + rooting\ area + drinker + rooting\ area.drinker$$

Here π denotes the expected proportion present in the area. The observed average numbers of pigs (Y) were considered as pseudo binomial data with variance proportional to binomial variance, i.e.

$$variance(Y) = \varphi n \pi (1-\pi)$$

Here φ denotes a dispersion parameter and n the number of animals in the pen. Estimates for the model parameters and F-tests for the terms in the model were obtained using the quasi-likelihood method (see McCullagh & Nelder, 1989). An estimate for φ was calculated from Pearson's chi-square. When the interaction effect was not significant(P>0.05), the model was reduced to main effects only. Under the latter model odds ratios (OR) for Rooting area and Drinker were found to be constant.

$$OR_{Root} = \frac{Prob(present\ in\ area|Root))/(1-Prob(present\ in\ area|Root))}{Prob(present\ in\ area|NoRoot))/(1-Prob(present\ in\ area|NoRoot))}$$

Estimates for the root of OR were obtained directly exponentiation of the estimated root effect, i.e. $OR_{root}=e^{root\ effect}$ and similarly for drinker. The 95% confidence intervals for the odds ratio were computed after first computing a 95% confidence interval for the main effect on logistic scale (lower bound, upper bound) and then with exponentiation of the bounds to confidence interval $OR= (e^{lower\ bound}, e^{upperbound})$

The other days averaged fouling scores per area per pen were analysed in two steps. First the totals (Z) of fouling scores averaged over the eight areas were analysed with a logistic regression model to determine the proportions of total scores relative to the maximum total score of 32. This approach is similar to the analysis of the average number of pigs. Then π denotes the expected proportion and $var(Z) = 32\varphi\pi(1-\pi)$.

In the second step average fouling scores per area were analysed dependant of the total fouling score of the pen, using the logistic regression approach similar to the analysis of the average number of pigs. Then π stands for the expected fouling proportion for the area.

All calculations were performed with GenStat (VSN International, 2012)

3. Results

Figure 2 shows the predicted proportion for occupation of the outdoor run after fitting a logistic model allowing for interaction between Rooting area and Drinker.

Since the logistic model with Rooting area x Drinker interaction resulted in no significant interaction ($P>0.05$), the interaction was dropped from the model. The main effects estimated for Rooting area and Drinker, as calculated odds ratios with 95% confidence intervals are shown in table 1 together with corresponding standard errors (s.e.).

More pigs occupied the Area 2 solid floor after it had been converted to a rooting area. The slatted floor in Area 3 contained more pigs when a rooting area was present. In addition, more pigs occupied the outdoor run in pens with rooting areas than in pens without a rooting area. Fewer pigs were present in area 3 of pens with an additional outdoor drinker and more in area 4 (with drinker) compared to pens without additional drinker.

Figures 3 and 4 provide an indication of the numbers of pigs in the outdoor run and in the rooting area throughout the day. It also provided an indication of the attractiveness of the rooting area and a peak of outdoor activity in the late afternoon.

Predictions of the percentage fouling for each area and for total pen area were calculated from the fitted logistic model including interaction. These predictions including standard errors are presented in figure 5 (outdoor) and figure 6 (indoor).

Since interaction was significant for area 8 the odds ratio for the comparison between drink and no drink differs according to the presence or lack of rooting area and is similarto the odds ratio for comparing root with no root. The interaction was explored by testing pairwise differences between treatment means on the logistic scale using t-tests. The calculated P-values showed:

- a significant ($P<0.05$) effect of Drinker on area 8 fouling only when no rooting area was provided. The odds ratio for Drink versus Nodrink is significantly larger than 1. Effect of Drink using a rooting area points in the opposite direction, but was not significant;
- a significant ($P<0.05$) effect of Rooting area on area 8 fouling only when an extra drinker was provided. The odds ratio for root versus no root is significantly smaller than 1. Effect of root using no drinker points in the opposite direction, but was not significant.

Since interaction was not significant for the areas 1 to 7 the logistic model with main effects excluding interaction was fitted. The estimated dispersion parameter varied from 0.04 to 0.38. The estimated main effects with standard errors (s.e.), P-values (t-prob), odds ratios (OR) with 95% confidence intervals are presented in table 2.

Floors were cleaner in pens where a rooting area was present, mainly due to a cleaner area 2. Areas 1 and 3 had higher fouling scores in the presence of a rooting area. However, 10% of the pens of Root area 2 had fouling scores 3 and 4 indicating that the rooting area had become a “toilet” (Figure 7), a preferred location for urination and defecation.

The slatted floor in Area 4 (outdoors) was cleaner when it contained an extra drinker. The indoor areas 5, 6 and 7 were al dirtier in the presence of an outdoor drinker.

The predicted means for proportional pen fouling for the treatments Noroot Nodrink, Noroot Drink, Root Nodrink and Root Drink were respectively 43.5, 48.1, 37.4 and 40.1% with s.e. 1.3 and significant differences for Rooting area ($P<0.001$) and Drinker ($P=0.011$) and no significant interaction. This means that provision of a rooting area reduces the mean total fouling score and provision of an extra drinker increases the total fouling score per pen .

4. Discussion

The main objective of the experiment was to improve the hygiene of the outdoor run of pens for organic growing-finishing pigs by providing attractive environmental enrichment. As stated by Stolba and Wood-Gush (1989) and Baxter (1984) pigs separate functional areas and if an area is "occupied" by other activities then the pigs search for an alternative excretion area. The experiment resulted in improvement of the cleanliness of the solid floor in Root, but it was not totally clean: In 10% of cases the pigs used the rooting area as a dunging area and some groups kept the rooting area clean, but used it as a lying area. This confirms the conclusions of Olsen et al. (2001) that the preferred dunging area is away from the roughage. We did not collect specific information on rooting behaviour, but it was obvious that the pigs became very active with the fresh fibrous material provided around 9 am.

The majority of dunging behaviour took place in the outdoor run as found by Olsen et al (2001) . This occurred especially in the slatted far end of the outdoor run behind the partition of the rooting area (area 3) in the pens with a rooting area. The distance from the lying area in the kennels to the outdoor slatted area was 10 m, which is within the preferred range of 5 to 15 m suggested by Stolba and Wood-Gush (1989). In pens without a rooting area use of a concentrated dunging area was less pronounced. A partition alone could also restrict dunging behaviour to the slatted area and prevent dunging on the solid floor. Subsequently, the solid floor at the rooting area location can become a complicating factor by becoming an attractive alternative dunging area. It might become necessary to stimulate activities like rooting and exploration there to prevent dunging on the solid floor.

Indoor pens with only an indoor drinker resulted in behaviour similar to that described by Hacker et al. (1994): The pigs eat, drink, urinate and defecate in a fixed sequence. After drinking the pigs go outside to urinate and defecate. The slatted indoor floor in pens with an outdoor drinker had double fouling scores compared to pens with only an indoor drinker. If the pigs don't use the indoor drinker this area becomes a safe secluded place for the vulnerable position during excretion (Baxter, 1984). The animals did not seem to use the indoor drinker when there was an outdoor drinker available, however water usage was not recorded. Possible reasons for preference for the outdoor drinker could include the outside climate, less competition outdoors or the size of the outdoor drinking bowl compared to the smaller indoor bowl. From the viewpoint of the pig farmer indoor dunging is undesirable behaviour and can be prevented by maintaining only an indoor drinking bowl, so that pigs only drink from this indoor drinker and keep the indoor area clean. When this area is used for drinking or other specific behaviour it will not be regarded by the pigs as potential dunging area.

In pens with 2.3 m² per finishing pig and 60% solid floor it is crucial to understand the sequence of behaviours and offer pigs specific functional areas for lying, eating, dunging and exploration. Stolba and Wood-Gush (1989) confirmed this separation under semi natural conditions. In this experiment the pigs seemed to have a fixed route from lying to eating, drinking, defecating and urinating, exploration and back to the lying area, as stated by Hacker et al (1994). Only when we offer pigs a pen with functional areas can they perform their natural behaviour and separate dunging from other behaviours and so minimize fouling within the pen.

5. Conclusions

A rooting area replenished daily with fresh chopped lucerne hay on the solid floor of the outdoor run attracted more pigs to spend time outdoors and improved the cleanliness of the total pen and particularly the outdoor run.

An additional outdoor drinker resulted in a cleaner area around the drinker, but reduced cleanliness indoors.

6. Acknowledgement

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Table captions:

Table 1. Estimated main effects of presence of pigs per area of the outdoor run with standard error (s.e.), P-value effect and estimated odds ratios with corresponding 95% confidence intervals

Table 2. Estimated main effects on pen fouling per area with s.e., P-values (tprob), calculated odds ratios with 95 % confidence intervals

Figure captions:

Figure 1. Layout of the room with 4 pens on each side; the upper left pens show the area codes used in this study with areas 1 and 8 always on both sides of the exit.

Figure 2. Predicted % presence with standard errors from fitting logistic model with interaction between Rooting area and Drinker.

Figure 3. Proportion of pigs present in the 4 areas of the outdoor run per treatment combination based on the predicted values per hour with standard errors.

Figure 4. Proportion of pigs present in area 2 of the outdoor run per treatment combination based on the predicted values per hour with standard errors.

Figure 5. Predicted percentages pen fouling per outdoor area with standard errors from fitted logistic model with interaction

Figure 6. Predicted percentages pen fouling per indoor area with standard errors from fitted logistic model with interaction.

Figure 7. Distribution of fouling scores of area 2 for the treatments Noroot and Root.

Table 1

Table 1. Estimated main effects of presence of pigs per area of the outdoor run with standard error (s.e.), P-value effect and estimated odds ratios with corresponding 95% confidence intervals

	Root vs Noroot				Drink vs Nodrink			
Area	Effect (se)	P-value[1)]	odds ratio	CI odds ratio	Effect (se)	P-value	odds ratio	CI odds ratio
Area 1	-0.15 (0.11)	0.182	0.86	(0.69, 1.08)	0.12 (0.11)	0.293	1.12	(0.90, 1.41)
Area 2	0.82 (0.18)	0.000	2.28	**(1.56, 3.32)**	-0.32 (0.17)	0.080	0.73	(0.51, 1.04)
Area 3	0.41 (0.08)	0.000	1.50	**(1.26, 1.79)**	-0.30 (0.08)	0.001	0.74	**(0.62, 0.88)**
Area 4	0.05 (0.09)	0.563	1.05	(0.88, 1.27)	0.32 (0.0.9)	0.002	1.37	**(1.14, 1.66)**
Total outdoor	0.31 (0.10)	0.003	1.36	**(1.12, 1.65)**	-0.06 (0.09)	0.534	0.94	(0.78, 1.14)

[1)]P-value, referring to an F-distribution, correcting for the remaining main effects

Table 2

Table 2. Estimated main effects on fouling scores with se, P-values, calculated odds ratios with 95 % confidence intervals from reduced model with main effects only.

	Root vs Noroot				Drinker vs Nodrinker			
Area	Effect(se)	P-value[1)]	odds ratio	CI odds ratio	Effect(se)	P-value	odds ratio	CI odds ratio
Area 1	0.21 (0.06)	0.002	1.24	**(1.09, 1.40)**	-0.21 (0.06)	0.002	0.81	**(0.72, 0.92)**
Area 2	-0.84 (0.18)	0.000	0.43	**(0.30, 0.63)**	0.14 (0.17)	0.429	1.15	(0.81, 1.63)
Area 3	0.19 (0.04)	0.000	1.20	**(1.10, 1.32)**	-0.03 (0.04)	0.429	0.97	(0.88, 1.06)
Area 4	0.21 (0.12)	0.092	1.23	(0.96, 1.57)	-0.80 (0.12)	0.000	0.45	**(0.35, 0.56)**
Area 5	0.14 (0.25)	0.582	1.15	(0.69, 1.92)	0.76 (0.27)	0.010	2.15	**(1.22, 3.76)**
Area 6	-0.93 (0.45)	0.051	0.40	(0.16, 1.00)	1.21 (0.48)	0.019	3.35	**(1.25, 9.00)**
Area 7	0.10 (0.11)	0.356	1.11	(0.89, 1.39)	1.07 (0.12)	0.000	2.92	**(2.28, 3.73)**
Area 8				Root x drink interaction				
Total area	-0.29(0.05)	0.000	0.74	**(0.67, 0.83)**	0.15(0.05)	0.011	1.16	**(1.04, 1.50)**

[1)]P-value, referring to an F-distribution, correcting for the remaining main effects

Figure 1
Click here to download high resolution image

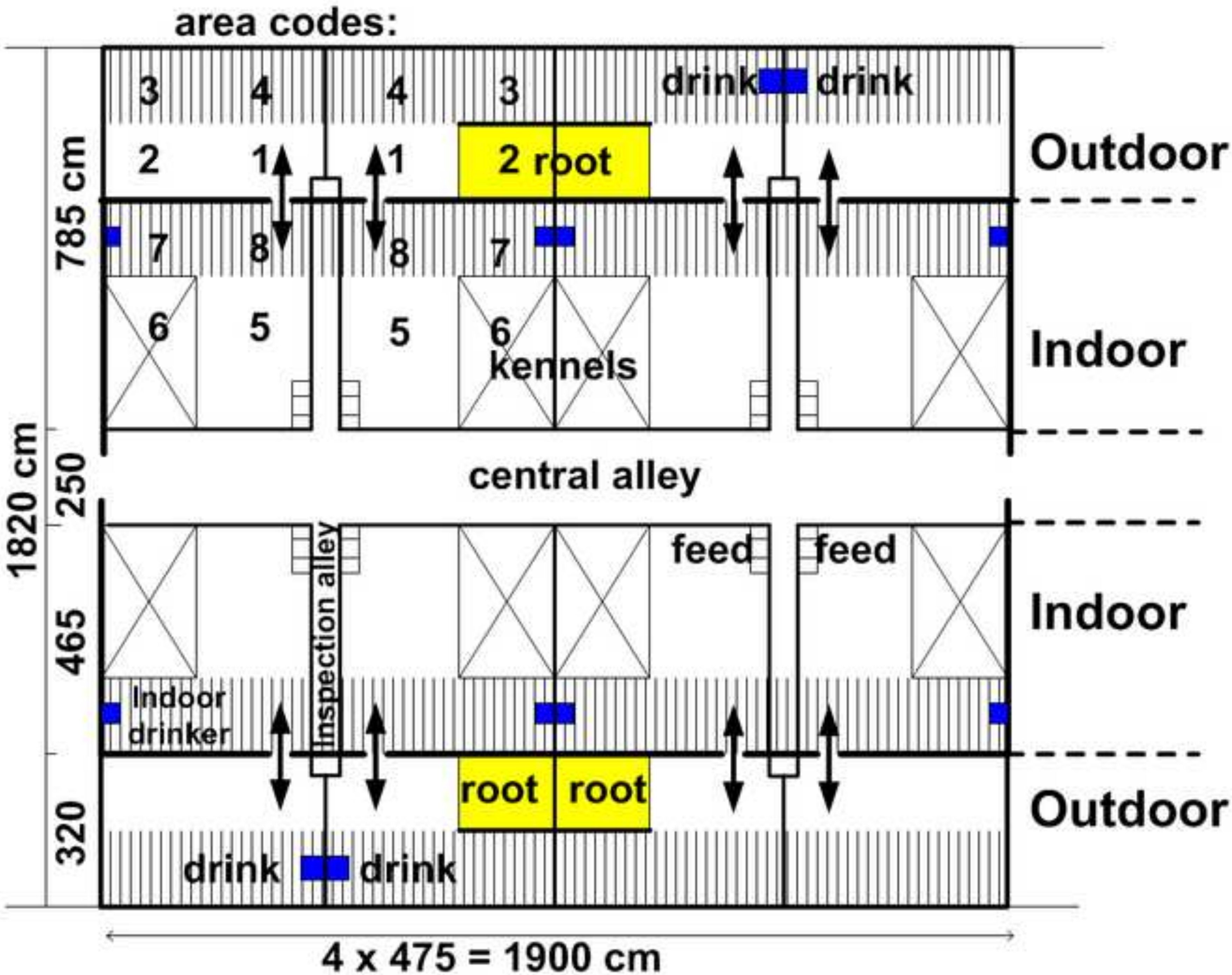
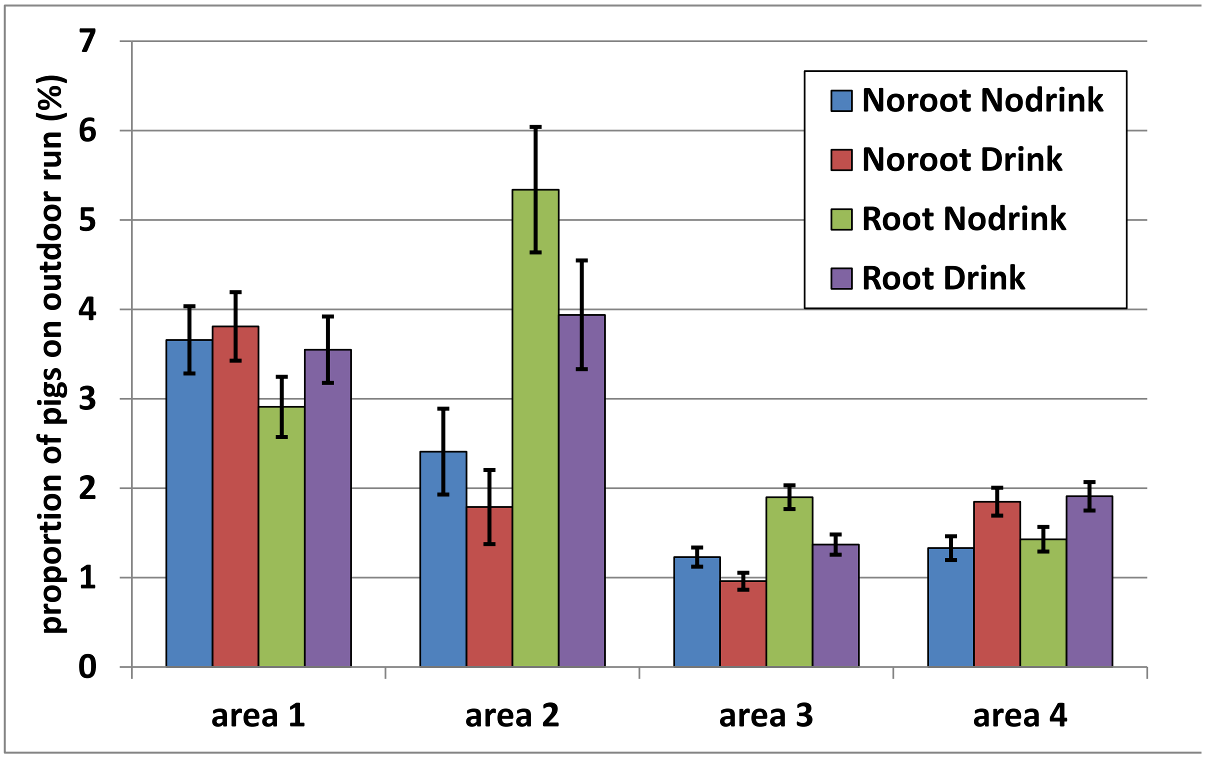
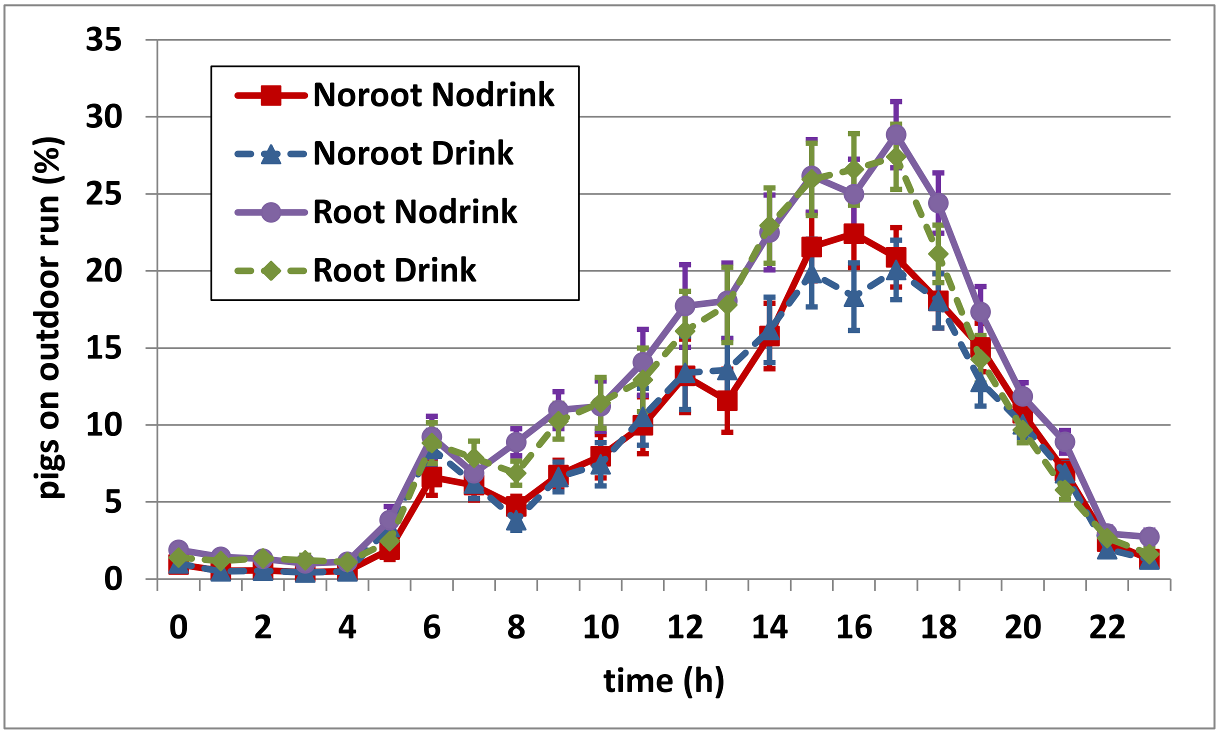


Figure 2



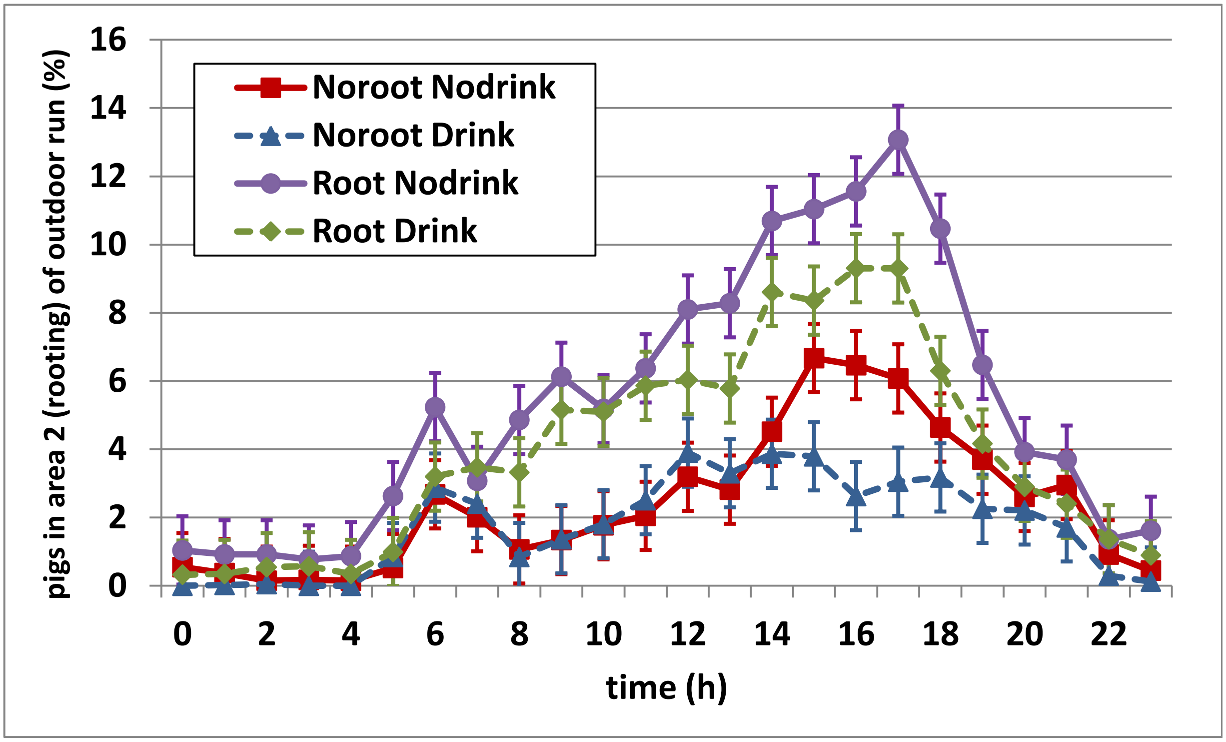
7
6
5
4
3
2
1
0
proportion of pigs on outdoor run (%)
Noroot Nodrink
Noroot Drink
Root Nodrink
Root Drink
area 1
area 2
area 3
area 4

Figure 3



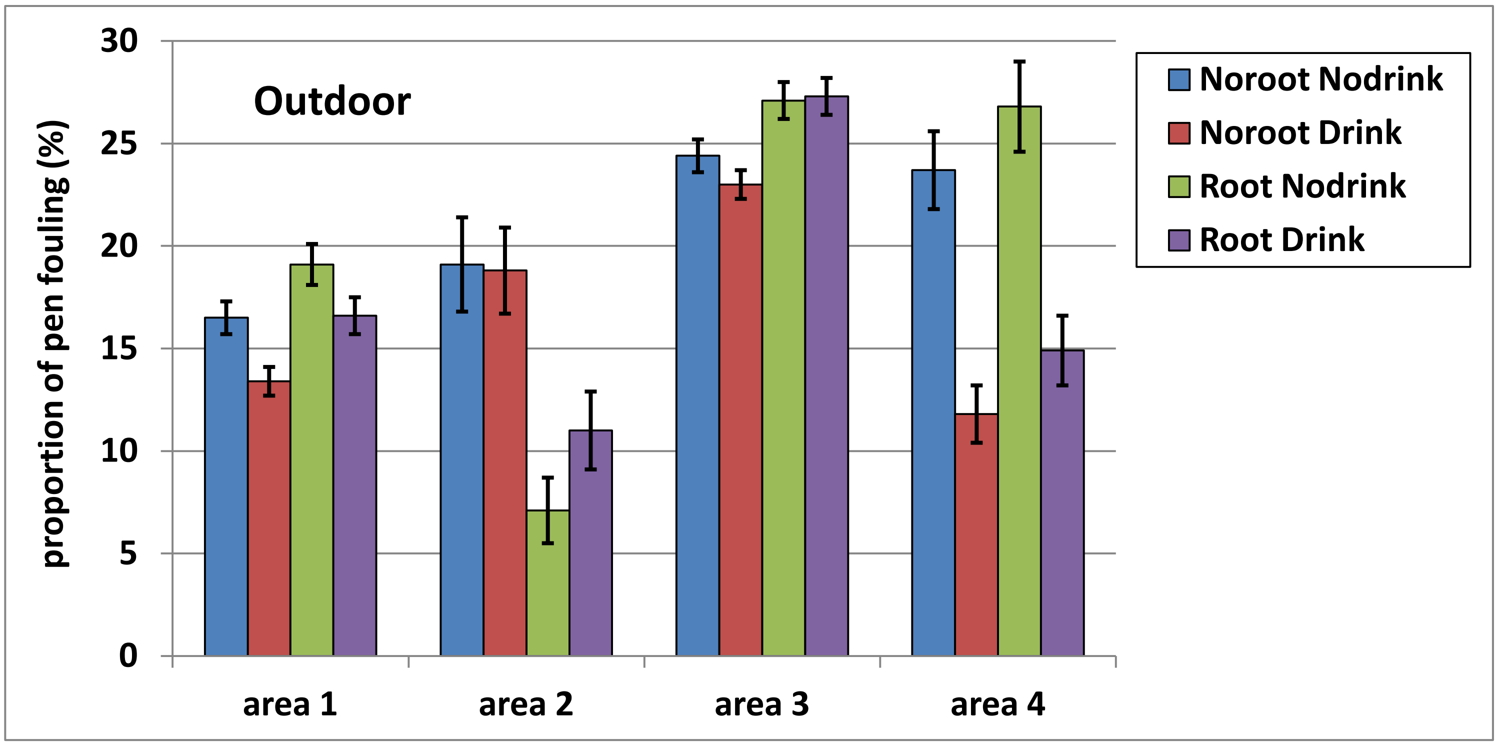
Noroot Nodrink
Noroot Drink
Root Nodrink
Root Drink
pigs on outdoor run (%)
time (h)
35
30
25
20
15
10
5
0
0
2
4
6
8
10
12
14
16
18
20
22

Figure 4



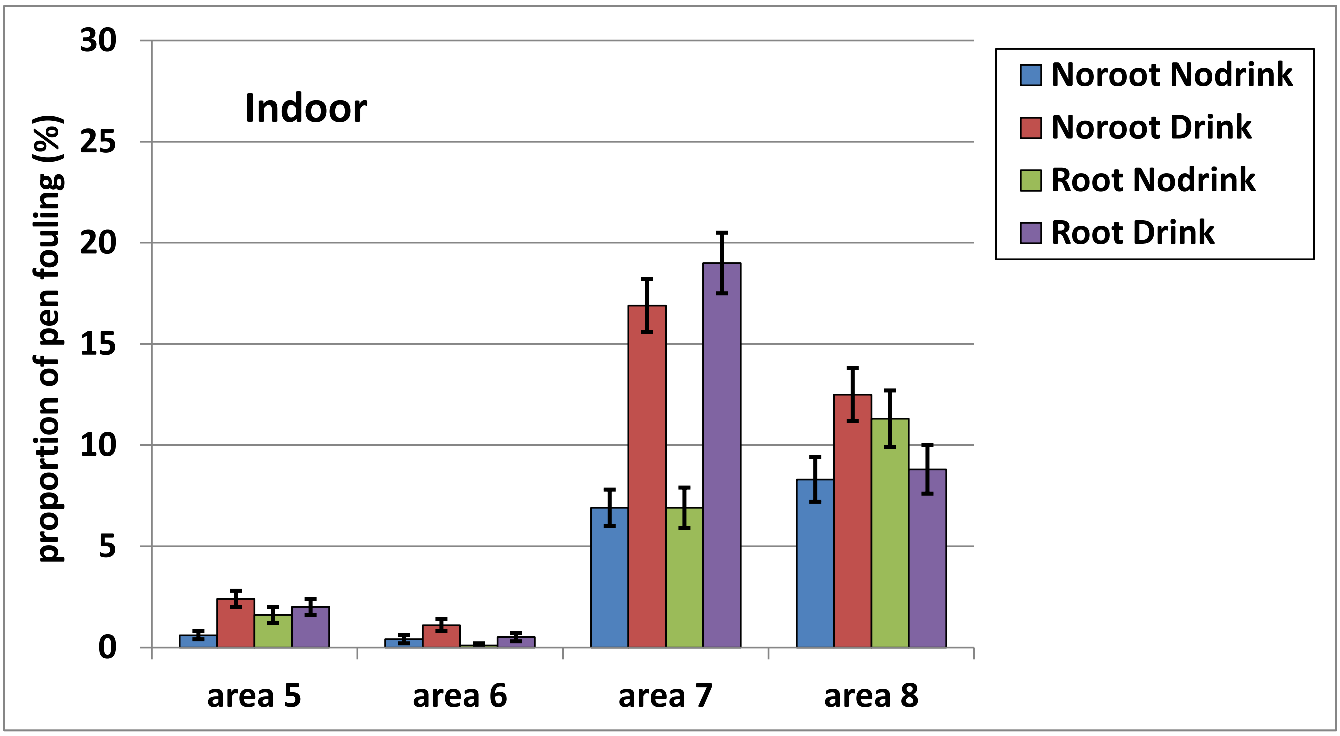
Noroot Nodrink
Noroot Drink
Root Nodrink
Root Drink
pigs in area 2 (rooting) of outdoor run (%)
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
18
20
22
time (h)

Figure 5



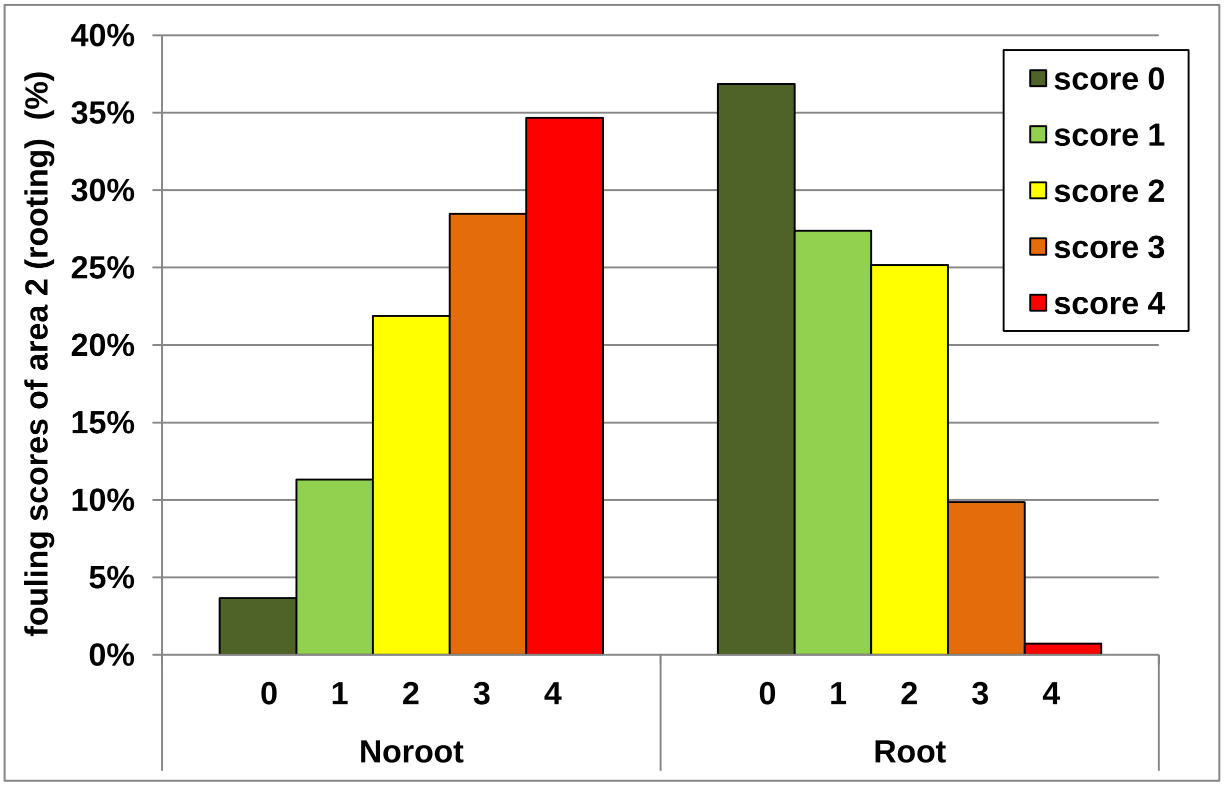
Outdoor
proportion of pen fouling (%)
30
25
20
15
10
5
0
area 1
area 2
area 3
area 4
Noroot Nodrink
Noroot Drink
Root Nodrink
Root Drink

Figure 6



Indoor
proportion of pen fouling (%)
0
5
10
15
20
25
30
area 5
area 6
area 7
area 8
Noroot Nodrink
Noroot Drink
Root Nodrink
Root Drink

Figure 7



40%
35%
30%
25%
20%
15%
10%
5%
0%
fouling scores of area 2 (rooting) (%)
score 0
score 1
score 2
score 3
score 4
0
1
2
3
4
Noroot
0
1
2
3
4
Root