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Use of functional areas, perch acceptance and selected behavioural traits in three different layer strains kept in furnished cages, small group systems and modified small group systems with elevated perches

Nutzung von Funktionsbereichen, Sitzstangenakzeptanz sowie ausgewählte Verhaltensmerkmale in Legehennen aus ausgestalteten Käfigen, Kleingruppen- und modifizierten Kleingruppenhaltungen mit erhöhten Sitzstangen

Swaantje Rönchen, Britta Scholz, H. Hamann and O. Distl

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Introduction

The development of an appropriate housing system for laying hens, which on the one hand meets the needs of animal welfare and on the other hand allows for large-scale hygienic egg production, is a major point of discussion. Conventional cages for laying hens have been heavily criticised as they have brought about welfare problems due to limited space and poor environmental conditions. In the EU, conventional cages will be banned after 2012 and replaced by furnished cages, small group systems or non-cage housing conditions. In Germany, also furnished cages will be phased out after 2020 and substituted by either non-cage systems or small group housing systems according to the German legal regulations. In comparison to the EU-variant, these systems provide more space per hen (800 cm^2 instead of 750 cm^2), an increased minimum cage height of 50 cm instead of 45 cm, a minimum floor space of 2.5 m^2 and elevated perches. Presently, a lot of research on small group systems is being carried out in order to advance and optimise these systems, which had been introduced and approved of by the German government in 2006. From beginning of 2010, the German small group system has to fully replace conventional cages in the country if farmers want to retain cage-related egg production. Laying hens' behaviour is an important parameter to evaluate the adequacy of a housing system (Weitzenbürger et al., 2006) and it is a good indicator to reflect states of suffering such as fear, frustration and pain (Duncan, 1998).

In the present study, behavioural observations in three layer lines were performed in different housing environments with special regard to use of functional areas, perch acceptance and selected traits of comfort behaviour. The study included small group housing systems (Eurovent (EV) 625a-EU (SG)), modified compartments of small group housing systems with elevated perches (MSG) and furnished cage systems Aviplus (AP) (Big Dutchman International GmbH, Vechta, Germany). All housing systems fully conformed to the EU Directive 1999/74/EC. Within MSG, perches were installed at three different positions, thus meeting one of the key requirements of the German small group system. The aim of the study was to compare small group systems and furnished cages (according to the EU regulations) with modified small group systems (fulfilling the German policies related to perch arrangement) and to evaluate the effect of housing system and perch position on selected behavioural traits.

Material and Methods

Trial 1 and 2

Behavioural observations of Lohmann Brown (LB) and Lohmann Selected Leghorn (LSL) layers kept in three different housing environments were performed throughout two laying periods comprising the period August 2004 until October 2006 (experimental farm Wesselkamp, Ankum). In each trial, a total number of 5,760 cage-reared laying hens was transferred to the experimental stable at the age of 18 weeks. In the first trial, LSL and LB hens were used to equal parts, whereas in the second trial only LSL layers were kept. Housing systems evaluated were installed in parallel position to each other within the same experimental building and hens were provided with fully identical management conditions. Ad libitum feeding was automatically delivered three or four times a day via chain feeding and water was supplied ad libitum via nipple drinkers. The light period comprised 14 hours (04:00 – 18:00 h). Light intensity was set to approximately 10 lux (aisle). In the first trial, a furnished cage system (Aviplus (AP)), a small group housing system (EV 625a-EU (SG)) and modified small group housing system EV 625a-EU (MSG) were compared. Housing systems fully conformed to EU standards except for the perch arrangements in MSG, which were in accordance to the German regulations. Thus, minimum compartment heights (45 instead of 50 cm) and space per hen (750 instead of 800 cm^2) were slightly different to the present policies on German small group systems. Compartments of SG and MSG contained groups of 40 and 60 layers (floor space: 241.2 and 361.8 cm ¥ 125.0 cm, 2,880 hens in total). In AP, hens were

Institute of Animal Breeding and Genetics, University of Veterinary Medicine Hannover, Hannover, Germany

kept in groups of 10 and 20 (floor space: 120.6 and 241.2 cm ¥ 62.5 cm, 2,880 hens in total). Compartments of AP were arranged double-sided, whereas compartments of SG and MSG were built without centre partition. Compartments of all housing systems were equipped with perches (two perches in AP, four perches in SG and MSG), nest boxes (equipped with Astroturf or Aviplus mats), dust baths and claw abrasion devices. Within SG and MSG, the supply pipe (Ø 45 mm, galvanised zinc) for dust bathing substrate, which was located in the centre of each compartment, also served as perching space, thus providing each hen 15 cm perch length in all housing systems. Within SG and AP, non-elevated, white plastic perches were installed in parallel position to the length of each compartment (90 mm perch height). Perches had an oval/rectangular profile, a flat up- and underside and riffles on the front- and backside (20.1 mm contact area for layers' feet). MSG compartments were equipped with non-elevated perches in the front and elevated back perches (BE, 200 mm distance to wire floor). Elevated perches were roundly shaped (Ø 35 mm) and made of metal with a galvanised zinc surface. Dust baths in SG and MSG were furnished with Astroturf mats and were accessible throughout the entire day. Dust baths in AP were only temporarily accessible throughout the day and closed with a grating to prevent oviposition. In AP, SG and MSG, dust bathing substrate (wood shavings, Ø 2 – 3 mm) was offered automatically once a day.

In the second trial, when only LSL hens were kept, compartments of MSG were equipped with three variants of perch positions and compared to AP. In addition to BE-compartments (trial 1), compartments were also equipped with elevated front perches (FE, 200 mm) and with both front and back perches heightened and also incorporated in a stepped (ST) position (275 and 200 mm) (Figure 1). Non-elevated and elevated perches were of an identical design compared to trial 1.

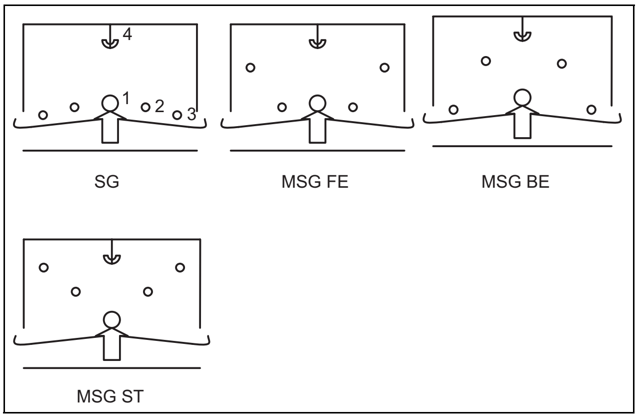

Figure 1. Cross-section of perch positions within compartments of SG and MSG.
SG: small group system Eurovent 625a-EU with non-elevated perches; MSG: modified compartments of Eurovent 625a-EU with elevated perches; FE: front perches elevated; BE: back perches elevated; ST: elevated front and back perches and stepped position; 1: supply pipe for dust bathing substrate; 2: back perch; 3: front perch; 4; nipple drinker.
Querschnitt der Sitzstangenpositionen in Abteilen von SG und MSG. SG: Kleingruppenhaltung Eurovent 625a-EU mit nicht erhöhten Sitzstangen; MSG: modifizierte Abteile von Eurovent 625a-EU mit erhöhten Sitzstangen; FE: vordere Sitzstangen erhöht; BE: hintere Sitzstangen erhöht; ST: vordere und hintere Sitzstangen erhöht und stufig installiert: 1: Zuleitungsrohr zur Befüllung des Sandbades; 2: hintere Sitzstange; 3: vordere Sitzstange; Tränke.

Trial 3

At a different research farm (field station Ruthe), behavioural observations were performed in floor-reared Lohmann Silver (LS) laying hens which were kept in a furnished cage system Aviplus (AP, 1,440 hens) and a modified small group housing system Eurovent 625a-EU (MSG, 1,500 hens). Observations were carried out within the period September 2005 to October 2006. Housing systems were installed in separate rooms within the same experimental building and layers were kept under identical management conditions. Ad libitum feeding was provided three or four times a day via chain feeding and water was offered ad libitum via nipple drinkers. The light period lasted 14 hours (05:00 – 19:00 h, approximately 10 lux). Both housing systems tested were built and furnished equally to MSG and AP described above, except a differing group size in AP, which comprised groups of 10, 20 and 30 hens (floor space 30 hens: 361.8 × 62.5 cm). MSG-compartments were equipped with perches in BE and ST position.

Behavioural Observations

Behavioural observations were carried out during the light period using a method of direct observation and instantaneous scan sampling. Observations were conducted in the laying months 6 and 12 (trial 1) and 3, 6 and 12 (trial 2). In trial 3, behavioural observations were performed in the laying months 3, 6, 9 and 12. In each observation month, observations were carried out on four consecutive days, covering two different time schemes. In trial 1 and 2, each compartment was observed on two days within the time periods 7:30 – 10:00 h, 10:30 – 13:00 h and 14:30 – 17:00 h and on two days from 09:30 – 12:00 h and 12:30 – 15:00 h in each observation month. In trial 3, observation times lasted during two days from 08:30 – 10:30 h, 12:00 – 14:00 h and 15:30 – 17:30 h and on two days from 10:30 – 12:00 h and 13:30 – 15:30 h. During each time frame, each compartment was observed twice per day at random order. An individual time per compartment (approx. 60 s) was given before the observation started in order to habituate laying hens to the presence of the observer. The observer tried to keep the greatest distance possible to the compartments observed. During feeding, observations were intermitted and continued after approximately 15 minutes. In each trial, two compartments of the same group size, layer line (trial 1) and perch position were observed to assure a repetition (trial 1: 21 compartments, trial 2: 16 compartments, trial 3: 14 compartments in total), except for groups of 60 LSL hens in SG when only one compartment of this group size, layer line and perch position could be observed in trial 1. The localisation of compartments within each housing system was identical in trial 1 and 2 and at all observations times. Within each compartment observed, the number of hens using the functional areas wire floor, dust bath, nest box, perch (all perches, including supply pipe of dust bath in SG and MSG), non-elevated perch (MSG compartments, including supply pipe), elevated perch (MSG compartments) and the number of layers showing resting behaviour on perch (hen sitting, neck withdrawn and eyes closed or head tucked into the feathers above wing base or behind wing; all perches including supply pipe), resting behaviour on non-elevated perch (MSG compartments, including supply pipe) and resting on elevated perch (MSG compartments, trial 2 and 3) was recorded once per time period. In addition, dustbathing and pecking behaviour (dust bathing in dust baths (except AP), dust bathing on wire floor, pecking in dust baths, pecking against objects (floor, partitions, furniture elements)), feather pecking and locomotion activity (walking on wire floor, walking on non-elevated perches (trial 1)) were recorded. As dust baths in AP were only temporarily accessible, the trait dust bathing activity in AP was excluded when comparisons between housing systems were made. The behavioural traits observed were not mutually exclusive and hens were recorded performing two different (overlapping) behavioural traits, for example 'standing on wire floor' and 'feather pecking', at the same time interval.

Statistical Analysis

Statistical analysis was performed using the MIXED procedure of SAS, version 9.2. (Statistical Analysis System Institute Inc., Cary, NC, USA, 2009). The fixed effects of housing system, layer line (trial 1), group size within housing system, laying month, observation time and perch position within housing system were included in the statistical model. Compartment of housing system was treated as a randomly distributed effect.

Statistical model for trial 1:

$$Y_{ijklmnop} = \mu + SYS_i + GR(SYS{*}LIN)_{ijk} + LIN_k + MON_l + PER(SYS{*}LIN)_{ikm} + TIME_n + comp(SYS)_{io} + e_{ijklmnop}$$

$Y_{ijklmnop}$:	relative frequency of behavioural trait
μ:	model constant
SYS_i:	fixed effect of housing system (i = 1 – 2)
$GR(SYS{*}LIN)_{ijk}$:	fixed effect of group size within housing system and layer line (j = 1 – 8)
LIN_k:	fixed effect of layer line (k = 1 – 2)
MON_l:	fixed effect of laying month (l = 1 – 2)
$PER(SYS{*}LIN)_{ikm}$:	fixed effect of perch position within housing system and layer line (m = 1 – 3)
$TIME_n$:	fixed effect of observation time over two days (n = 1 – 4)
$comp(SYS)_{io}$:	random effect of compartment of housing system (o = 21)
$e_{ijklmnop}$:	random error coefficient

Statistical model for trial 2:

$$Y_{ijklmno} = \mu + SYS_i + GR(SYS)_{ij} + MON_k + PER(SYS)_{il} + TIME_m + comp(SYS)_{in} + e_{ijklmno}$$

$Y_{ijklmno}$:	relative frequency of behavioural trait
μ:	model constant
SYS_i:	fixed effect of housing system (i = 1 – 2)
$GR(SYS)_{ij}$:	fixed effect of group size within housing system (j = 1 – 4)
MON_k:	fixed effect of laying month (k = 1 – 3)
$PER(SYS)_{il}$:	fixed effect of perch position within housing system (l = 1 – 4)
$TIME_m$:	fixed effect of observation time over two days (m = 1 – 4)
$comp(SYS)_{in}$:	random effect of compartment of housing system (n = 16)
$e_{ijklmno}$:	random error coefficient

Statistical model for trial 3:

$$Y_{ijklmno} = \mu + SYS_i + GR(SYS)_{ij} + MON_k + PER_l + TIME_m + comp(SYS)_{in} + e_{ijklmno}$$

$Y_{ijklmno}$:	relative frequency of behavioural trait
μ:	model constant
SYS_i:	fixed effect of housing system (i = 1 – 2)
$GR(SYS)_{ij}$:	fixed effect of group size within housing system (j = 1 – 5)
MON_k:	fixed effect of laying month (k = 1 – 4)
PER_l:	fixed effect of perch position (l = 1 – 3)
$TIME_m$:	fixed effect of observation time over two days (m = 1 – 4)
$comp(SYS)_{in}$:	random effect of compartment of housing system (n = 14)
$e_{ijklmno}$:	random error coefficient

Results

In trial 1, both LSL and LB layers were significantly more often on the wire floor in AP compared to hens in MSG and SG (Table 1). Furthermore, LB and LSL hens in SG were observed less on the floor compared to hens in MSG. The frequency of hens in dust baths did not differ between SG and MSG. Nest boxes were frequented more often by LSL layers kept in AP compared to hens kept in SG and MSG. The frequency of LB hens walking on wire floor was significantly lower in AP compared to SG and MSG. The frequency of LSL layers walking on wire floor in BE-compartments of MSG was significantly higher than in SG-compartments. Perch use of hens within the different housing systems significantly differed. LB and LSL layers housed in SG with non-elevated perches used perches more frequently than hens kept in MSG (elevated perches) and AP. Also, LB layers in AP used perches significantly more often than hens in MSG with modified perch positions. Hens in MSG used non-elevated perches in 10.71% (LB) and 9.69% (LSL). Elevated back perches were used in 0.21% (LB) and 0.74% (LSL). Resting behaviour on perches only significantly differed in LSL layers between the different housing systems. Hens in SG with non-elevated perches used perches significantly more often for resting than layers housed in MSG with elevated perches. No difference was found in the number of LB and LSL hens resting in AP and SG on non-elevated perches. As regards walking activities on non-elevated perches, LB and LSL hens in SG were significantly more often walking on non-elevated perches compared to AP.

With relation to dustbathing and pecking behaviour, no difference in the number of hens dust bathing in dust baths or on the wire floor could be detected between hens kept in SG, MSG and AP (AP: only dust bathing on wire floor recorded), whereas in almost all treatments, more dust bathing on the wire floor was observed compared to dust bathing in dust baths. In comparison to AP, hens in MSG performed significantly more pecking in dust baths. Differences between MSG and SG were almost significant ($P = 0.05$) with hens showing more pecking behaviour in dust baths in MSG. In AP, the incidence of feather pecking in LB layers was significantly higher compared to SG and MSG, whereas no difference could be detected between SG and MSG. In LSL hens, pecking against objects was significantly more often recorded in AP compared to SG and MSG, whereas no difference could be detected in LB layers.

In the second trial, when only LSL hens were kept, the highest frequency of hens was also staying on the wire floor in AP and differences to the three types of MSG (BE, ST, FE) were significant (Table 2). Within MSG, the number of hens on the wire floor significantly differed between each comparison of perch design variant. Lowest

Table 1. Trial 1. Least square means (LSM), their standard errors and significant differences between relative frequencies (%) of behavioural traits in LSL and LB hens kept in compartments of furnished cages (AP), small group system (SG) and modified small group system (MSG) with elevated back perches (BE).
LS-Mittelwerte (LSM), ihre Standardfehler und signifikante Unterschiede zwischen den relativen Häufigkeiten (%) der beobachteten Verhaltensmerkmale von LSL und LB Hennen aus Abteilen des ausgestalteten Käfigs (AP), Kleingruppenhaltung (SG) und modifizierter Kleingruppenhaltung (MSG) mit hinten erhöhten Sitzstangen (BE).

	Housing system and perch position		
	AP	MSG BE	SG
Floor			
LB	76.3[a] ± 1.30	68.7[b] ± 1.30	60.5[c] ± 2.25
LSL	71.3[a] ± 1.30	67.2[b] ± 1.30	55.7[c] ± 1.54
Dust bath			
LB	–	9.02 ± 0.43	7.65 ± 0.74
LSL	–	9.86 ± 0.43	10.0 ± 0.51
Nest box			
LB	3.49[a] ± 0.54	2.72[a] ± 0.54	3.85[a] ± 0.93
LSL	8.91[a] ± 0.54	6.51[b] ± 0.54	5.76[b] ± 0.64
Walking on floor			
LB	2.65[c] ± 0.40	5.68[a] ± 0.40	4.28[ab] ± 0.69
LSL	3.20[ab] ± 0.40	4.04[a] ± 0.40	2.65[b] ± 0.47
Use of perches			
LB	14.5[b] ± 0.79	10.9[c] ± 0.79	19.1[a] ± 1.36
LSL	12.4[b] ± 0.79	10.4[bc] ± 0.79	22.9[a] ± 0.93
Use of non-elevated perches in MSG compartments (perch and supply pipe)			
LB	–	10.7 ± 0.61	–
LSL	–	9.69 ± 0.61	–
Use of elevated perches in MSG compartments (back perch)			
LB	–	0.208 ± 0.25	–
LSL	–	0.735 ± 0.25	–
Resting on perches			
LB	0.167[a] ± 0.22	0.000[a] ± 0.22	0.162[a] ± 0.38
LSL	0.814[a b] ± 0.22	0.398[b] ± 0.22	1.37[a] ± 0.26
Walking on perches			
LB	1.46[b] ± 0.31	–	4.57[a] ± 0.54
LSL	1.92[b] ± 0.31	–	2.92[a] ± 0.37
Dust bathing in dust baths			
LB	–	0.266[a] ± 0.09	0.514[a] ± 0.15
LSL	–	0.098[a] ± 0.09	0.002[a] ± 0.10
Dust bathing on floor			
LB	0.725[a] ± 0.22	0.645[a] ± 0.22	0.387[a] ± 0.38
LSL	1.02[a] ± 0.22	0.848[a] ± 0.22	1.08[a] ± 0.26
Pecking in dust baths			
LB	1.13[b] ± 0.28	2.14[a] ± 0.28	1.04[a b] ± 0.48
LSL	0.426[b] ± 0.28	1.74[a] ± 0.28	1.23[ab] ± 0.33
Feather pecking			
LB	1.39[a] ± 0.22	0.289[b] ± 0.22	0.340[b] ± 0.38
LSL	0.565[a] ± 0.22	0.176[a] ± 0.22	0.095[a] ± 0.26
Pecking against objects			
LB	2.34[a] ± 0.41	2.47[a] ± 0.41	1.18[a] ± 0.70
LSL	4.58[a] ± 0.41	2.13[b] ± 0.41	2.16[b] ± 0.48

LSM within a row with no common superscripts differ significantly ($P < 0.05$).
LSM innerhalb einer Zeile ohne gemeinsamen Index unterscheiden sich signifikant ($P < 0.05$).

percentage of hens on the wire floor was recorded in FE, followed by BE and ST compartments. No differences were found in the percentage of hens frequenting dust baths and nest boxes between the different housing systems. Walking on wire floor was significantly more often performed by hens kept in MSG (ST perch) compared to hens in AP and MSG (FE, BE perch). Also, hens in MSG (BE, FE perch) were walking more on the wire floor compared to AP,

Table 2. Trial 2. Least square means (LSM), their standard errors and significant differences between relative frequencies (%) of behavioural traits in LSL hens kept in compartments of furnished cages (AP) and modified small group system (MSG) with three different perch treatments.
LS-Mittelwerte (LSM), ihre Standardfehler und signifikante Unterschiede zwischen den relativen Häufigkeiten (%) der beobachteten Verhaltensmerkmale von LSL Hennen in Abteilen des ausgestalteten Käfigs (AP) und modifizierter Kleingruppenhaltung (MSG) mit drei Varianten der Sitzstangenpositionierung.

	Housing system and perch position			
	AP	MSG BE	MSG ST	MSG FE
Floor	68.8^{a} ± 1.04	57.3^{b} ± 1.04	60.2^{c} ± 1.04	50.5^{d} ± 1.04
Dust bath	–	11.5^{a} ± 0.45	12.2^{a} ± 0.45	11.9^{a} ± 0.45
Nest boxes	8.64^{a} ± 0.65	7.92^{a} ± 0.65	7.02^{a} ± 0.65	7.27^{a} ± 0.65
Walking on floor	3.87^{a} ± 0.44	5.19^{b} ± 0.44	6.88^{c} ± 0.44	5.24^{b} ± 0.44
Use of perches	14.00^{ab} ± 1.18	16.9^{a} ± 1.18	13.3^{b} ± 1.18	23.5^{c} ± 1.18
Use of non-elevated perches*	14.4^{a} ± 1.15	12.1^{a} ± 1.15	7.48^{b} ± 1.15	19.1^{b} ± 1.15
Use of elevated perches	–	4.68^{a} ± 0.82	5.77^{a} ± 0.82	4.30^{a} ± 0.82
Resting on perches	0.396^{a} ± 0.18	0.475^{a} ± 0.18	0.963^{bc} ± 0.18	1.21^{b} ± 0.18
Resting on non-elevated perches	0.390^{a} ± 0.15	0.335^{a} ± 0.15	0.397^{a} ± 0.15	1.01^{b} ± 0.15
Resting on elevated perches	–	0.143^{a} ± 0.11	0.581^{b} ± 0.11	0.207^{a} ± 0.11
Dust bathing in dust baths	–	0.248^{a} ± 0.14	0.321^{a} ± 0.14	0.551^{a} ± 0.14
Dust bathing on floor	1.08^{a} ± 0.34	0.879^{a} ± 0.34	1.25^{a} ± 0.34	1.16^{a} ± 0.34
Pecking in dust baths	–	1.40^{a} ± 0.28	1.51^{a} ± 0.28	1.73^{a} ± 0.28
Feather pecking	0.523^{a} ± 0.14	0.362^{a} ± 0.14	0.269^{a} ± 0.14	0.141^{a} ± 0.14
Pecking against objects	7.12^{a} ± 0.87	3.04^{b} ± 0.87	3.67^{b} ± 0.87	3.46^{b} ± 0.87

BE: elevated back perches; ST: elevated front and back perches and stepped position; FE: elevated front perches;
* supply pipe of dust bathing substrate in MSG ST.
BE: hintere Sitzstangen erhöht; ST: vordere und hintere Sitzstangen erhöht und stufig installiert; FE: vordere Sitzstangen erhöht;
* Zuleitungsrohr zur Befüllung des Sandbades in MSG ST.
LSM within a row with no common superscripts differ significantly ($P < 0.05$).
LSM innerhalb einer Zeile ohne gemeinsamen Index unterscheiden sich signifikant ($P < 0.05$).

whereas no difference was found between MSG compartments with BE and FE perch variants.

Perch use significantly differed between the different housing systems tested. In MSG, perch use was significantly higher in FE compartments (23.52%) compared to AP (14.11%) and MSG compartments with BE (16.88%) and ST (13.29%) perches. Furthermore, perches were used significantly more often in BE compartments compared to ST. Perch use in FE and BE compartments was mainly due to the use of non-elevated perches (19.10% and 12.07%). The supply pipe of dust bathing substrate, which is the only non-elevated perch in ST compartments, was used in 7.48% of layers. Use of elevated perches in FE and BE compartments (4.30% and 4.68%) did not differ significantly.

Perches were significantly more often used for resting in ST- and FE-compartments of MSG compared to AP. Within MSG, the highest incidence of hens resting on perches was recorded in FE compartments and differences to BE compartments were significant. However, in both FE and BE compartments, resting mainly occurred on non-elevated perches (1.01% and 0.34%) rather than on elevated perches (0.21% and 0.14%) and differences between hens resting on non-elevated perches in FE and BE compartments were significant.

With relation to exploring and comfort behaviour, the frequency of hens dust bathing in dust baths in MSG (BE, ST, FE) did not differ significantly and ranged between 0.25% and 0.55%. Dust bathing behaviour on the wire floor was most often shown in ST compartments of MSG (1.25%) but differences between BE (0.88%), FE (1.16%) compartments of MSG and AP (1.08%) were not significant. The number of hens pecking in dust baths did not differ between the different perch variants of MSG compartments. Feather pecking was more often observed in AP, but differences to FE compartments of MSG could not be statistically proved ($P = 0.054$). Hens in AP were significantly more often pecking against objects (7.12%) compared to hens in BE (3.04%), ST (3.67%) and FE (3.46%) compartments of MSG.

In trial 3, a significantly higher number of LS hens was staying on wire floor in AP compared to BE-compartments of MSG, whereas no difference was found between BE and ST compartments (Table 3). Layers in AP used nest boxes significantly more often than hens in BE-compartments of MSG. The number of hens walking on the wire floor was significantly higher in MSG (BE, ST) compared to AP, whereas no differences could be observed between hens in BE and ST compartments. Resting behaviour was more frequently observed in AP and differences to both variants of MSG were significant.

Perch use was significantly higher in BE compartments of MSG (19.23%) and AP (20.05%) compared to ST compartments (14.88%). Elevated perches were used in 3.67% (MSG BE) and 5.04% (MSG ST). Laying hens in AP used perches more often for resting compared to hens in BE compartments. Elevated perches in BE compartments were frequented in 0.05% for resting. In ST compartments, 0.23% of hens used perches for resting behaviour.

Dust bathing in dust baths was observed in 0.96% (BE) and 0.90% (ST) of hens in MSG, whereas dust bathing on the wire floor occurred to 0.20% and 0.10% respectively. Differences among BE and ST were not significant. In AP, the highest number of hens dust bathing on the wire floor was recorded (0.99%) and differences to BE and ST com-

Table 3. Trial 3. Least square means (LSM), their standard errors and significant differences between relative frequencies (%) of behavioural traits in LS hens kept in compartments of furnished cages (AP) and modified small group system (MSG) with two different perch treatments.
LS-Mittelwerte (LSM), ihre Standardfehler und signifikante Unterschiede zwischen den relativen Häufigkeiten (%) der beobachteten Verhaltensmerkmale von LS Hennen in Abteilen des ausgestalteten Käfigs (AP) und modifizierter Kleingruppenhaltung (MSG) mit zwei Varianten der Sitzstangenpositionierung.

Trait	Housing system and perch position		
	AP	MSG BE	MSG ST
Floor	65.6[a] ± 1.61	58.1[b] ± 1.97	61.8[ab] ± 1.97
Dust baths	–	13.8[a] ± 0.96	12.8[a] ± 0.96
Nest boxes	4.50[a] ± 0.31	3.44[b] ± 0.37	4.11[ab] ± 0.37
Walking on floor	2.38[b] ± 0.52	4.36[a] ± 0.63	5.92[a] ± 0.63
Resting	1.98[a] ± 0.27	0.809[b] ± 0.33	0.838[b] ± 0.33
Use of perches	20.1[a] ± 1.10	19.2[a] ± 1.35	14.9[b] ± 1.35
Use of elevated perches	–	3.67[a] ± 0.61	5.04[a] ± 0.61
Resting on perches	1.11[a] ± 0.22	0.197[b] ± 0.28	0.558[ab] ± 0.27
Resting on elevated perches	–	0.054[a] ± 0.08	0.230[b] ± 0.08
Dust bathing in dust baths	–	0.956[a] ± 0.18	0.897[a] ± 0.18
Dust bathing on floor	0.986[a] ± 0.16	0.195[b] ± 0.20	0.104[b] ± 0.20
Pecking in dust baths	–	1.83[a] ± 0.42	2.18[a] ± 0.41
Feather pecking	0.468[b] ± 0.15	0.782[ab] ± 0.18	1.11[a] ± 0.18
Pecking against objects	2.00[b] ± 0.33	3.22[a] ± 0.40	2.39[ab] ± 0.40

BE: elevated back perches; ST: elevated front and back perches and stepped position.
BE: hintere Sitzstangen erhöht; ST: vordere und hintere Sitzstangen erhöht und stufig installiert.
LSM within a row with no common superscripts differ significantly ($P < 0.05$).
LSM innerhalb einer Zeile ohne gemeinsamen Index unterscheiden sich signifikant ($P < 0.05$).

partments of MSG were significant. Pecking in dust baths did not differ between the different housing systems and perch designs tested. Feather pecking was mostly observed in ST compartments of MSG and differences to AP were significant, whereas pecking against objects was observed most often in BE compartments of MSG with differences to AP also being significant.

Discussion

In all three trials, hens kept in the furnished cage system Aviplus (AP) spent more time on the wire floor compared to hens in SG or MSG. These results correspond to findings of WEITZENBÜRGER et al. (2006), who also found the highest number of hens staying on the wire floor in a furnished cage system AP.

In trial 1, most hens were found on perches when only non-elevated perches were offered in the small group systems (SG). In addition, the number of hens on the floor in compartments with elevated perches (BE) was significantly higher. These findings suggest a higher acceptance of non-elevated perches, which could be due to their shape and material (oval-shaped, riffled plastic), their low position, which provides an easy access, the greater distance between perch and cage roof or the necessity of crossing perches when hens were moving between different compartment areas. In trial 2, when only MSG compartments were provided, most hens were found on the floor in ST compartments, thus indicating a low acceptance of elevated back and front perches during the day. In all three trials, perch use of hens in MSG compartments was mainly due to non-elevated perching opportunities. Also, the higher perch acceptance of hens in BE, FE (trial 2) and BE (trial 3) compartments compared to ST confirms a low acceptance of raised perches during daytime. STRUELENS et al. (2008) found a significant effect of cage height on perch height preference. When cage height was lowered, hens preferred using lower perches and also reduced perching time. In the present study, the cage height above elevated perches in ST compartments was 250 mm (back perch) and 175 mm (front perch). STRUELENS et al. (2008) described a minimum perch to roof distance of 190 to 240 mm, which hens seemed to require when preferring elevated perches for night-time roosting. During day-time, median perch heights preferred were lower, thus leaving hens with a higher perch to roof distance. In compartments with ST perches, perch to roof distances might have been too short for comfortable perching activities during the day. According to STRUELENS et al. (2008), perch heights of approximately 60 to 100 mm were preferred for day-time perching when cage heights ranged between 450 and 500 mm. These results correspond to the present findings as the non-elevated perches had a distance of 90 mm to the cage floor and provided a perch to roof distance of approximately 430 mm. TAYLOR et al. (2003) described a significant influence of perch colour on the latency to jump on a perch together with a low light intensity. As elevated perches were of a dark grey colour, this might have contributed to a lower perch acceptance as hens could have experienced problems in accessing elevated perches. In addition, the shape and surface material of elevated perches (round, galvanised zinc) differed from the non-elevated ones. As more efforts were required to climb up on elevated perches, hens' risk of sliding while accessing these perches could have possibly been increased although sliding on perches could not be observed while hens were sitting on elevated metal perches. Elevated perches should be tested with different material and perch surface to possibly provide a better grip and visibility. The higher thermal conductivity of elevated perches due to their galvanised zinc surface might have also contributed to lower acceptance compared to the surface of non-elevated plastic perches which was probably of a more comfortable surface temperature. Sewerin (2002) observed an instable position of layers' feet while grasping smooth plastic perches, which could have partly accounted for the generally low perching activities on non-elevated perching opportunities during the day in all three trials. The different rearing systems in trial 1 and 2 (cage) and trial 3 (floor) could have also impacted perching behaviour. A higher percentage of floor-reared LS hens seemed to use perches in AP and MSG (BE) compartments (trial 3) compared to the cage-reared LB (trial 1) and LSL hens (trial 1 and 2). Weitzenbürger et al. (2006) also described differences in perch use in hens from different rearing systems with more floor-reared hens standing on perches compared to cage-reared layers. Gunnarsson et al. (2000) suggested that cage-reared hens without early access to perches might have difficulties to use perches due to lack of motor skills and inability to keep balance. However, even if particularly elevated perches in the ST position were less frequently used, their position provided relatively more floor space and allowed hens to move within compartments without having to cross or stand on even perches.

In all three trials, higher walking activities in SG and MSG compared to AP could be observed. These results indicate that compartments with a larger ground floor seem to stimulate laying hens' locomotion activities and correspond to findings of Weitzenbürger et al. (2006). Also, the higher walking activity of hens in BE compartments compared to SG (trial 1) suggests that walking activities on the floor seem even higher when perches do not have to be crossed while moving between different cage areas and elevated back perches seem to allow for more uninterrupted walking activities. The same results apply to the second trial, when walking activities on the floor were highest in ST compartments (both back and front perches elevated) compared to BE and FE compartments with either back or front perches heightened. Olsson and Keeling (2000) found more hens moving when perches were inaccessible after lights had been switched off and interpreted this behaviour as increased frustration and/or exploration to find a roosting site. As elevated perches might have been difficult to access due to their design and probably due to flock mates walking constantly very close below them, also at daytime, a higher activity in these compartments could possibly be related to frustration. However, possible frustration was not expressed by an increase in H/L-ratio, a reliable indicator of stress in poultry, which was analysed in hens kept in MSG at field station Ruthe in trial 3 (Scholz et al., 2008). Hens kept in MSG with elevated back perches showed significantly lower H/L-ratios compared to hens in AP with perches in standard position, thus suggesting a lower stress exposure. Buchenauer (2005) described hens' mobility within compartments be restricted by flock mates, which are standing on the floor. This argument primarily seems to apply to hens in AP as the highest number of layers was found to stay on the floor and also showing least walking activities.

Locomotion activities on non-elevated perches were reported in the first trial. As hens in SG were more frequently walking on perches compared to AP, the extended lengths of perches might have played an important role. These results correspond to the higher locomotion activities (walking on the floor) in SG and MSG compared to AP.

In all three trials, resting behaviour was more often observed on non-elevated perches compared to elevated perches. Blokhuis (1984) found out that daytime resting in Jungle Fowl was not necessarily related to perches and hens stopped whatever they were doing and assumed a resting posture, whereas laying hybrids rested in 64% on perches during the day. Non-elevated perches, which had to be crossed automatically when hens were moving between different compartment areas, were most probably used more often for resting as they were easy to access. Unlike findings of Blokhuis (1984), only a relatively small number of hens was resting on perches during the day in the present study. In ST compartments (trial 2 and 3), a greater number of hens used elevated perches for resting rather than the non-elevated supply pipe. However, these results have to be carefully discussed, as the supply pipe of dust bath filling served as the only non-elevated perching opportunity in ST compartments and hens might not have been able to use the supply pipe for a secluded resting posture.

Laying hens used dust baths not exclusively for dust bathing activity. In fact, the number of hens standing, sitting, lying and resting in dust baths was much higher than the percentage of hens performing dust bathing behaviour. Furthermore, in trial 1 and 2, dust bathing activity on the wire floor was observed more often rather than dust bathing in dust baths, which was also found by Weitzenbürger et al. (2006). Important key stimuli for dust bathing behaviour are light and adequate substrate. In housing systems with insufficient light intensity of dust bath areas, Buchenauer (2005) observed an increased dust bathing activity on the cage floor close to the light source and described hens using food particles as substrate. Lindberg and Nicol (1997) explained the attractiveness of food particles as dust bathing substrate in furnished cages by its continuous availability from the food chain, while dust bathing substrate supplied other than food in dust baths was always rapidly depleted due to hens' scratching activities. In the present study, hens frequently used food particles as dust bathing substrate and performed dust bathing behaviour on the wire floor. Furthermore, in SG and MSG, dust bathing activities on the floor could be observed close to the dust bath mats. Layers might not have been able to get access to dust bath mats at all times as these had been occupied by dust bathing flock mates. However, in trial 3, LS hens used dust baths for dustbathing more often than the wire floor, which contradicts results of trials 1 and 2. In AP, the temporarily defined access to dust baths could have forced hens to perform dust bathing on the floor when dust baths were closed. When dust bathing substrate was offered, dust baths in all housing systems tested were instantaneously frequented by a large number of hens and due to their limited size, hens were observed sitting or standing on each other, thus making the performance of dust bathing almost impossible. This was particularly observed in SG and MSG. In an investigation by Abrahamsson and Tauson (1997), hens kept in larger groups of furnished cages preferred to perform dust bathing behaviour on the wire floor (using food particles as substrate) rather than in the dust baths offered. The authors also suggested an inadequate size of dust baths as a possible explanation. Furthermore, they mentioned the social aspect of dust bathing behaviour. More hens were able to perform dust bathing behaviour at the same time when it was performed on the wire floor. In the present study, the amount of dust bathing substrate provided did not seem to be sufficient for the number of hens within a compartment. Due to scratching activities, dust bathing substrate was rapidly removed of the dust bath mats and only very few hens could perform dust bathing activities with the substrate provided.

Weitzenbürger et al. (2006) mentioned a relation between lack of adequate dust bathing substrate and increased incidence of feather pecking, which was caused by misdirected exploring and foraging behaviour on flock mates' plumage. Wechsler and Huber-Eicher (1998) also described a significant effect of the provision of foraging material on the rate of feather pecking interactions. The higher feather pecking rate of LB hens in AP suggests that the consistence and amount of dust bathing substrate offered together with only temporary access to dust baths may not have satisfied hens' behavioural requirements. In LSL hens, insufficient provision of dust bathing substrate could have been associated with the increased occurrence of pecking against objects in AP (trial 1 and 2). However, in trial 3, LS hens showed a higher incidence of feather pecking in MSG (ST) compared to AP. Increased feather pecking behaviour could have been enhanced by poor perch acceptance and the resulting high bird density on the floor, which might have increased the numbers of agonistic interactions (Cordiner and Savory, 2001). Wechsler and Huber-Eicher (1998) also mentioned that hens sitting or standing on the floor are likely to elicit feather pecking.

In order to improve welfare of laying hens kept in small group systems, it is suggested to advance furniture elements, particularly dust baths and perch design. Dust baths should be enlarged to enable the performance of simultaneous dust bathing activities for a larger number of hens and to prevent dust bathing behaviour on the wire floor. Also, dust baths should be accessible throughout the whole day (AP) and substrate should be offered at more frequent intervals to possibly impact the incidence of feather pecking. Layers' apparent preference of perching on non-elevated perches, although elevated perches were provided, could have possibly been due to the design of the elevated perches or their position. It is suggested to test different perch designs in order to ameliorate layers' grip while accessing perches and also to provide more space above elevated perches by either lowering perches or extending the height of compartments in order to make perching more attractive. The small group system according to the German policies might relieve this criterion to a certain extent due to required compartment heights of 500 to 600 mm and the possibility of providing hens with higher perch to roof distances.

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Summary

Behavioural observations were conducted at two different farms in Lohmann Selected Leghorn (LSL), Lohmann Brown (LB) and Lohmann Silver (LS) laying hens kept in furnished cages (Aviplus (AP)), small group systems (Eurovent 625a-EU (SG)) and modified compartments of small group systems (MSG) with three variants of elevated perches (back perches elevated (BE), front perches elevated (FE), both perches elevated (ST)). The study comprised three trial periods and layers' use of functional areas (wire floor, dust bath, nest box, perch), resting behaviour, locomotion and dustbathing and pecking behaviour were analysed during daytime. The highest number of hens on the wire floor was recorded in AP. Hens in SG and MSG showed highest locomotion activities. The frequency of hens walking on the wire floor was highest in ST compartments when longer distances could be covered without crossing non-elevated perches. Dust baths were frequented more often for other activities rather than dust bathing behaviour. Feather pecking and pecking against objects was highest in AP (LSL, LB), whereas in LS layers, it mainly occurred in MSG. Perch use was highest in SG with non-elevated perches. In all three variants of MSG compartments, elevated back and/or front perches were only used to a small extent and highest perching and resting activity was observed on non-elevated perches. The study shows that SG and MSG housing systems could increase layers' locomotion activities, whereas the possibility to perform dust bathing appears insufficient. However, in LS hens, dust bathing on wire floor was more frequent in AP compared to SG and MSG and in the latter two systems more dustbaths were performed on dustbathing mats in comparison to wire floor. Elevated perches were only accepted to a small extent during the day, which might be due to inappropriate perch design and/or perch position.

Key words

Functional areas, perch acceptance, small group system, elevated perches, laying hens

Zusammenfassung

Nutzung von Funktionsbereichen, Sitzstangenakzeptanz sowie ausgewählte Verhaltensmerkmale in Legehennen aus ausgestalteten Käfigen, Kleingruppen- und modifizierten Kleingruppenhaltungen mit erhöhten Sitzstangen

Auf zwei experimentellen Farmen wurden über insgesamt drei Legedurchgänge Verhaltensuntersuchungen bei Lohmann Selected Leghorn (LSL), Lohmann Brown (LB) und Lohmann Silver (LS) Legehennen durchgeführt, die in ausgestalteten Käfigen (Aviplus (AP)), Kleingruppenhaltungen (Eurovent 625a-EU (SG)) und modifizierten Kleingruppenabteilen (MSG) mit drei verschiedenen Varianten der Sitzstangenpositionierung (hintere Stangen erhöht (BE), vordere Stangen erhöht (FE), beide Stangen erhöht und stufig installiert (ST)) gehalten wurden. Während der Lichtphase wurde die Verteilung der Hennen innerhalb der Abteile (Gitterboden, Staubbad, Nest, Sitzstangen), das Ruhe- und Bewegungsverhalten sowie das Staubbade- und Pickverhalten mittels Direktbeobachtung erfasst. Die größte Anzahl an Hennen auf dem Gitterboden wurde in AP beobachtet. Hennen in SG und MSG zeigten die höchsten Bewegungsaktivitäten. Die höchste Frequenz an Hennen, die sich auf dem Gitterboden fortbewegte, wurde in ST Abteilen beobachtet, da diese den Hennen die Möglichkeit boten, sich über längere Distanzen fortzubewegen, ohne nicht erhöhte Sitzstangen überqueren zu müssen. In allen Haltungssystemen wurden die Legenester während des Tages als Rückzugsort aufgesucht. Staubbäder wurden vermehrt für andere Aktivitäten genutzt als für Staubbadeaktivitäten. Federpicken und Picken gegen Objekte wurde am häufigsten in AP (LSL, LB) beobachtet, während LS Hennen dies vornehmlich in MSG Abteilen zeigten. Die Sitzstangennutzung war in SG Abteilen mit nicht erhöhten Sitzstangen am höchsten. In allen drei Varianten der MSG Abteile wurden die erhöhten hinteren und/oder vorderen Sitzstangen nur zu einem geringen Prozentsatz angenommen und die häufigste Sitzstangennutzung sowie Ruheverhalten auf den Stangen erfolgte auf den nicht erhöhten Sitzstangen. Die Studie zeigte, dass SG

und MSG Abteile das Bewegungsverhalten der Hennen steigern konnten, jedoch Möglichkeiten zum Komfortverhalten (z.B. Staubbadeverhalten) unzureichend waren. Im Vergleich zu AP trat bei LS Hennen in SG und MSG jedoch weniger Staubbadeverhalten auf dem Drahtboden auf und die Staubbadematten wurden für diese Verhaltensweise mehr genutzt als der Drahtboden. Erhöhte Sitzstangen wurden nur zu einem sehr geringen Anteil während des Tages frequentiert, was möglicherweise auf ein ungünstiges Design, ungenügende Abteilhöhe sowie auf die Positionierung innerhalb der Abteile zurückzuführen ist.

Stichworte

Funktionsbereiche, Sitzstangenakzeptanz, Kleingruppenhaltung, erhöhten Sitzstangen, Legehennen

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Correspondence: Dr. Britta Scholz, Friedrich-Loeffler-Institut, Institute of Animal Welfare and Animal Husbandry, Dörnbergstrasse 25/27, 29223 Celle, Germany; e-mail: britta.scholz@fli.bund.de.