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Welfare assessment of laying hens in furnished cages and non-cage systems: an on-farm comparison

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Abstract

From 2012 onwards, all laying hens in Europe will need to be housed either in furnished cages or non-cage systems (aviaries or floor-housing systems). In terms of animal welfare, furnished cages and non-cage systems both have advantages and disadvantages. Data on direct comparisons between the two, however, are limited. The aim of this study was to carry out an on-farm comparison of laying hens' welfare in furnished cages and non-cage systems. To meet this aim, six flocks of laying hens in furnished cages and seven flocks in non-cage systems (all without an outdoor run) were visited when hens were around 60 weeks of age and a number of measures were collected: behavioural observations, fearfulness, plumage and body condition, incidence of bone breaks, bone strength, TGI-score (or Animal Needs Index), dust levels and mortality. In non-cage systems, birds were found to be more active and made greater use of resources (scratching area, perches) than in furnished cages. These birds also had stronger bones and were less fearful than birds in furnished cages. On the other hand, birds in furnished cages had lower mortality rates, lower incidence of bone fractures and lower airborne dust concentrations. When all the welfare indicators were integrated into an overall welfare score, there were no significant differences between systems. These results indicate that furnished cages and non-cage systems have both strong and weak points in terms of their impact on animal welfare.

Keywords: *animal welfare, behaviour, health, housing, laying hens, welfare assessment*

Introduction

From 2012 onwards, conventional cage housing for laying hens will be prohibited in the European Union, in keeping with EU-directive 1999/74 and only furnished cages and non-cage systems (aviaries and floor housing) will be permitted. Furnished cages and non-cage systems both appear to have advantages and disadvantages regarding animal welfare (Rodenburg *et al* 2005).

In furnished cages, birds have limited space and litter availability compared with non-cage systems, which leads to comparatively lower levels of comfort behaviour (Appleby *et al* 2002; Albentosa & Cooper 2004) and dust bathing (Cooper *et al* 2004). Cage housing may also affect fearfulness. Hansen *et al* (1993) studied fearfulness of birds in conventional cages compared to aviaries and found that birds in conventional cages were more fearful than birds in aviaries, at the end of the laying period. It is not known whether this also applies to furnished cages.

In non-cage systems, birds are housed in large groups (5,000 up to 30,000 birds) and with larger groups comes an increased risk of feather pecking compared to small groups (Nicol *et al* 1999; Bilcík & Keeling 2000). Feather pecking can develop into cannibalism and lead to high mortality rates. Although feather pecking does also cause problems in cage systems, an outbreak of feather pecking is more difficult to control in non-cage systems. A second welfare issue in non-cage systems is bone fractures. Wilkins *et al* (2004) found that 50 to 80% of birds in non-cage systems had old bone fractures in the keel or furculum. In an earlier study by Gregory *et al* (1990), this percentage was found to be much lower (25% in non-cage systems and 5% in conventional cages). Such data suggest that the problems caused by bone fractures are, at present, on the increase. Mortality rates also tend to be higher for non-cage systems compared to cages (Michel & Huonnic 2004).

Data on direct comparisons between furnished cages and non-cage systems are limited. The aim of this study was to carry out an on-farm comparison of the welfare of laying hens in furnished cages and non-cage systems.

Table 1 Overview of the visited flocks.

Flock	Farm	System	Country	Date	Age (weeks)	Beak trimmed	Hybrid	Stocking density (birds m^{-2})	Group size	Light intensity (lux)
1	1	Floor	NL	9/2005	65	Y	Hyline	9	32,000	14.2
2	2	Cage	B	9/2005	60	Y	LSL	15	40	4.7
3	3	Floor	NL	10/2005	55	Y	ISA Brown	9.5	9,702	6.8
4	2	Cage	B	10/2005	62	Y	ISA Brown	16	44	7.6
5	4	Aviary	B	11/2005	59	Y	Bovans Gold	18	9,300	7.2
6	5	Aviary	NL	11/2005	59	Y	Bovans Gold	17	27,000	20.7
7	6	Cage	B	1/2006	63	Y	ISA Brown	13	40	3.1
8	6	Aviary	B	1/2006	63	Y	ISA Warren	8	500	10.4
9	6	Cage	B	1/2006	63	Y	ISA Brown	12	20	3.8
10	7	Floor	B	1/2006	72	Y	ISA Brown	9	10,400	182
11	8	Cage	G	2/2006	82	N	Lohmann Brown	14.5	44	11.3
12	9	Floor	B	2/2006	65	Y	Bovans Gold	8	5,875	6.6
13	19	Cage	G	6/2006	54	N	LSL	14.6	50	9.1

NL: The Netherlands; B: Belgium; G: Germany.

Materials and methods

Farms

Thirteen flocks of laying hens on ten farms were included in this study (Table 1). Six flocks were housed in furnished cages and seven in non-cage systems. Of these seven flocks, three were housed in aviaries and four in floor housing systems. Only farms without an outdoor run were included. Regarding the farms with furnished cages, only farms with fully equipped furnished cages (perches, nest, scratching area) were included. The scratching area consisted of an Astroturf® mat, upon which a limited amount of litter was supplied, once a day. The farms were visited when birds were approximately 60 weeks of age (ranging from 55 to 82 weeks of age). Farms from three different countries were included in the study (Belgium, The Netherlands and Germany). In each flock, a series of measurements and observations were conducted and a questionnaire filled out together with the farmer. Each farm visit took approximately a day-and-a-half. There was a degree of variation in stocking density, group size and light intensity among farms (Table 1). In all farms, birds had access to perches; in furnished cages only low perches were available while in non-cage systems birds had both low and high perches. On all farms, birds had nest, feeder and drinker spaces, in accordance with EU-directive 1999/74. All systems offered a scratching area, although the amount of litter available was extremely limited (if present at all) in each of the furnished cage systems visited. All furnished cage and aviary systems had manure belts that were emptied regularly whereas, with the exception of farm 1, floor housing systems had no manure belts.

Behavioural observations

In each flock, four 30 min behavioural observations were conducted; two in the scratching area and two close to the perches. The observations took place between 1200 and 1600h and observations in the scratching area and perches were alternated. In the present study, it was not possible to study perch use during the night. Before starting each observation, in an observation area 2 m wide and 1 m deep, birds were habituated to the presence of the experimenter for a period of five minutes. After habituation, the observation started and the behaviour of each bird was recorded every five minutes using scan sampling in six subsequent scans. Gentle and severe feather pecking, aggressive pecking and toe pecking were observed continuously using behaviour sampling (see Table 2 for the ethogram).

For the behaviours observed using scan sampling, percentages of time spent on each behaviour were calculated per flock. For the behaviours observed using behaviour sampling, numbers of bouts (gentle feather pecking) or pecks (other behaviours) per flock were used in the further analysis. A bout of gentle feather pecking ended when the bird changed its behaviour to a different state, stopped pecking for longer than five seconds or started pecking a different body area or a different bird. Feeding and drinking were excluded from the analysis as feeding and drinking in the scratching area or near the perches was not possible in each system. The total amount of foraging, dust bathing and perching was included in the overall welfare score.

In addition to the observations on feather pecking, plumage condition was assessed on a sample of 30 birds per flock, using the method developed by Tauson *et al*

(2005). Feather damage on the neck, breast, vent, back, wings and tail region was assessed on a four-point scale, ranging from 4 (no damage) to 1 (completely denuded). The total feather score (sum of the six regions) was included in the overall welfare score.

Tonic immobility test

The tonic immobility test was conducted on a sample of 15 birds per flock. Birds were caught in an alternating order, in furnished cages from the top, middle and bottom tiers, in non-cage systems from the floor and from the tiers or perches and from different locations within the house. A bird was caught and restrained on its back on a small plastic table with the head hanging over the edge of the table to measure the duration of tonic immobility. One hand rested on the bird's breast and the other covered its head. The bird was restrained for 10 s. After that, the experimenter carefully removed his hands and time measurement started. If the bird stood up within 10 s, tonic immobility was induced again. The number of inductions and the latency to stand up were recorded. The test ended after a maximum of 5 min. Birds were tested within the house: in furnished cages between two rows of cages, in non-cage systems in the scratching area (with the experimenter sitting on a chair in front of the table with the bird). At the other side of the table was a crate, into which tested birds were collected. This crate helped ensure the test bird was not disturbed by other birds in the non-cage systems. The latency to stand up was included in the overall welfare score.

Body condition

Body condition was assessed on a sample of 30 birds per flock, using the method developed by Tauson *et al* (2005). Wounds to both the comb and the region around the vent, along with incidences of foot pad dermatitis were also assessed on the same birds, using the same scoring system as before: 4 (no damage) to 1 (serious wounds). Furthermore, the keel bone and furculum of these birds were palpated carefully to detect bone fractures, using a two-point scale, ranging from 0 (no fractures) to 1 (fractures), in accordance with the method described by Wilkins *et al* (2004). Birds were caught in an alternating order, in furnished cages from the top, middle and bottom rows, in non-cage systems from the floor and from the tiers or perches and from different locations within the house.

Fifteen of these 30 birds had previously been tested in the tonic immobility test described above. These 15 birds were killed humanely (using an electrical stunner or the CASH poultry killer, Accles & Shelvoke, Sutton Coldfield, UK) and dissected to obtain a more concise determination of the fracture severity in the keel bone, using a five-point scale, ranging from 0 (no breaks) to 4 (multiple breaks, large keel bone deformity) as described by Wilkins *et al* (2005). The percentage of birds with fractures in the keel bone, based on dissection data, was included in the overall welfare score.

Table 2 Ethogram used for the behavioural observations.

Behaviour	Description
Scan sampling	
Feeding	Pecking in the feeder
Drinking	Pecking at the nipple/drinking from bell-drinker
Foraging	Pecking at/scratching the floor
Comfort	Preening feathers or legs/stretching wings or legs
Dust bathing	Dust bathing, pecking at the floor in a lying position
Object pecking	Pecking at an object (wall, etc)
Walking	Walking or running
Standing	Standing without other activity
Sitting	Sitting without other activity
Perch use	Standing or sitting on the perch
Behaviour sampling	
Gentle feather pecking bout	Bout of gentle pecking at the feathers of another bird (gentle pecking movements, no reaction recipient)
Severe feather peck	Severe peck at the feathers of another bird (forceful pecks, reaction incipient)
Aggressive peck	Aggressive peck at the head or neck of another bird
Toe peck	Peck at the toes of another bird

Bone strength

From the same 15 birds dissected to study bone fracture severity, the right and left leg (tibia) and wing (humerus) bones were removed, as well as the keel bone (sternum). These bones were used to measure bone strength, determined via a three-point compression test using a single column motorised test stand (Versatest 2500 N, Unitek Eapro, Helmond, The Netherlands) and a digital force gauge (Mecmesin 1000 N, Unitek Eapro, Helmond, The Netherlands) with a straight knife mounted below. A constant head speed of 30 mm min^{-1} was applied. Breaking strength of the keel bone (lateral surface; not the location of keel bone fractures) was determined using a round-headed probe (5 mm). For each bone, the maximum force (N) needed to break the bone was assessed. For the leg and wing bones, the mean breaking strength of the left and right bone was used for further analysis. The mean breaking strength of the leg, wing and keel bones was included in the overall welfare score.

Table 3 The welfare indicators with weighting factors that were included in the overall welfare score.

Welfare indicator	Weighting
Feather score	8.92
Mortality	8.71
Bone fractures	8.54
Red mites	7.54
Foraging	7.38
Bone strength	6.77
Dust bathing	6.46
Perch use	6.15
Enterobacteriaceae	4.31
TGI-score	4.25
Respirable dust	4.08
Tonic immobility	3.92
Shell quality	3.62
Shell cleanliness	3.23
Inhalable dust	3.15
Eggshell bacteria	2.69
Airborne bacteria	2.00

TGI-200

The TGI-200 was used in order to record environment-based welfare indicators, such as stocking density, group size and housing design (Striezel *et al* 1994; Mollenhorst *et al* 2005). The information needed for the TGI-200 was included in a questionnaire and filled out in conjunction with the farmer. Light intensity was measured in the house at ten different points close to the feeding and drinking facilities. The mean light intensity was included in the TGI. Other indicators that were assessed by the observer in the house were: the presence and quality of the litter; the presence of high and low perches; feather damage at flock level; the distribution of birds over the system; the smell of the air in the house; whether or not the birds were beak-trimmed and the cleanliness of the system. Furthermore, the sizes of the nests and scratching area were measured and the height of the perches and the distance between the perches were recorded. The total TGI-score was included in the overall welfare score.

Dust levels and general hygiene

Airborne dust levels were measured using a Dust Sampling Kit (SKC, Dorset, UK), consisting of a Sidekick pump, an IOM dust sampler and a Cyclone dust sampler. The IOM sampler was used to collect a sample of the inhalable dust (particle size: 1 to 100 µm) and the Cyclone was used to collect respirable dust (particles: < 8.5 µm). The samplers were connected to the Sidekick pump (IOM: throughput 2 l min^{-1}; Cyclone: throughput 2.2 l min^{-1}). Each dust sampler was used in a separate 45 min session. In the first session on each farm, the IOM sampler was used and the observer moved throughout the house collecting other samples. In the second session on each farm, the Cyclone was used and the observer performed behavioural observations in two different locations in the house. Each sampler was fixed on the collar of the observer and a sample was collected during 45 min in each session. The filters which collected the dust were weighed before and after sampling, after keeping the samplers in a climate-controlled storage unit (to control for differences in humidity) for 24 h. The levels of inhalable and respirable dust were included in the overall welfare score.

Further hygiene-related aspects studied, included airborne concentration of *Enterobacteriaceae* and aerobic bacteria, presence of aerobic bacteria on the eggshell, eggshell quality and cleanliness and incidence of red mite infestations. Although these aspects are described in more detail by de Reu *et al* (2008), the main results are given here to facilitate an accurate interpretation of the overall welfare score.

Mortality rate

The mortality rate up to and including 60 weeks of age was reported by the farmer in an interview (data from written farm records). In this interview, the farmer was also asked to report the major causes of mortality (if known) and incidences of health problems. Mortality, expressed as the percentage of hens that had died from the onset of the laying period until 60 weeks, was included in the overall welfare score.

Overall welfare score

The overall welfare score was based on 17 separate welfare indicators (Table 3). In the present study, the contribution of each of these 17 indicators to the overall welfare score is presented. These indicators were integrated into an overall score based on weighting factors assigned by experts on a scale from 0 (poor welfare) to 10 (good welfare) (Rodenburg *et al* 2008). The scores from each welfare indicator were standardised using the following formula: (score flock – mean score for all flocks)/standard deviation. Furthermore, the direction of the scores of each welfare indicator was also standardised, so that a high score indicated good welfare. After standardisation, the overall welfare score was calculated using the following formula:

(standardised score A × weighting factor A) + (standardised score B × weighting factor B) + …/(sum weighting factors).

The scores are between –1 (poor welfare) and 1 (good welfare).

Statistical analysis

Data were averaged at flock level and checked for normality. Data were analysed in SAS using a General Linear Model with flock as experimental unit, to study the effect of type of housing (furnished cages, aviaries, floor housing). Hybrid (Bovans Goldline, ISA Brown, Other) and age (> 55 weeks, 55–65 weeks, > 65 weeks) were included in the model but not for those indicators where they had no significant effect. Hybrid only had a significant effect on the amount of gentle feather pecking and mortality. Age had no significant effect on any indicator.

Table 4 Percentages of foraging, preening, dust bathing, walking, standing and sitting in furnished cages (n = 6) and in floor housing and aviary systems (n = 7) and the level of significance for each comparison.

	Furnished cage	Floor housing	Aviary	Level of significance
Foraging	5.4 ± 2.6[a]	16.6 ± 6.0[b]	16.6 ± 2.2[b]	$P < 0.05$
Preening	7.0 ± 1.5	6.1 ± 1.0	6.2 ± 2.8	ns
Dust bathing	2.5 ± 0.9	3.3 ± 1.5	5.0 ± 1.2	ns
Walking	3.5 ± 1.3[a]	15.9 ± 3.5[b]	16.4 ± 1.5[b]	$P < 0.001$
Standing	73.3 ± 3.1[a]	57.9 ± 8.7[b]	54.7 ± 2.0[b]	$P < 0.05$
Sitting	7.7 ± 3.3[a]	0.0 ± 0.0[b]	0.7 ± 0.7[b]	$P < 0.05$

Superscripts differ significantly.

In the first analysis, both types of non-cage systems (aviaries and floor housing) were analysed separately, but no significant differences were found between them, possibly due to the small sample size. Thus, they were combined in the final analysis, although the results are presented separately for floor housing and aviaries in the Tables and Figures. Data are presented as means (± SEM).

Results

Behavioural observations

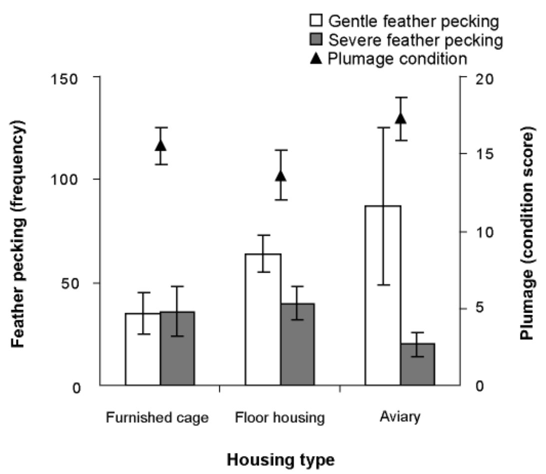
Birds kept in non-cage systems demonstrated more foraging behaviour ($F_{1,12}$ = 6.77; $P < 0.05$) and walked more ($F_{1,11}$ = 25.81; $P < 0.001$) in the scratching area than birds in furnished cages (Table 4). Birds in furnished cages spent more time standing ($F_{1,12}$ = 8.10; $P < 0.05$) and sitting ($F_{1,12}$ = 6.01; $P < 0.05$), than birds in non-cage systems. There were no significant differences in preening and dust bathing between systems, although most of the dust bathing in furnished cages was actually sham dust bathing (no litter available). The birds in non-cage systems also had a higher perch use during the day (53 vs 26%; $F_{1,10}$ = 13.08; $P < 0.01$).

Regarding gentle and severe feather pecking behaviour, no differences were found between systems (Figure 1; left y-axis); feather pecking occurred in all systems. There were also no significant differences in plumage condition between furnished cages and non-cage systems (Figure 1, right y-axis). The mean plumage condition was average in all three systems and ranged between 14 and 17 (score 24 = no feather damage; score 6 = completely denuded) (Tauson *et al* 2005).

Tonic immobility test

In the tonic immobility test, birds from furnished cages showed a longer latency to stand up than birds from non-cage systems ($F_{1,12}$ = 179.6; $P < 0.001$; Figure 2). Furthermore, in non-cage systems, more inductions were needed to induce tonic immobility, compared with furnished cages (2.9 vs 2.0 inductions; $F_{1,12}$ = 10.59; $P < 0.01$). This gave an indication that birds from furnished cages were more fearful than birds from non-cage systems.

Figure 1



Mean frequency of gentle and severe feather pecking and plumage condition in furnished cages, floor housing and aviary systems.

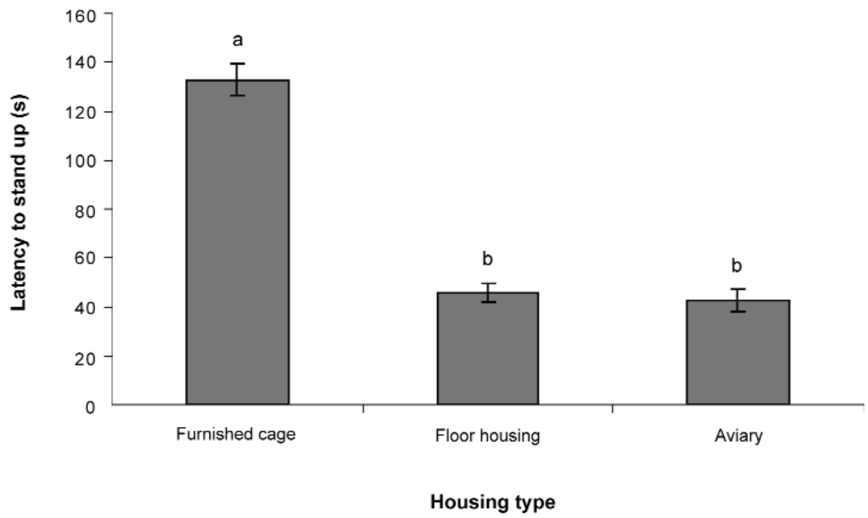
Body condition

No differences were found regarding vent or comb wounds or foot pad dermatitis among the different housing systems and serious wounds or problems tended to occur very rarely. High levels of keel bone fractures were found in all systems, with there being more in non-cage systems than furnished cages ($F_{1,12}$ = 12.43; $P < 0.01$; Table 5). Furthermore, fractures tended to be more severe in non-cage systems ($F_{1,12}$ = 14.89; $P < 0.01$). A minimal number of furculum breaks were found in all systems (data not shown).

Bone strength

Birds in non-cage systems had stronger wing bones ($F_{1,12}$ = 17.26; $P < 0.01$) and a stronger keel bone ($F_{1,11}$ = 30.63; $P < 0.001$) than birds in furnished cages (Figure 3). No differences were found in leg bone strength between the different systems ($F_{1,12}$ = 1.47; $P > 0.10$).

Figure 2



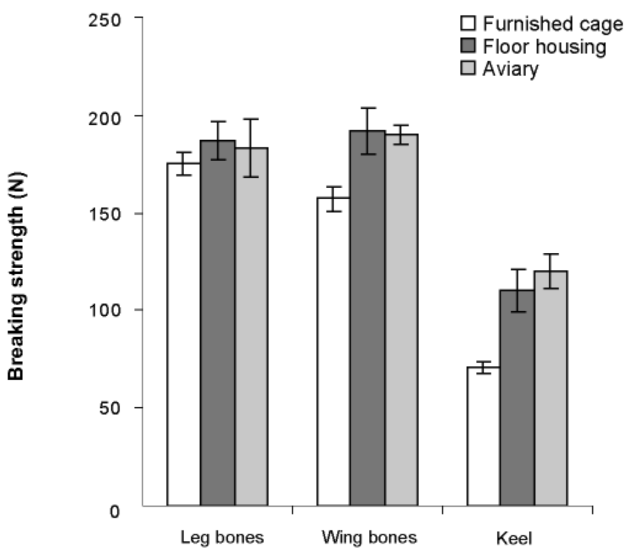
Mean latency to stand up in the tonic immobility test in birds from furnished cages, floor housing and aviary systems.

Table 5 Wounds to the vent, comb and legs (4 = no wound, 1 = serious wound) and incidence and severity of keel bone fractures (1 = single fracture, 4 = multiple fractures, large keel bone deformity) in furnished cages, floor housing and aviary systems.

	Furnished cage	Floor housing	Aviary
Wounds vent	3.8 ± 0.1	3.5 ± 0.2	3.8 ± 0.1
Wounds comb	3.2 ± 0.1	3.3 ± 1.0	3.4 ± 0.1
Wounds legs	3.8 ± 0.1	3.8 ± 0.1	3.6 ± 0.1
Keel bone fractures (%)	62.0 ± 6.1[a]	82.0 ± 5.7[b]	97.0 ± 3.3[b]
Severity fractures	1.2 ± 0.1[a]	1.6 ± 0.1[b]	1.6 ± 0.2[b]

Superscripts differ significantly ($P < 0.01$).

Figure 3



Mean breaking strength (N) of the leg bones, wing bones and keel for birds in furnished cages, floor housing and aviary systems.

TGI-200

Non-cage systems received a higher total score for the TGI-200 than furnished cages ($F_{1,12} = 21.29$; $P < 0.001$; Figure 4). This was due mainly to differences in the availability of high perches and litter (data not shown). In non-cage systems, birds had access to both low and high perches and had a large amount of litter available whereas in furnished cages, birds had no high perches available and very little, if any, litter.

Dust levels and general hygiene

In non-cage systems, higher levels of inhalable ($F_{1,12} = 8,79$; $P < 0.05$; Figure 5, upper) and respirable dust ($F_{1,11} = 11,59$; $P < 0.01$; Figure 5, lower) were found than in furnished cages. Total numbers of aerobic bacteria were also higher in non-cage systems than furnished cages; both in the air ($P < 0.001$) and on eggshells ($P < 0.001$; data not shown). There was no significant difference in concentrations of airborne *Enterobacteriaceae* between systems. Eggshell quality was better in non-cage systems than furnished cages: in furnished cages more broken and hair-cracked eggs were found. There were no significant differences in either eggshell cleanliness or red mite infestations (data not shown).

Figure 4

TG1-200 scores for furnished cages, floor housing and aviary systems.

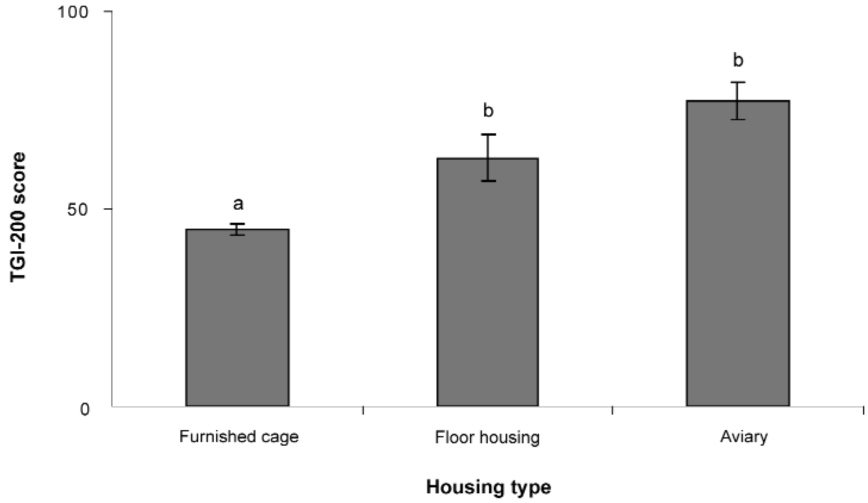


Figure 5

Mean levels of inhalable (upper) and respirable (lower) dust in furnished cages, floor housing and aviary systems.

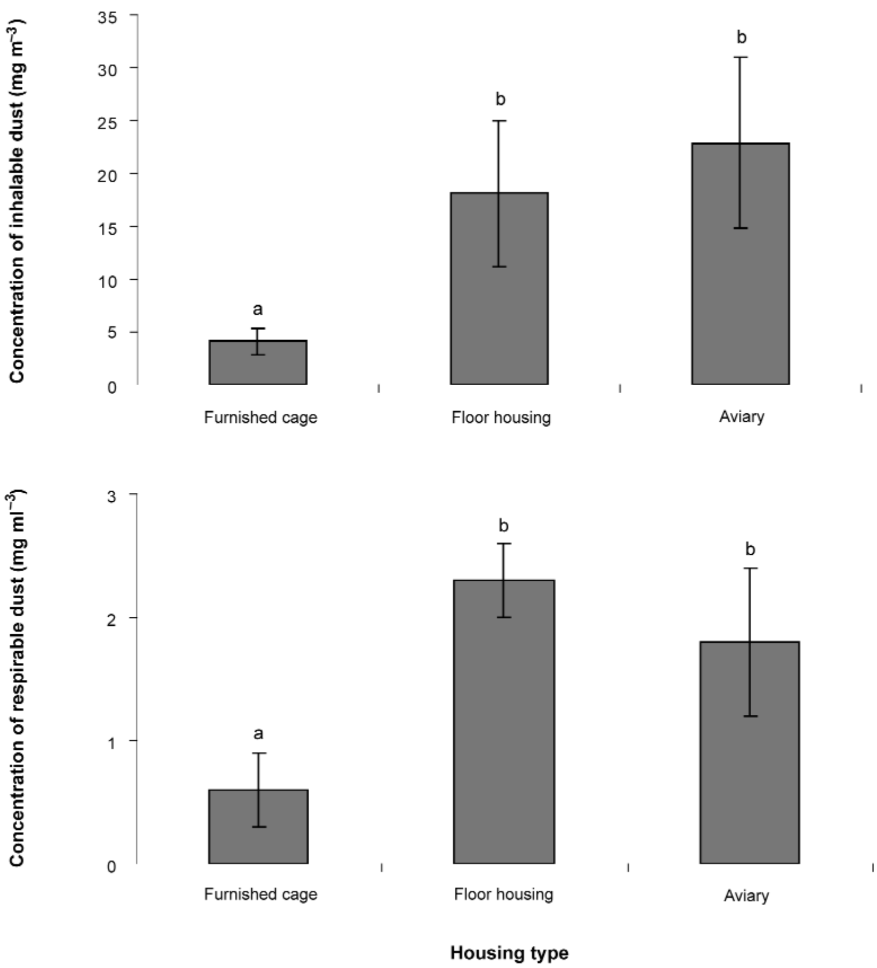


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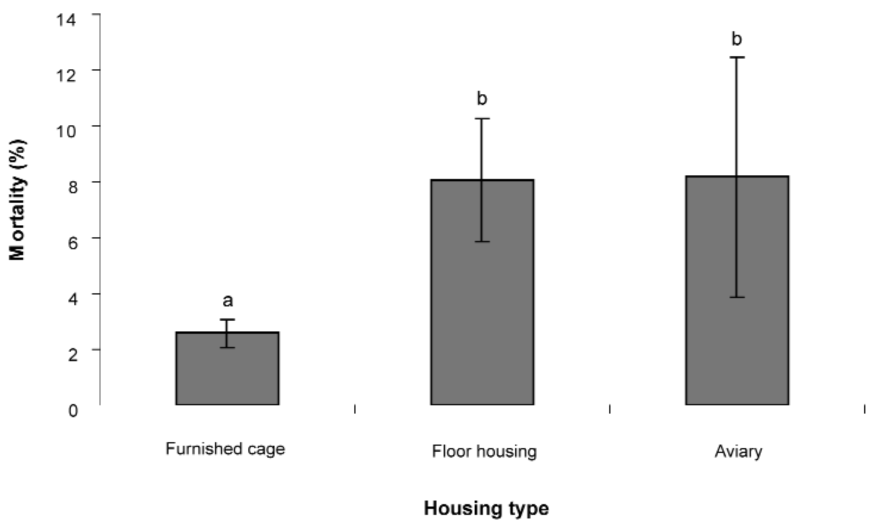
Figure 6



Mortality (%) until 60 weeks of age in flocks from furnished cages, floor housing and aviary systems.

Table 6 Standardised scores multiplied by weighting factors for each welfare indicator included in the overall welfare score for furnished cages and non-cage systems.

Welfare indicator	Furnished cages	Floor housing	Aviary systems
Feather score	0	–5	6
Mortality	6	–6	–6
Bone fractures	6	–3	–9
Red mites	–3	2	1
Foraging	–5	4	4
Bone strength	–6	5	5
Dust bathing	–3	1	6
Perch use	–5	4	5
Enterobacteriaceae	–1	0	3
TGI-score	–4	1	5
Respirable dust	3	–4	–2
Tonic immobility	–4	3	4
Shell quality	–1	0	2
Shell cleanliness	1	–2	0
Inhalable dust	2	–1	–3
Eggshell bacteria	1	–1	0
Airborne bacteria	2	–1	–2
Total	–11	–3	19
Overall welfare score	–0.11 ± 0.15	–0.01 ± 0.11	0.23 ± 0.39

Mortality

Mortality (up to and including 60 weeks of age) was higher in non-cage systems than furnished cages ($F_{1,11}$ = 8.99; $P < 0.05$; Figure 6). The main causes of mortality in non-cage systems were feather pecking and cannibalism, health problems (*Escherichia coli*, infectious bronchitis), infections with red mites (*Dermanyssus gallinae*) and smothering when birds crowd together. Furthermore, there was a significant interaction between type of housing and hybrid: in non-cage systems, ISA Brown and Bovan Goldline birds had lower mortality rates than other hybrids such as Hy-line and ISA Warren (5.3 and 5.6% vs 13.6%; $F_{1,11}$ = 20.56; $P < 0.01$). In furnished cages there were no such differences in mortality between hybrids.

Overall welfare score

In Table 6, the weighted scores are shown for each of the 17 welfare indicators included in the overall welfare score. Furnished cages had higher scores than non-cage systems for mortality, bone fractures and hygienic aspects. Non-cage systems received higher scores for behavioural activity, TGI-score, freedom from fear and bone strength, than furnished cages. When all the welfare indicators were combined into an overall score, there were no significant differences found between non-cage systems and furnished cages (0.1 [± 0.3] vs –0.1 [± 0.1]; $F_{1,12}$ = 2.42; P = 0.15).

Discussion

Birds in non-cage systems were found to be more active in the scratching area. This was probably due to large differences in litter availability between systems: in non-cage systems, there was always a large scratching area filled with litter, whereas in furnished cages litter supply was limited (if present at all). No differences in comfort behaviour and dust bathing between systems were observed which is in direct contrast to the results of other studies (Appleby *et al* 2002; Albentosa & Cooper 2004; Cooper *et al* 2004). However, most of the dust bathing observed in furnished cages, in the present study, was actually sham dust bathing (no litter available). Sham dust bathing may have led to an overestimation of the level of dust bathing in furnished cages.

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There also was a difference in perch use during the day. The presence of both high and low perches in the non-cage systems created a clear demarcation between active birds (in the scratching area or on the low perches) and resting or preening birds (on the high perches). In the furnished cages, only low perches were available and perches were placed in the middle of the cage. This made the distinction between resting and active birds more difficult in furnished cages. Struelens *et al* (2008) demonstrated that perch height has an effect on daytime behavioural activity in furnished cages. There is no available data on perch use during the night in this study. The fact that perches were readily used and that the legal minimum of 15 cm perch length per hen was provided in all systems, suggests that large differences in perch use during the night may not be expected.

No differences were found in gentle and severe feather pecking or feather damage between the systems, although clear evidence exists that feather pecking causes more problems in large groups compared to small (Nicol *et al* 1999; Bilcík & Keeling 2000). Farm interviews suggest that the higher mortality seen in non-cage systems compared to furnished cages, was due in part to feather pecking and cannibalism. It may be that the majority of the birds in non-cage systems targeted by severe feather pecking and cannibalism died before 60 weeks of age. Feather damage was found in all flocks, indicating the development of feather pecking. It may also be the case, though, that more rigorous behavioural observations are needed, or a larger sample of birds assessed, in order for a more complete picture of pecking damage in a flock to be obtained.

The tonic immobility response indicated that birds from furnished cages were more fearful than those from non-cage systems. This is in accordance with the findings of Hansen *et al* (1993), who also found that birds in cages were more fearful than birds in non-cage systems, at the end of the laying period. Birds in non-cage systems can escape from other birds and from staff and can keep their distance from potential threats. In furnished cages, space to avoid other birds or staff is limited. It was remarkable that hybrid type was found to have no effect on fearfulness as major differences in fearfulness in birds from different genetic backgrounds have been reported in other studies (Jones *et al* 1995; Uitdehaag *et al* 2008).

In terms of body condition, high levels of keel bone fractures were found in all systems but this number was greater in non-cage systems. Furthermore, fractures were more severe in non-cage systems than in furnished cages. Similarly, Wilkins *et al* (2004) found that the majority of birds in non-cage systems had old bone fractures in the keel or the furculum. In an earlier study by Gregory *et al* (1990), this percentage was found to be much lower. A possible explanation for this increase in bone fractures over time is the improvement in techniques for detecting bone fractures. The severity of the fractures can vary although, in the majority of cases, birds have a single break in the keel bone without deformation of the keel. This type of fracture is hard to detect using only palpation methods. Despite the fact that the level of distress caused by various types of keel bone fractures remains unclear, as does their potential impact on welfare, the experts attached a great deal of significance to this indicator (Table 3).

Birds in non-cage systems had stronger wing bones and a stronger keel bone than birds in furnished cages. Michel and Huonnic (2004) found that birds in non-cage systems had stronger leg and wing bones than birds in conventional cages. In our study, when comparing non-cage systems and furnished cages, no differences were noted in leg bone strength. One reason for this could be that birds have more space to move around in furnished cages compared to conventional cages. Moreover, birds have access to perches in furnished cages which may also improve leg bone strength. The differences in activity found between non-cage systems and furnished cages seem mainly to affect wing and keel bone strength, but not leg bone strength. The stronger wing bones found in our study may be a result of birds in non-cage systems using their wings more often from rearing onwards, allowing a better development of the wing bones. The difference in bone strength between systems indicates that the higher incidence of keel bone fractures in non-cage systems were not caused by bone weakness. It is assumed that this greater incidence is due to the greater risk of collisions in non-cage systems (Wilkins *et al* 2004).

Non-cage systems received a higher TGI-200 score than furnished cages. This was mainly due to differences in high perch and litter availability. Other measures included in the TGI-200, such as feather-pecking damage at flock level, stocking density and light intensity had very little effect on scores in the present study.

The concentrations of inhalable and respirable dust were higher in non-cage systems compared to furnished cages. This is probably attributable to the large amount of litter present in the non-cage systems. Guarino *et al* (1999) showed that high dust concentrations are linked with high mortality rates. Dust concentration is also related to bacteria concentration and evidence of this was found in the present study; the total number of aerobic bacteria was higher in non-cage systems compared to furnished cages, both airborne and on the eggshell. High concentrations of airborne bacteria can impact negatively on animal health (Pedersen *et al* 2000). More broken and cracked eggs were found in furnished cages than in non-cage systems. No differences were found in the other aspects of hygiene.

Mortality, which received a high weighting compared to other indicators, was higher in non-cage systems than furnished cages. Michel and Huonnic (2004) noted a similar difference, in their comparisons of non-cage systems and conventional cages. In our study, we detected a significant interaction between type of housing and hybrid used: in non-cage systems ISA Brown birds and birds from the Bovans Goldline had a lower mortality rate than the other hybrids observed in non-cage systems. These hybrids may be better suited for non-cage systems than other hybrids used.

When we combined all the welfare indicators into an overall welfare score, no significant difference was found between

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non-cage systems and furnished cages; both systems clearly had their strong and weak points, in terms of animal welfare.

The overall welfare score was developed by integrating expert opinion as a tool to compare the integrated welfare status among different housing systems for laying hens (Rodenburg *et al* 2008). In this study it was put to the test for the first time. Here, we would like to evaluate the overall welfare score. Firstly, regarding the issue of standardisation, we chose to standardise each farm's score by comparing them to the mean value of all farms. This can affect the scores as it may be that all farms studied have very good or very poor welfare. An alternative would have been to compare the scores to values found in literature or based on expert opinion but this would also be quite difficult to achieve. Secondly, we chose not to correct for indicators that showed no significant differences between systems, but worked with the actual scores for each farm. Another possibility would have been to assign the same score to all farms, if no significant differences between systems had been detected. Thirdly, a major issue considering the overall welfare score, as used in the present study, is whether welfare indicators should be completely independent of each other. This was not the case in the present study. For instance, litter availability (through TGI-score) and foraging behaviour were both included in the overall welfare score. We felt it was important to include both the availability and the use of facilities in the score whilst accepting that there may be some degree of overlap between indicators. As all indicators can be grouped into either physical or mental health, it may prove very difficult to engineer a protocol with only unrelated welfare indicators. The absence of any significant difference between systems may be due to the relatively small sample size used in the present study. This means it could be difficult to separate management effects from the effect of housing system and negative results, in particular, should be interpreted cautiously. The number of farms with fully equipped furnished cages is still limited in this part of Europe and therefore it was not possible to visit a larger number of farms in the present study.

As discussed in a previous study (Rodenburg *et al* 2008), some experts involved in assigning weightings to the welfare indicators were doubtful about integrating welfare indicators into an overall welfare score. They suggested it would be better to integrate welfare indicators up to the level of the Five Freedoms (Brambell 1965), or to the level of physical and mental health. We feel, however, that it is informative to combine all welfare indicators into an overall score, especially when combined with information on the individual welfare indicators. Furthermore, for many applications of animal welfare monitoring, such integration into an overall welfare score is essential.

Conclusion and animal welfare implications

In the non-cage systems, birds were more active and made greater use of resources (scratching area, perches) compared to furnished cages. The birds also had stronger bones and were less fearful. On the other hand, birds in furnished cages had lower rates of mortality, lower incidence of bone fractures and there were lower concentrations of airborne dust. For furnished cages, there is a suggestion it may be beneficial to improve litter availability, as well as provide birds with more space and high perches. This would stimulate behavioural activity and allow separation of active and resting birds. Large, furnished cages offer better opportunities for such improvements as these can be fitted with larger scratching areas and more complex perch designs than small furnished cages. For non-cage systems, a reduction of mortality would be an important step forward. For this, better control over feather pecking and cannibalism is needed, by improving breeding, rearing and husbandry methods. Secondly, the high levels of bone fractures should be reduced by adapting housing design and providing birds with the opportunity to learn how best to navigate in these housing systems. When all the welfare indicators included in this study were integrated into an overall score, no significant difference was found between non-cage systems and furnished cages. Both systems clearly have pros and cons regarding animal welfare and both provide room for improvements.

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