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Evaluation of substrate quality in two different housing systems (barn systems and furnished cages) for laying hens with respect to dustbathing and foraging behaviour

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Summary

In this experiment we investigated the substrate quality with respect to dustbathing and foraging behaviour in two housing systems for laying hens. As we were only able to evaluate a small number of farms the results should be interpreted with care and regarded as an indication. We observed dustbathing and foraging behaviour on five farms with a barn system (single tier, in The Netherlands) and two experimental farms with furnished cages (in Belgium and Germany). Dustbathing and foraging behaviour were observed in the middle of the light period, and in addition foraging behaviour was scored at the end of the light period. In the latter period we also scored the number of hens showing feather pecking or aggressive pecking. Dustbathing behaviour was observed in about nine percent of the hens (in the substrate area) in barn systems and five percent of the hens (in the substrate area) in furnished cages. In addition, in furnished cages sham dustbathing was observed. No complete dustbaths were observed in furnished cage systems whereas in barn systems about 55% of the dustbaths were complete. Foraging behaviour was observed in about 17% of the hens in barn systems and five percent of the hens in furnished cage systems in the middle of the light period, and in about 38% of the hens in barn systems and 15% of the hens in furnished cage systems at the end of the light period. Aggressive pecking and feather pecking were hardly observed in both systems. The results of this study suggest that substrate in barn systems gives more opportunities for laying hens to perform dustbathing and foraging behaviour as compared to the substrate area in furnished cage sytems. The low proportion of hens performing foraging behaviour and the absence of complete dustbaths in furnished cage systems indicate that the substrate areas in these systems do not fulfil the needs of the hens, confirming the results of earlier studies in furnished cage systems.

1. Introduction

In Council Directive 1999/74/EC (CEC, 1999) it is stated that in furnished cage systems for laying hens litter should be provided in such a way that pecking and scratching are possible. Besides pecking and scratching litter has a function in the performance of dustbathing behaviour in laying hens. However, observations in furnished cages suggest that the supplied litter is inappropriate for dustbathing, as dustbathing behaviour is often disturbed and abnormal behaviours like feather pecking and cannibalism are still present (Appleby *et al.*, 2002; Olsson and Keeling, 2002). This may indicate that the litter as provided in these systems does not fulfil the behavioural needs of the hens. In alternative systems like aviaries or free-range systems, feather pecking can be a major problem as well, especially when non beak-trimmed hens are used (Savory, 1995). This suggests that also here the environment is not completely adequate to the hens, which may have negative implications for their welfare.

Although not all studies clearly show that dustbathing behaviour or access to substrate to perform either dustbathing or foraging is important for laying hens, there is evidence that hens may work to get access to a substrate area (see Cooper and Albentosa, 2003 for a review of these papers). In addition, research showed that birds have a preference for dustbathing in litter (Matthews *et al.,* 1995; Widowski and Duncan, 2000). In cage systems without a litter substrate hens often engage in bouts of sham dustbathing, but it has not been proven yet if hens are frustrated by the absence of a substrate. However, there is some indication that sham dustbathing is not satisfactory as it did not reduce the amount of dustbathing when given access to litter (Olsson *et al.,* 2002). It is clear that more fundamental research to understand dustbathing behaviour is necessary (AHAW, 2005). Substrate is not only used for dustbathing, but also for foraging behaviour. It has been shown that if substrate is not suitable for dustbathing, hens still have a high demand for it presumably for foraging behaviour

(Gunnarsson *et al.*, 2000). It has also been shown that laying hens will work to get access to substrate to perform foraging behaviour (Matthews *et al.*, 1995; de Jong *et al.*, 2005b). The risk of feather pecking is significantly reduced when an appropriate foraging material is supplied (e.g., AHAW, 2005).

In this study we aimed to get an impression of the substrate quality in furnished cage systems and barn systems with respect to the possibilities to perform dustbathing and foraging behaviour. In task 4.4 we defined criteria to evaluate the substrate quality with respect to the performance of dustbathing and foraging behaviour (de Jong *et al.*, 2005a). Dustbathing behaviour is predominantly present in the middle of the light period (Vestergaard, 1982; de Jong *et al.*, 2005a). We therefore measured in this period the proportion of hens engaged in this behaviour, as well as if the dustbathing behaviour is incomplete or complete. Incomplete dustbathing behaviour may indicate that the supplied substrate may be inappropriate to perform this behaviour (Van Liere *et al.*, 1990; de Jong *et al.*, 2005a). Foraging behaviour is predominantly present just before the dark period (Savory *et al.*, 1978). We therefore measured in this period the proportion of hens performing foraging, as well as the proportion of hens engaged in feather pecking and aggressive pecking. The latter behaviours may indicate that the supplied litter is inappropriate (Oden *et al.*, 2002; de Jong *et al.*, 2005a). In the Netherlands, there is a growing number of barn system farms due to the provisional ban on cages in 2012. We therefore chose five barn system farms to evaluate substrate quality. Because one of the aims of the LAYWEL project is to evaluate furnished cage systems we compared the results of the barn system farms with to observations on two experimental farms with furnished cages. As there are no commercial or experimental farms using furnished cages in The Netherlands, we visited a Belgian and a German experimental farm.

2. Methods

2.1. Farms

The substrate related behaviours of laying hens were observed on five barn system farms in The Netherlands and 2 experimental farms with furnished cages in Germany and Belgium. In appendix 1 and 2 detailed information about the farms is shown. For the barn system farms, the percentage of dry matter was calculated in two samples of the substrate per farm.

2.2. Behavioural observations

Behaviour was observed by direct observations on the farms and by analysing behaviour of the hens recorded on video tape. With the direct observations, we calculated the proportions of hens performing substrate-related behaviours. With the video recordings we determined the quality of dustbathing behaviour, i.e. if hens performed complete or incomplete dustbaths (de Jong *et al.*, 2005a).

2.2.1. Direct observations

For the direct observations in the barn systems, two persons observed the behaviour of the hens in 6 areas per unit (for each farm, only one unit was selected for behavioural observations). Two observers randomly selected three squares of 2.5 x 2.5 m per person in the litter area of the unit (left and right, front side, middle and rear side of the unit). In the middle of the light period they focussed on dustbathing and foraging behaviour. After a period of 20 min for habituation, they scored every 2.5 min the total number of hens in this square, the number of hens performing dustbathing, laying down and foraging (see Table 1 for the ethogram). In total, they scored the behaviour of the hens 12 times per location. Thereafter,

they switched to another location in the unit. Again after 20 min of habituation they observed the hens for 30 min, etc. We also measured the number of hens laying down because in a dustbathing bout often a period of laying down (and apparently doing nothing) is observed (Van Liere, 1991). The number of hens laying down thus may give an indication of the number of hens that is possibly also dustbathing. Two hours before lights off two persons again observed the behaviour of the hens on six locations, but they now focussed on foraging behaviour, feather pecking and aggressive pecking. Again the behaviour of the hens in six squares of 2.5 x 2.5 m was scored, but now 1.5 minute during 15 min per square the total number of hens, the number of hens foraging, the number of hens performing feather pecking and the number of hens performing aggressive pecking was scored (see the ethogram in table 1). A habituation period of 15 min was used before starting the observations and between changing the locations.

For the furnished cage systems the observation protocol differed per farm because the two farms had different furnished cage systems. In Germany, observations were performed on the left row of cages in a unit (on one of the three types of systems that were present at the farm). This system had four tiers, of which the behaviour was observed on the two lowest tiers because these cages could be completely scanned by the observers. The first observation session started at 10.00 h, one hour after substrate was provided and after a habituation period of ten minutes. Two cages were sampled at the same time by one observer during 30 minutes. Every 2.5 minutes the observer sampled both cages. In total, each observer sampled 12 cages twelve times, of which half of the cages were at the lowest tier and half of the cages were at the second lowest tier. Each observer calculated the number of hens in the substrate area, the number of hens performing dustbathing, laying down or foraging in the substrate area and the number of hens performing sham dustbathing in the whole cage except the substrate area. The second observation period started at 15.30 h. Again two cages were sampled at the same time

by one observer, during 15 minutes. Every 1.5 minute the observer sampled both cages. In total, each observer sampled 12 cages 10 times, of which half of the cages were at the lowest tier and half of the cages were at the second lowest tier. Each observer calculated the number of hens in the substrate area, and the number of hens performing foraging, feather pecking and aggressive pecking in the substrate area.

At the Belgian farm, observations were performed in two units. Three tiers of cages were present, of which the cages of the lowest and middle tier were sampled. Four different types of cages were present, i.e. cages with either a pan feeder or trough feeder and cages with substrate provided on a matting and cages with a substrate box. In the first observation period after a 10 minutes habituation period each observer sampled two cages each 2.5 min during 30 min, thus twelve times per cage, starting at 11.00 h. During the first part of the first observation session the substrate boxes were closed. In total each observer sampled 6 pairs of cages. Each observer calculated the number of hens in the substrate area, the number of hens performing dustbathing, laying down or foraging in the substrate area and the number of hens performing sham dustbathing in the whole cage except the substrate area. In the second observation period, each observer again sampled six pairs of cages. The second observation period started at 16.25 h. Each 1.5 min the observer scanned two cages ten times during 15 minutes. Each observer calculated the number of hens in the substrate area, and the number of hens performing foraging, feather pecking and aggressive pecking in this area.

Table 1. Ethogram of the behavioural measurements

Behaviour	Description
Dustbathing	Sequence of behaviours starting with scratching and bill-raking in the substrate, followed by the bird laying down and performing wing-shaking, head rubbing, bill raking, scratching with one leg, side lying only or side-rubbing. This may be interrupted with elements from the first phase like scratching and bill-raking. A dustbath ends with standing up and feather shaking (see (Van Liere, 1991) for a detailed description).
Incomplete dustbath	Dustbath lacking one or more elements as described above.
Sham dustbathing	Birds go through the sequence of dustbathing but on the bare wire floor
Laying down	The hen is laying on her side, apparently doing nothing
Foraging	Pecking and scratching at potential food sources involving locomotor activity
Feather pecking	Pecking and pulling at the feathers of other hens
Aggressive pecking	Forceful, usually downward pecks aimed at the head or dorsal region

2.2.2. Analysis of videotapes

Behaviour of the hens was recorded on videotape on both sides of the room during 3 h and analysed using the Observer software (Noldus, Wageningen, The Netherlands). Per side we tried to select 15 dustbaths that were clearly visible and we scored for these dusthbaths if they were either complete or incomplete, according to the ethogram (Table 1), thus, in total we tried to analyse 30 dustbaths per farm. Analysis of the dustbaths started 5 min after the installation of the camcorder in the room. For incomplete dustbaths it was scored if they were

either disturbed by another hen pecking at the dustbathing hen, another hen running over or pushing the dustbathing hen, or other (unknown) reasons.

2.3. Plumage condition

The plumage condition was scored using the scoring system as described by Tauson et al. (Tauson *et al.*, 2005). For six body parts scores of 1-4 were given for plumage condition. The higher the plumage score, the better the status of the plumage, i.e. a score of 4 was given to undamaged feathers, a score of 1 was given to heavily damaged feathers/nude areas. Per farm, the feather score was performed on 40 hens by two observers. For the barn system farms, 40 hens were randomly selected and scored. For the farms with furnished cages, 20 hens per tier were randomly selected from 10 cages per tier and scored.

2.4. Statistical analysis

This experiment was designed as a descriptive study, i.e. too little farms could be observed to perform any statistical analysis on factors affecting substrate-related behaviours on barn system farms or to compare barn system farms and furnished cage farms. For the farms with furnished cages, the sample size (number of cages) was large enough to perform a statistical analysis to compare the behaviour between hens housed in 40 or 60 bird cages (German farm) or cages with substrate matting, substrate boxes, pan feeders and feed chains (Belgian farm). Data were logit transformed and a binomial model was used. Data were analysed using the Genstat software (Committee, 2000).

3. Results

3.1. Direct observations

3.1.1. Barn system farms

Table 2 and 3 show the results of the direct observations in the barn systems, per farm and an average over the five farms. About nine percent of the hens in the observed area perform dustbathing behaviour in the middle of the light period, which may possibly be about three percent more due to hens in the lying phase of dustbathing (Table 2). In the middle of the light period about 17 % of the hens shows foraging behaviour (Table 2), which increases to about 38% at the end of the light period (Table 3). Feather pecking and aggressive pecking were hardly observed (Table 3).

Table 2. Mean number of hens per observation square and the percentage hens dustbathing, laying down or foraging in the middle of the light period, scored by direct observations on the barn system farms.

Farm	mean nr of hens per square	% hens dustbathing	% hens laying down	% hens foraging
barn 1	58.8	13.0	7.4	14.0
barn 2	45.6	8.4	3.1	21.1
barn 3	41.3	11.7	2.7	12.8
barn 4	44.1	8.0	3.5	15.8
barn 5	47.0	4.8	1.2	25.1
average barn system farms	**47.4**	**9.1**	**3.8**	**17.7**

Table 3. Mean number of hens per observation square and the percentage of hens foraging, showing feather pecking or aggressive pecking during the last two hours of the light period, as observed by direct observations on the barn system farms.

Farm	mean nr of hens per square	% hens foraging	% hens feather pecking	% hens aggressive pecking
barn 1	37.4	35.8	0.3	0.1
barn 2	39.9	37.8	1.6	0.3
barn 3	41.4	27.6	3.8	0.1
barn 4	42.8	48.7	0.4	0.3
barn 5	43.9	39.4	0.9	0.7
average barn system farms	**41.4**	**38.0**	**1.4**	**0.3**

3.1.2. Furnished cages

Table 4, 5 and 6 show the proportion of hens performing dustbathing behaviour, foraging and sham dustbathing in the middle of the light period. For the Belgian farm, observations were split into observations before and after opening of the substrate box. At the German farm, significantly more hens in the 60 bird cages as compared to the 40 bird cages were dustbathing (Table 4). At the Belgian farm, significantly more hens were laying down ($P<0.01$) and sham dustbathing ($P<0.01$) in cages with a substrate box as compared to cages with substrate matting. A higher proportion of hens at the Belgian farm performed dustbathing, laying down and foraging as compared to the German farm.

Table 4. Mean number of hens in the substrate area, and the percentage of hens showing dustbathing, laying down, foraging and sham dustbathing in the furnished cages in Germany. [a,b]: significant difference (P<0.05).

		mean nr of hens in substrate	% hens dustbathing[1]	% hens laying down[1]	% hens foraging[1]	% of hens sham dustbathing[2]
lowest floor	40 bird cages	5.5	1.7[a]	3.2	11.1	15
	60 bird cages	8.0	7.1[b]	3.1	8.4	16.2
middle floor	40 bird cages	6.8	3.8[a]	0.8	3.6	4.5
	60 bird cages	6.9	5.1[b]	4.3	5.4	9.2
farm average		**7.0**	**4.5**	**2.4**	**6.9**	**11.2**

[1] Proportions calculated as proportion of the number of hens in the substrate area.

[2] Proportion calculated as proportion of the number of hens in the whole cage.

Table 5. Mean number of hens in the substrate area, and the percentage of hens showing dustbathing, laying down, foraging and sham dustbathing in the furnished cages in Belgium, in the period that the substrate boxes were closed.

		mean nr of hens in substrate area	% hens dust-bathing[1]	% hens laying down[1]	% hens foraging[1]	% of hens sham dustbathing[2]
pan feeder	substrate matting	6.3	5.4	5.8	10.7	1.6
	substrate box	*	*	*	*	4.0
chain feeder	substrate matting	4.6	4.9	5.55	3.7	2.6
	substrate box	*	*	*	*	8.5
farm average		**5.4**	**5.2**	**5.7**	**4.8**	**4.2**

* substrate boxes closed; [1] Proportions calculated as proportion of the number of hens in the substrate area;

[2] Proportion calculated as proportion of the number of hens in the whole cage.

Table 6. Mean number of hens in the substrate area, and the percentage of hens showing dustbathing, laying down, foraging and sham dustbathing in the furnished cages in Belgium, in the period that the substrate boxes were open.

		mean nr of hens in substrate	**% hens dust-bathing[1]**	**% hens laying down[1]**	**% hens foraging[1]**	**% hens sham dustbathing[2]**
pan feeder	substrate matting	7.6	10.1	3.8	11.8	1.0
	substrate box	1.9	12.2	27.9	37.5	1.75
chain feeder	substrate matting	6.7	7.1	5.8	13.7	0
	substrate box	1.9	18.2	13.2	17.6	5.12
farm average		**4.5**	**11.9**	**12.7**	**20.2**	**2.0**

[1] Proportions calculated as proportion of the number of hens in the substrate area.

[2] Proportion calculated as proportion of the number of hens in the whole cage.

Table 7 and 8 show the proportion of hens showing foraging, aggressive pecking and feather pecking at the end of the light period. At the Belgian farm, the proportion of hens feather pecking was highest.

Table 7. The proportion of hens foraging, feather pecking and aggressive pecking in furnished cages (German farm), expressed as percentage of the number of hens in the substrate area.

		mean nr of hens in substrate	**% hens foraging**	**% hens feather pecking**	**% hens aggressive pecking**
lowest floor	40 bird cages	6.0	18.4	0.8	1.9
	60 bird cages	6.0	19.2	1.3	1.8
middle floor	40 bird cages	5.9	14.1	1.7	1.6
	60 bird cages	6.2	19.6	1.6	0.8
farm average		**6.0**	**17.3**	**1.4**	**1.5**

Table 8. The proportion of hens foraging, feather pecking and aggressive pecking in furnished cages (Belgian farm), expressed as percentage of the number of hens in the substrate area.

		mean nr of hens in substrate	**% hens foraging**	**% hens feather pecking**	**% hens aggressive pecking**
pan feeder	substrate matting	8.0	12.7	6.2	0.2
	substrate box	0.9	21.3	23.9	0
chain feeder	substrate matting	5.4	17.3	9.2	2.0
	substrate box	0.7	16.2	5.2	0
farm average		**3.6**	**14.3**	**7.7**	**0.7**

3.2. Video observations

Figure 1 shows the duration of complete and incomplete dustbaths in barn and furnished cage systems, figure 2 shows the proportion of complete and incomplete dustbaths in both systems. For only two barn system farms 30 dustbaths could be observed. For the barn system farms at least 21 dustbaths could be observed (in total, 128 dustbaths for barn system

farms). For the furnished cage systems, 11 dustbaths could be observed for the German farm and 15 dustbaths for the Belgian farm. In furnished cage systems, no complete dustbaths were observed. Interrupted dustbaths in furnished cages were mainly caused by hens being pushed or ran over by other hens. The duration of these incomplete dustbaths was longer in furnished cages than in barn systems.

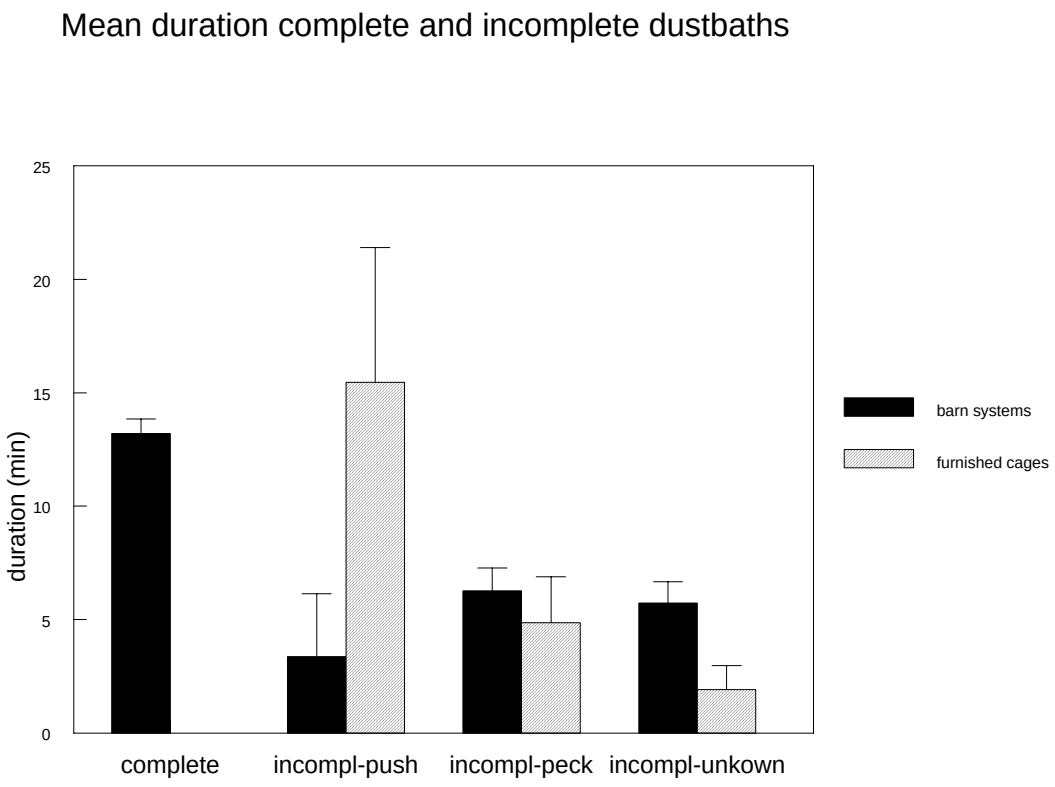

Figure 1. Mean duration of complete dustbaths and incomplete dustbaths in barn system and furnished cage systems. Incompl-push: dustbath interrupted by other hens pushing or running over the dustbathing hen; Incompl-peck: dustbath interrupted by pecking by other hens; Incompl-unknown: dustbath interrupted by unknown reasons.

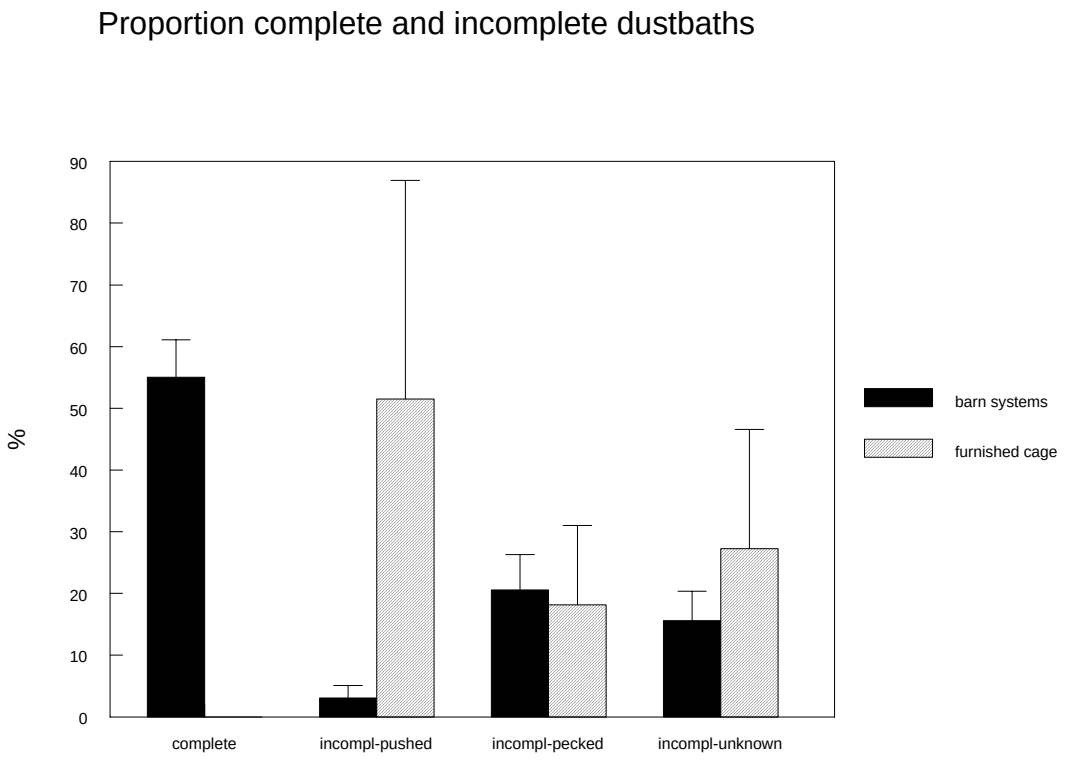

Figure 2. Proportion of complete and incomplete dustbaths in barn system and furnished cage systems. Incompl-push: dustbath interrupted by other hens pushing or running over the dustbathing hen; Incompl-peck: dustbath interrupted by pecking by other hens; Incompl-unknown: dustbath interrupted by unknown reasons.

3.3. Plumage condition

Table 9 shows the scores for plumage condition for the barn system farms and furnished cage farms. The plumage condition at the Belgian farm was very good but these birds were sampled at an earlier age as compared to the other farms. Only a slightly less plumage condition was found at the barn system farms as compared to the German furnished cages. This may also be related to the age of the hens as the average age of hens in barn systems was slightly higher.

Table 9. Plumage condition scores for the six body parts scored, averaged per farm and all farms.

	Neck	Back	Breast	Wings	Tail	Cloaca/Vent
barn 1	2.3	3.3	3.3	3.3	3.2	3.3
barn 2	2.3	2.8	2.8	3.1	2.9	2.6
barn 3	2.9	3.2	3.1	3.3	2.8	3.2
barn 4	4	4	2.8	3.9	2.2	3.5
barn 5	2.6	3.1	2.4	3.2	2.8	1.9
average barn systems	**2.8**	**3.3**	**2.9**	**3.4**	**2.8**	**2.9**
enriched Germany	3.0	3.4	3.6	3.6	3.7	3.6
enriched Belgium	4	4	4	4	4	4

3.4. Percentage dry matter

Average percentage of dry matter of the barn system farms was 74.3% (range 71.5-77.0%).

4. Discussion and conclusion

To get an impression of the substrate quality in barn systems and furnished cage systems for laying hens with respect to dustbathing and foraging behaviour we observed these behaviours in five barn systems and two furnished cage systems. Because of the low number of farms in this study the results should be handled with care and for a more reliable evaluation of substrate quality the number of farms should be increased.

With the interpretation of the results it should be noticed that in barn systems the substrate area is large enough to contain all hens, whereas in furnished cage systems only a small part of the hens in the cage can stay in the substrate area at the same time. The proportion of hens that performs dustbathing behaviour does not differ between barn systems and furnished cage systems, but it should be noticed that in the furnished cage systems sham dustbathing was observed on the wire floor.

The proportion of complete dustbaths is a good indicator of the suitability of substrate for dustbathing behaviour (de Jong *et al.*, 2005a). One of the most striking results we observed here is that in furnished cages no complete dustbaths were observed. The largest part of the incomplete dustbaths was caused by dustbathing hens ran over or pushed by other hens. The substrate area in furnished cages is very small. Laying hens are birds that aim to synchronise their behaviour (Mench and Keeling, 2001) which is not possible in the substrate areas in furnished cage systems. This may be the causation of sham dustbathing which was observed in furnished cage systems. The results we observed in this experiment support earlier studies indicating that the supplied litter in furnished cage systems may be inappropriate for dustbathing (Olsson and Keeling, 2002; Appleby, 2004). However, it should also be noticed that in the barn system systems about half of the proportion of dustbaths was incomplete, mainly caused by pecking by other hens.

The proportion of hens performing foraging behaviour at the end of the light period is higher in barn systems as compared to furnished cage systems. We observed that no substrate was present in the furnished cage systems in the second observation period, thus, foraging behaviour in the substrate area will not be stimulated in this period. The observers saw many hens pecking at the wire or at the empty feeders, which may have been caused by the motivation to forage but lack of appropriate foraging substrate. These observations may indicate that with respect to foraging behaviour barn systems seem to provide the hens more opportunities to perform this behaviour as compared to enriched cage systems.

Feather pecking behaviour was hardly observed, although in the barn systems feather damage was observed that was most likely caused by feather pecking. The observation method used in the present experiment may not have been suitable for a reliable analysis of feather pecking behaviour, but, feather pecking may also be present on the wire floor of the barn systems which was not included in our observations. The observers noted that the wire floors were very crowded. High proportions of aggressive pecking may indicate that the substrate area is too crowded for the hens to perform their behaviours (Oden *et al.*, 2002) but in this study very low proportions of aggressive pecking were observed.

Conclusions

Although we can not draw firm conclusions due to the small sample size of this study, the results suggest that substrate in barn systems gives more opportunities for laying hens to perform dustbathing and foraging behaviour as compared to the substrate area in furnished cage systems. The low proportion of hens performing foraging behaviour and the absence of complete dustbaths in furnished cage systems may indicate that the substrate areas in these systems do not fulfil the needs of the hens, as has been suggested in earlier studies (see e.g.

(AHAW, 2005), although more research into this subject is necessary to draw firm conclusions. It should be noticed that the results of this study are directed towards the furnished cage designs used in the experimental facilities, and that it would be interesting to study if furnished cage designs can be improved with respect to laying hen welfare by increasing the litter area, litter depth and/or frequency of litter supply. Currently mash feed is often used as litter substrate in furnished cage systems (Fiks, personal communication), but it is not known if this would produce different results with respect to substrate quality for dustbathing and foraging behaviour.

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Appendix 1. Detailed information of the barn system farms visited.

	Barn system 1	Barn system 2	Barn system 3	Barn system 4	Barn system 5
Location	Woudenberg NL	Zurich NL	Ruinerwold NL	Makkinga NL	Witteveen NL
Substrate at start of laying period	wood shavings	sand	wood shavings and straw	none	wood shavings
Additional substrate during the laying period	no	no	some straw	no	no
System producer	Jansen	Jansen	Jansen	Vencomatic	Jansen
Nr of hens in the observed unit	10500	5170	6000	7800	9200
Particle width litter	small	small	small	small	small
Litter quality	dry, loose, some plaques	dry, many plaques, some clods	dry, loose, some clods	dry and loose, some clods	dry and loose
% Lay	83	80	85	84	76
Egg weight	67	63.5	63	68	65.5
Feed intake	126	135	125	135	125
Age at sampling	66	64	47	71	69
Breed	Isabrown	Bovans GL	Isabrown	Lohmann Brown	Isabrown
Light period	04.00-20.00	03.50-18.00	06.00-21.00	03.00-18.00	04.00-20.00
Other	-	-	-	-	System with outdoor area, but this area has not been open for 3 days when observing

Appendix 2. Detailed information of the experimental farms with furnished cages.

	Furnished cages 1	Furnished cages 2
Location	Germany	Belgium
System producer	Big Dutchman	Specht
Nr of hens per cage, dimensions per cage	40, 2.4 x 1.24 m 60, 3.6 x 1.24 m height ca 50 cm	39, 2.40 x 1.10 m (feed chain) 43, 2.40 x 1.20 m (pan feeder) height 52 cm
Dimensions substrate area	0.6 x 0.54 m	matting 0.50 x 0.37 m box 0.22 x 0.59 m
Substrate type	Wood shavings	Wood shavings
Times of substrate provision	9:00 h, 13.30 h	13.30 h
% Lay	88%	94%
Egg weight	62.3 gr	60.15 g
Feed intake	not determined	116.5 g
Age of the hens when observing	50 weeks	29 weeks
Breed	Lohmann Brown	Isabrown
Light period	04:30 – 18:00 h, twilight 04:00-04:30, 18:00-18:30	03.00 – 21.00 h
Other remarks	Experimental facilities with different cage types of which one system was selected for observations	Experimental facilities Two rooms with both types of feeding systems, half of these cages per room have a substrate box, the other half a substrate matting