Question to EURCAW-Poultry-SFA

Reference of the query: Q2E-Poultry-SFA-2021-004
Query received 27.10.21
Date of admissibility: 23.11.21
Replied sent: 15.02.22

Background context provided by the solicitor

None

Question

The space needed for a pullet at feeder (to preview that at certain moment most of the hens might be eating at the same time).

In Portugal, the mean age of transition to the production house is at around 16-18 weeks of age and the type of hens used are mostly Hyline and ISA Brown but also H&N and Lohmann. The body weight at the end of rearing is about 1,900 Kg

The question is: what is the space at feeder needed during rearing period so that pullets can eat all at the same time, including at the end of the rearing. If possible, to have some scientific support that cover different breeds of laying hens, concerning to feeding equipment.

The usable area needed:

We would like to know which area is needed per pullet in order to satisfy main behavioural needs (exploration, foraging, resting, comfort behaviour). If possible, to have some scientific support that cover different breeds of laying hens, concerning to minimal useful area.

It would be appreciated if you can provide scientific element about how to assess the impact of space allowance and feeder space on the behaviour, physiological and other animal welfare indicators of pullet hens, such as feather damage, wounds, traumatism, etc…

Answer

Background arising from expertise

Introduction

Determining minimum required feeding space and usable area for pullets is not straightforward. Pullets grow rapidly throughout the rearing period meaning required feeding space and usable area changes over time. To ensure sufficient space is provided throughout the entire rearing period, recommendations must be made based on the maximum size that birds reach during rearing, which is nearly their mature body size, at the end of the rearing period.

The strain of bird must also be considered as mature body weights, as well as body shape, differ between hybrids. Additionally, flock size and genetic differences may contribute to differences in social and feeding behaviour such as motivation to feed synchronously as well as inter-bird distance preferences (Knierim, 2000). While all of these factors must be considered when recommending required feeder space and usable area, pullet size, specifically pullet body width, provides a starting point, as data on other factors are extremely limited.

Housing system is also important to consider when recommending usable area. On commercial farms, day old chicks are placed in one house (cage, on the floor or in a three-dimensional system) and reared until 16-18 weeks of life before being moved to a laying farm just prior to onset of lay. Pullets destined for furnished cages as adults are often raised in collective cages whereas pullets destined for cage-free systems are usually raised in floor systems, and those for aviaries are reared in multi-tier systems. In many systems, chicks are initially confined to one part of the house and given access to larger areas as they age.

EU Directive 1999/74 does not apply to chicks or pullets before the onset of lay, thus whatever the housing system, there are no specific EU regulations that specify stocking density nor feeder space for pullets. In current practice, pullets are kept at stocking densities (in terms of animals/m²) that are much higher compared to those in laying hens. In part, this is justified because pullets are growing.

1. Common housing systems for pullets

Floor systems: Pullets have traditionally been reared in basic floor systems. On arrival, day-old chicks are usually confined with a low barrier to a relatively small section of the whole house, termed the brooding area. Chicks are usually released from the brooding area after the first 7 to 14 days, and are gradually given access to the full house area. Feed is supplied via feed-tracks running throughout the house by chain or plates.

Aviary: Multi-tier (aviary) systems for rearing of pullets most often consist of rows of at least two tiers placed one above the other. Pullets can freely move within and between the tiers and have access to the littered ground floor between and often also under the rows of tiers. During the first 2 to 4 weeks of life, the lowest and/or the middle tiers can be closed by removable fronts and serve as starter tiers. In many aviary rearing systems, these starter tiers are partitioned in compartments by permanent or removable vertical grids such that pullets are kept in small caged groups during the few first weeks of life. After the first few weeks, the starter tiers are opened, and pullets have access to all other tiers and the littered ground floor. Feed is delivered via a chain or via round troughs in the starter tiers. After opening of all tiers, pullets may have access to additional feed troughs in the other tiers.

Collective cages: Collective cages for pullets must accommodate growing birds and so the heights of drinkers and feeders are always adjustable. Feed is distributed via a chain to troughs fitted to the outside of the cages. Some cage systems are designed so that day-old chicks are distributed to all tiers of the system from the day of their arrival. Other cage systems are designed with a starter (or brooder) tier, so that newly arrived chicks are kept within just one tier for the first few weeks of life. As birds grow, they are distributed manually within the other tiers.

2. Body dimensions of main strains of laying hens used in EU

Knowledge of pullet body width during rearing is scarce to non-existent, and data on hen body widths are limited and have only been formally measured for a select number of strains (Table 1).

Table 1: Average measures of pullet and hen body width in centimetres available from the literature as of January 1, 2022. Weight ranges obtained from the breed manuals for ISA Brown, ISA White, and H&N Brown Nick from 16-18 weeks are also included for reference, though there were no data on body widths available in the literature. LB : Lohmann Brown, LT : Lohmann Tradition, LSL : Lohmann Selected Leghorn

Age (wks)	Strain	Weight (kg)	Width (cm)	Method	Posture	Reference
8	LB and LT	0.64 ± 0.06	10.82 ± 0.97*; 10.70 ± 1.10**	digital images, front view	Perching (standing; sitting)	Giersberg et al., 2017
8	LSL	0.57 ± 0.05	10.30 ± 0.86*; 10.53 ± 1.00**		Perching (standing; sitting)	Giersberg et al., 2017
12	LB and LT	1.03 ± 0.09	10.66 ± 0.94*; 10.70 ± 1.01**		Perching (standing; sitting)	Giersberg et al., 2017
12	LSL	0.90 ± 0.06	10.39 ± 1.12*; 10.42 ± 1.09**		Perching (standing; sitting)	Giersberg et al., 2017
16-18	ISA White	1.17 to 1.33				Breed manual
16-18	ISA Brown	1.41 to 1.54				Breed manual
16-18	H&N Brown Nick	1.37 to 1.52				Breed manual
19	LSL	unknown	13.12 ± 0.98	digital images, front view	Perching	Briese and Spindler, 2013
19	LB	unknown	15.08 ± 0.76		Perching	Briese and Spindler, 2013
19	LB and LT	1.56 ± 0.14	13.90 ± 1.07*; 13.96 ± 1.11**		Perching (standing; sitting)	Giersberg et al., 2017
19	LSL	1.13 ± 0.06	12.60 ± 1.12*; 13.00 ± 1.14**		Perching (standing; sitting)	Giersberg et al., 2017
25	Hisex Brown medium hybrid	unknown	11.70 ± 0.11	callipers pressed to the hen's skin at the widest point of the shoulders	unknown	Cooper and Appleby, 1996
28	Dekalb White	1.61 ± 0.31	15.52	Still images, width was measured using a line across the widest part of a hen's body	Standing	Riddle et al., 2018
28	W36	1.58 ± 0.42	14.94		Standing	Riddle et al., 2018
28	Hy-Line Brown	2.06 ± 0.29	18.63		Standing	Riddle et al., 2018
28	Bovans Brown	1.98 ± 0.21	19.34		Standing	Riddle et al., 2018
34	LB Plus (conventional)	1.88 ± 0.01	14.77 ± 0.08	digital image, ImageJ image processing program, horizontal connecting line between	Perching (standing or sitting)	Giersberg et al., 2019
34	Lohmann Dual (hybrid)	1.79 ± 0.02	15.95 ± 0.08		Perching (standing or sitting)	Giersberg et al., 2019

				the outer contours of the hen's wings at the level of the carpal joints		
36	LSL	1.74 ± 0.12	13.44 ± 0.97	digital images, front view	Perching	Briese and Spindler, 2013
36	LB	2.04 ± 0.19	15.41 ± 1.32		Perching	Briese and Spindler, 2013
58	LSL	1.71 ± 0.20	13.56 ± 0.97		Perching	Briese and Spindler, 2013
58	LB	1.81 ± 0.18	15.28 ± 1.13		Perching	Briese and Spindler, 2013

* standing; **sitting

At 19 weeks of age, pullet widths are around **13-15 cm** (in Lohman young hens). Hen widths ranged from 11.70 cm for a "medium" hybrid at 25 weeks of age, the Hisex Brown, up to 19.34 cm for the Bovans Brown strain at 28 weeks of age. One challenge in comparing bird width estimates between studies is the utilization of inconsistent methods. Cooper and Appleby (1996) utilized callipers pressed directly on the hens' skin at the widest point of their shoulders, whereas the remaining studies obtained measures from digital images, thus including feather cover in the bird width estimation. When comparing birds across similar ages, brown strains of birds were heavier and wider than their white counterparts. There were not significant differences in body width whether birds were in a sitting or standing posture (Giersberg et al., 2017), therefore bird widths while perching were also included in this review.

3. Space needs

In contrast to available research on space allowance in adult laying hens, there is a gap in the literature on knowledge from the rearing phase. However, it is well-recognised that welfare problems in adult birds are strongly influenced by the rearing conditions of the pullets (Janczak and Riber, 2015; de Haas et al., 2021).

Behavioural space

Sufficient floor space is a fundamental precondition for poultry to perform normal behavioural patterns. This sufficient space is dependent on the body space and the additional space required for characteristic behaviours (behavioural space) and for adequate inter-individual distances, and room to perform social interactions have to be taken into account.

Studies on adult hens indicate the space needed for different behaviours (Table 2).

Table 2 : Area covered by an adult hen (compiled from Dawkins and Hardie (1989) (pen); Mench and Blatchford (2014) (test-pen), Riddle et al. 2018 (aviary)).

Behaviour	Area covered by an adult hen
Standing	475 cm^2 to 573 cm^2
Scratching	856 cm^2
Wing stretching	893 cm^2
Dustbathing	1000 to 1190 cm^2
Grooming	1150 cm^2
Turning	1272 to 1315 cm^2
Wing flapping	1378 cm^2 to 3345 cm^2

There are differences between layer genotypes in the body sizes, but also in the intensity in which foraging and exploring are performed (Chew et al., 2021). For instance, brown hens required more space than white hens for most of behavioural expressions, except for wing flapping (Riddle et al. 2018).

Depending on live weight, age, plumage condition and body position, Spindler et al. (2015) observed that 22 week old LB hens occupied an **average area of 542 cm^2** when standing and LSL hens **457 cm^2** (measured in aviary systems), and that hens needed an average of 75 cm^2 (18%) more space in sitting compared to standing body position.

Effects of densities in pullets

Von Eugen et al. (2019) reviewed several studies showing effects of densities in pullets (Table 3).

Table 3: Literature overview research on effects of space allowance during the rearing period on the laying hen. Density is expressed in cm² per chick. Per parameter is depicted if the study found an increase, decrease, or no difference (nd) with increasing stocking densities. If the study did not consider the specific parameter, it is designated with '-'. The parameters considered are: body weight (BW), food intake (FI), uniformity of physique (U), fluctuating asymmetries (FA), mortality (M), plumage condition (PC), heterophil:lymphocyte (H:L) ratio, behaviour, laying performance (LP). Source: Von Eugen et al. (2019)

Author	Year	Reference	Density (cm^2/Chick)	BW	FI	U	FA	M	PC	H:L	Behavior	LP
Anderson & Adams	1992	[30]	192/221	(0–16) ↓ (16+) ↑	nd	nd	-	nd	nd	-	-	-
Bestman et al.	2009	[2]	(0–4) 294.1/476.2 (5–6) 416.7/555.6 (7–17) 952.4/010.1	-	-	-	-	-	-	-	↑ feather pecking	-
Blokhuis & van der Haar	1989	[31]	625/1250/3703.7	-	-	-	-	-	nd	-	↓ ground pecking ↑ feather pecking	-
Bozkurt et al.	2008	[12]	(0–4) 105.9/134.8/185.3 (4–16) 211.8/274.5/370.6	-	-	↑	-	-	-	↑	-	-
Bozkurt et al.	2006	[32]	(0–4) 105.9/134.8/185.3 (4–16) 211.8/274.5/370.6	↓	↓	-	-	nd	-	-	-	-
Carey	1986	[33]	1) 239/259/311 2) 222/259/311	↓	↓	-	-	-	-	-	-	↑ egg weight ↓ egg production decline
Hansen & Braastad	1994	[34]	769.2/1538.5	nd	nd	-	-	nd	↓	-	↓ ground pecking ↑ feather pecking	nd
Hester & Wilson	1986	[35]	344/516/1031	-	-	-	-	-	-	-	-	↓ hard-shelled:shell-less eggs ↓ eggs:hens
Huber-Eicher & Audige	1999	[36]	(0–2) > 285.7/< 285.7 (3–16) > 1000/< 1000	-	-	-	-	-	-	-	↑ feather pecking	-
Hunniford	2016	[37]	(0-5) 194.6/285.2 (6–16) 387.1/775 (16+) 690	-	-	-	-	-	-	-	↓ activity	-
Leeson & Summer	1984	[38]	293/586	nd	↓	-	-	-	-	-	-	↑ egg weight ↓ eggs
Moller et al.	1995	[39]	357.1/416.7/500	-	-	-	↑	-	-	-	↑ tonic immobility	-
Patterson & Siegel	1997	[40]	(0–6) 97.8/116.1/142.9/185.8 (6–16) 195.6/232.3/285.9/371.6	↓	(0–2) ↓ (2+) ↑	nd	-	nd	-	-	-	-
Pavan et al.	2005	[41]	(0–6) 210.5/228.6/250/275.9 (6–16) 357.1/416.7/500 (16+) 375/450/562.2	nd	nd	nd	-	-	-	-	-	nd
Wells	1972	[42]	700/930/1390/1860	nd	nd	nd	-	nd	↓	-	-	nd
Zepp et al.	2018	[43]	436.7/552.5	-	-	-	-	-	-	-	↑ feather pecking	-

Von Eugen et al. (2019) also compared 3 different space allowances in cages (all increasing with age: 0-3, 4-7 and 8-10 weeks), termed crowding conditions; undercrowding (500-1000-1429 cm² per pullet), conventional crowding (167-333-500 cm² per pullet), or overcrowding (56-111-167 cm² per pullet). Pullets reared at high stocking density had higher corticosterone levels in plasma and feathers and displayed more anxious behaviour.

In high densities, pullets have been found to display more feather pecking (Hansen and Braastad, 1994; Huber-Eicher and Audige, 1999; Bestman et al., 2009; Zepp et al., 2018). Bozkurt et al. (2008) reported an increased H/L ratio while Patterson and Siegel (1998) did not find any impact of stocking density during rearing on H/L ratio.

In Fawcett et al. (2021), pullets were reared at 4 different stocking densities (from 247 to 335 cm²/bird, i.e. 30 to 40 pullets/m²) in large cages furnished with elevated perches and a platform. The measures on bones and muscles were not different according to the stocking density. A recent study from Hoffman et al. (2021) showed that stocking density during rearing had short- and long-term effects on the immune system of pullets reared in small experimental floor pens. Pullets reared from 7 to 17 weeks of age at high stocking density (23/m²; 435 cm²/pullet) had lower numbers of total lymphocytes at the end of the rearing period and in the laying period than those reared at lower density (13/m²; 769 cm²/pullet). Moreover, they showed less active behaviour (such as locomotion, foraging and preening), more aggressive pecking and a higher frequency of feather pecking behaviour as pullets, which continued during the laying period, resulting in worse plumage and integument conditions.

Pullets reared commercially in aviaries at 23 birds/m² showed more gentle feather pecking and severe feather pecking than pullets reared at 18 birds/m² (Zepp et al., 2018) and higher stocking rates have sometimes (Bestman et al., 2009; Hoffman et al., 2021), although not always (Liebers et al., 2019), been associated with reduced plumage condition. Low usable space allowance may also have negative consequences on other welfare indicators such as increased aggressive behaviour (Bestman et al., 2009) and physical injuries (Frankenhuis et al., 1991).

In addition to the space required for the behaviour of individual pullets, the tendency of hens to synchronize their behaviors in the flock, and the need for personal space, i.e., to maintain a certain distance between individuals, must be taken into consideration. Hens may prefer to distance themselves from other birds, but the strength of motivation to do so has not been thoroughly investigated, and preferred inter-individual distances may vary with activity (Savory et al., 2006, Grebey et al. 2020).

To summarize, space allowances of **450 cm² to 600 cm²** are thus known to impose severe restrictions on pullets at the end of rearing period, on comfort behaviours (such as wing flapping, leg stretching, dust bathing, preening, body shaking, etc.), foraging and exploring behaviours and resting behaviour that all have major relevance for animal welfare. This leads to frustration, stress and negative affective states.

Effects of insufficient feeder space

Social and feeding behaviour

When determining required feeding space, it is generally recommended that enough space is provided to allow all hens to access the feeder simultaneously (Appleby, 2004; UEP, 2017). Laying hens tend to synchronize their feeding behaviour, causing hens to cluster around the feeder and for large proportions of the flock to actively feed at the same time. Studies have reported feeding synchronization in caged hens (Hughes, 1971; Webster and Hurnik, 1994; Thogerson et al., 2009ab), enriched colony systems (Oliveira et al., 2019), and floor and aviary systems (Keeling et al., 2017).

Keeling et al. (2017) found that birds were more likely to feed synchronously when housed in smaller groups or cages, as opposed to larger flocks in more complex environments. In enriched colony cages when 12 cm per hen of feeder space was provided, a maximum of 59% of hens fed simultaneously, even though unoccupied feeder space was present (Oliveira et al., 2019). In conventional cages of 5 hens, all hens were only observed feeding at the same time 75% of the time (Thogerson et al., 2009b). In furnished cages, maximum ranges of 63 to 83% of hens were observed feeding simultaneously (Albentosa et al., 2007; Blatchford and Mench, 2014; Widowski et al., 2017).

In aviary systems, a similar maximum percentage of 65.2% was observed (Sirovnik et al., 2018). The number of birds choosing not to feed with the rest of the flock could be due to lower ranking hens avoiding agonistic behaviours arising from competition, or may be due to larger preferred inter-bird distances. When additional feeder space is provided, hens choose to increase the space between themselves (Oliveira et al., 2019). The inability to feed at the same time as the rest of the flock may cause frustration in lower ranking hens (Hughes and Dun, 1983).

Feeder access and nutrition

A link between feed particle distribution and plumage condition has been identified (Schreiter et al., 2021). Feed particle size may impact digestibility and feed intake. When there is competition at the feeder, more dominant birds have the advantage of selecting preferential feed particles. Nutrient deficiencies, most notably in methionine and lysine, may contribute to feather pecking and in severe cases, cannibalism (Kjaer and Bessei, 2013). Thus, if insufficient feeder space is provided, lower ranking hens risk inadequate nutrition which may trigger damaging behaviours such as feather pecking which contribute to reduced welfare.

Housing environment

Housing design impacts accessibility of feeders as well as the behavioural opportunities available to hens (Thogerson et al., 2009b). Availability, dispersal and level of competition affect how individuals utilize feeders and other resources within their environment (Leone and Estevez, 2008). The majority of data on feeder space allowances come from studies conducted with caged hens in small group sizes. The applicability of standards obtained from these data to pullets in alternative rearing systems where there may be behavioural opportunities other than feeding, is unclear. Housing environments with greater space and greater environmental complexity may affect feeding behaviour, and thus feeding space requirements (Widowski et al., 2017).

Possible indicators of insufficient usable area and insufficient feeder space

A previous report from EURCAW-SFA explains that no specific animal-based indicator was available for indicating insufficient usable area or feeder space in laying hens (DELIVERABLE: 2.1.1 – LIST OF RELEVANT WELFARE INDICATORS). It also applies in pullets. Insufficient usable area and insufficient feeder space can generally increase frustration, stress and negative affective states, impacting on pullets' welfare. However, behavioural and production impacts that have been observed are not specific to the insufficient usable area or feeder space, with the exception of crowding or "lining up" at the feeder, as they might be a consequence of others concerns. Unspecific indicators that have been observed (with some examples of literature sources) are;

with insufficient usable area:

- Increased corticosterone (Von Eugen et al. 2019),
- Increased Heterophil:lymphocyte (H/L) ratio (Bozkurt et al. 2008)
- Increased tonic immobility (Moller et al. 1995)
- Reduced active behaviour (Locomotion, foraging, preening) (Hansen & Braastad, 1994)
- Reduced lymphocytes T (Hoffman et al. 2021)
- Increased frequency of feather pecking (Bestman et al. 2009)
- Deteriorated plumage and integument conditions (Hansen & Braastad, 1994)
- Reduced body weight (Bozkurt et al. 2008)
- Reduced food intake (Bozkurt et al. 2008)

with insufficient feeder space:

- Birds crowding around or lining up to access the feeder
- Decreased feeding synchrony (Thogerson et al., 2009b; Oliveira et al., 2019)
- Reduced feeding time (Thogerson et al., 2009b; Oliveira et al., 2019)
- Reduced feeder visits (Huon et al., 1986; Oliveira et al., 2019)
- Increased feeder displacements by other birds (Widowski et al., 2017)
- Increased variation in individual feeding time (Thogerson et al., 2009b)
- Increased aggression at feeder (Sirovnik et al., 2018)
- Increased jostling at the feeder (Sirovnik et al., 2018)
- Reduced feed consumption (Davami et al., 1987)
- Decreased egg production (Garner et al., 2012)

- Poorer feed conversion (Thogerson et al., 2009a)

Overall, hens appear to adapt their feeding behaviour to meet their biological needs, even when feeding space does not allow for all hens to simultaneously feed. Multiple studies have suggested that hen growth and production parameters are not greatly impacted by reduced feeder space (Davami et al., 1987; Thogerson et al., 2009a; Anderson and Adams, 1991; Anderson and Adams, 1994). Further studies are necessary to examine the welfare impacts of insufficient feeder space, particularly on impacts of competition which may result in aggression, feather pecking or frustration.

4. Recommendations from breeding companies, (inter)national regulations, codes of practice and assurance scheme standards

For laying hens, usable area is defined in the Directive 1999/74/EC as an "area at least 30 cm wide with a floor slope not exceeding 14%, with headroom of at least 45 cm. Nesting areas shall not be regarded as usable areas". In alternative systems for laying hens, each bird must have at least 250 cm² of littered area, the litter occupying at least one third of the ground surface. The stocking density must not exceed **9 laying hens/m²** usable area. Notice that only tier-levels equipped with a manure belt can be regarded as useable area (perches or grids are not included in the usable area). In cage systems for laying hens, each bird must have at least 600 cm² usable area per hen (750 cm² including the nest area), corresponding to **16.6 hens/m²** usable area. About the feeding space it is noticed that "the drinking and feeding facilities must be distributed in such a way as to provide equal access for all hens", and "a feed trough which may be used without restriction must be provided".

Usable space

For pullets, recommendations on density from breeding companies vary according to the age of pullets and whether the farm is based in temperate or hot climate (Table 4 and Table 5).

Table 4 : Breeder recommendations for stocking density of pullets in cages

Density (animal/m²)	Age	Strain	Climate	Source
50	0-14 days	Novogen White	Temperate	Novogen, 2019
45	0-14 days	Novogen White	Hot	Novogen, 2019
80	0-14 days	Isa Brown		Isa Brown, 2019

71	0-21 days	Brown Nick		H&N International, 2019
40	2-5 weeks	Novogen White	Temperate	Novogen, 2019
30	2-5 weeks	Novogen White	Hot	Novogen, 2019
45	2-5weeks	Isa Brown		Isa Brown, 2019
15	5-10 weeks	Isa Brown	Temperate	Isa Brown, 2019
12	5-10 weeks	Isa Brown	Hot	Isa Brown, 2019
35	3 w-transfer	Brown Nick		H&N International, 2019
25	5w-transfer	Novogen White	Temperate	Novogen, 2019
20	5w-transfer	Novogen White	Hot	Novogen, 2019
10	10w-transfer	Isa Brown	Temperate	Isa Brown, 2019
9	10w-transfer	Isa Brown	Hot	Isa Brown, 2019
28	10-15 weeks	Isa Brown		Joice and Hills, 2015
13	16 weeks	Isa Brown		Joice and Hills, 2015
15	15 weeks	Hy-line Brown		Hy-Line, 2017
14	16 weeks	Hy-line Brown		Hy-Line, 2017
13	17 weeks	Hy-line Brown		Hy-Line, 2017
12	18 weeks	Hy-line Brown		Hy-Line, 2017

Table 5 : Breeder recommendations for stocking density of pullets in alternative systems

Density (animal/m²)	Age	Strain	Climate	Source
30	0-14 days	Novogen White	Temperate	Novogen, 2019
25	0-14 days	Novogen White	Hot	Novogen, 2019
30	0-14 days	Isa Brown		Isa Brown, 2019
21	0-21 days	Brown Nick		H&N International, 2019

15	2-5 weeks	Novogen White		Novogen, 2019
20	2-5weeks	Isa Brown		Isa Brown, 2019
15	5-10 weeks	Isa Brown	Temperate	Isa Brown, 2019
12	5-10 weeks	Isa Brown	Hot	Isa Brown, 2019
16	3 w- transfer	Brown Nick		H&N International, 2019
12-14	5w-transfer	Novogen White	Temperate	Novogen, 2019
8-10	5w-transfer	Novogen White	Hot	Novogen, 2019
10	10w-transfer	Isa Brown	Temperate	Isa Brown, 2019
9	10w-transfer	Isa Brown	Hot	Isa Brown, 2019
15	15 weeks	Hy-line Brown		Hy-Line, 2017
14	16 weeks	Hy-line Brown		Hy-Line, 2017
13	17 weeks	Hy-line Brown		Hy-Line, 2017
12	18 weeks	Hy-line Brown		Hy-Line, 2017

Then, at the end of the rearing period, breeding companies' recommendations vary in cages from maximum **9 pullets/m²** (=1 111 cm²/pullet) **to 35 pullets/m²** (=285 cm²/pullet); in alternative systems: from maximum **8-10 pullets/m²** (=1000 - 1250 cm²/pullet) **to 16 pullets/m²** (=625 cm²/pullet), which is considerable variation in space allowance, even when taking into account the variation in body size.

According to the Guide on best management practice for the welfare of pullets (Voluntary initiative group for the welfare of pullets, 2021), "the space allowance should be calculated in relation to their demands on the whole environment (including air quality), their age, live weight, health and their needs to express certain behaviour (…): feeding and drinking, wing flapping, dustbathing, foraging, perching, resting/sitting, preening".

In the literature, we found some recommendations for pullets. Krause and Schrader (2019) did some calculations based on the floor space that is required for the body of broiler chickens. The paper provides a tool to calculate the space needed according to the body weight. They conclude that pullets at the end of their rearing period should ideally be provided with a relative additional space of about 40–60% to their body size to rank layer pullets alongside broiler chickens. In their example, they concluded that – depending on the genetic strain – the stocking density should be **between 9 and 15 birds/m²** at the end of rearing period. Other authors such as Spindler et al. (2013) suggested that appropriate stocking densities during rearing are **11 to 15 birds/m²** in alternative housing systems.

Feeder space

Various groups including researchers, governmental agencies, non-governmental agencies, and breeders have published feeder space recommendations (Table 6).

In many cases, these space recommendations were determined with very little to no scientific support. Some recommendations (i.e. those from governmental and non-governmental groups) fail to account for strain of bird. Space recommendations for pullets attempt to adjust for bird size as they age, however, the time frames are often large and do not likely scale appropriately to the rapid changes in pullet body size that occur. In general, feeder space recommendations vary widely between various entities, and are often quite low relative to bird body widths.

Table 6. Feeder space per hen/pullet recommendations from the scientific literature, governmental agencies, non-governmental organizations, and breed management manuals.

Feeder Space (cm/hen)	Age	Strain	Feeder type	Housing type	Source
1	0 – 2 wks		Linear		National Farm Animal Care Council, 2017
2.5	0 - 5 weeks		Linear		Niedersachsen, 2013
2.5	0-3 wks	Brown Nick (H&N)	Linear	Cages	H&N International, 2019
4	0-3 wks	Brown Nick (H&N)	Linear	Floor	H&N International, 2019
5	0-3 wks	Hy-Line brown	Linear	Cages	Hy-line Brown, 2019
4	0-4 wks	Isa brown	Linear	Floor	ISA Brown, 2019
1.5	0-4 wks	Isa brown	Linear	Cages	ISA Brown, 2019
2	2 – 8 wks		Linear		National Farm Animal Care Council, 2017
8	8 wk	Brown layers	Linear	Alternative system	Giersberg et al., 2016
9	8 wk	Brown layers	Linear	Enriched cages	Giersberg et al., 2016
2.5 to 3.5	3 to 10 wks	Lohmann brown classic	Linear	Cages	Lohmann Brown - Classic, N/A
0.8	3 to 10 wks	Lohmann brown classic	Circular	Cages	Lohmann Brown - Classic, N/A
5	3-16 wks	Brown Nick (H&N)	Linear	Cages	H&N International, 2019
8	3-16 wks	Brown Nick (H&N)	Linear	Floor	H&N International, 2019
8	3-17 wks	Hy-Line brown	Linear	Cages	Hy-line Brown, 2019

5	5-16 wks	Isa brown	Linear	Floor and cages	ISA Brown, 2019
4.5	11 to 20 wks	Lohmann brown classic	Linear	Cages	Lohmann Brown - Classic, N/A
1.2	11 to 20 wks	Lohmann brown classic	Circular	Cages	Lohmann Brown - Classic, N/A
5	Pullets		Linear	Alternative system	RSPCA, 2016
2	Pullets		Circular	Alternative system	RSPCA, 2016
2.5	Pullets	Lohmann brown free range	Linear	Floor	Lohmann Brown Classic & Lite, N/A.
2	Pullets	Lohmann brown free range	Circular	Floor	Lohmann Brown Classic & Lite, N/A.
2.5	Pullets	Hy-Line brown	Linear	Multi-tier or floor	Hy-line Brown, 2019
5	Pullets	Hy-Line brown	Linear	Multi-tier or floor	Hy-line Brown, 2019
2	Pullets	Hy-Line brown	Circular	Multi-tier or floor	Hy-line Brown, 2019
4.5	Pullets > 6 wks		Linear		Niedersachsen, 2013
4	8 wks – transfer		Linear		National Farm Animal Care Council, 2017
13.0	Pullets at end of rearing	Brown layers	Linear		Broom and Fraser, 2007
12.0	Pullets at end of rearing	White Layers	Linear		Broom and Fraser, 2007
7.6	>16 weeks	White Leghorn	Linear	Cages	Bell, 2002
9	19 wk	White layers	Linear	Alternative system	Giersberg et al., 2016
11	19 wk	White layers	Linear	Enriched cages	Giersberg et al., 2016
12	Hens	Light hybrids	Linear	Cages	Appleby, 2004
14	Hens	Medium hybrids	Linear	Cages	Appleby, 2004
10	Hens	Medium hybrids	Linear	Deep cage	Faure, 1986
7.6	Hens		Linear		UEP, 2017
3.8	Hens		Circular		UEP, 2017
10	Hens		Linear	Alternative system	Council Directive 1999/74/EC
12	Hens		Linear	Enriched cages	Council Directive 1999/74/EC

4	Hens		Circular	Alternative system	Council Directive 1999/74/EC
7	Hens		Linear		National Farm Animal Care Council, 2017
8	Hens		Linear		Animal Welfare Ordinance, 2008
10 to 15	Hens	Brown Nick (H&N)	Linear		H&N International, 2019
5.0	Hens	Brown Nick (H&N)	Circular	Cages	H&N International, 2019
7 to 12	17 to 80 wks	Hy-Line brown	Linear	Cages	Hy-line Brown, 2019

Conclusion and Recommendation

Feeder space

Based on the limited data available, pullets are likely between 10 and 15 centimetres wide at the end of the rearing period (16-18 weeks). This would mean that the majority of space recommendations currently published would not allow every bird within the facility to feed at the same time. This could lead to negative welfare by contributing to frustration in lower ranking hens that are not able to access food at the same time as the rest of the flock and may lead to agonistic behaviours or nutritional imbalances as pullets compete for access to the feeder. As white and brown strains of hens differ in body shape, with white hens generally being narrower, the specific genetic strain being housed should be considered when determining feeder space. Additionally, little is known about birds' preferred spacing while feeding. In all reality, birds likely prefer some buffer space between each other while feeding, and thus additional feeder space should be provided to account for this. Preferred inter-bird distances are also likely to vary between genetic strains and warrants further investigation.

Usable area

According to limited quantity of studies available on pullets needs, a usable space under 600 cm^2 per pullet (over 16 pullets/m^2) at the end or rearing period strongly impacts welfare, taking into account the body space of the birds, which differs between genotypes. In addition to the space needed for the body itself, it is important to take into account the space needed for different behaviours and inter-individual distances. It can be considered that majority of recommendations from guidelines would pose restrictions on behavioural expression of the pullets at the end of the rearing period. Moreover, vertical space considerations are important for some behaviours, although this was not the object of this query, where focus was on usable (horizontal) space.

Relevant references and other documents

Albentosa, M., J. Cooper, T. Luddem, S. Redgate, H. Elson, and A. Walker. 2007. Evaluation of the effects of cage height and stocking density on the behaviour of laying hens in furnished cages. Br. Poult. Sci. 48:1-11.

Animal Welfare Ordinance. 2008. Tables 9–1. Swiss Animal Protection Regulations.

Appleby, M. 2004. What causes crowding? Effects of space, facilities and group size on behaviour, with particular reference to furnished cages for hens. Animal Welfare 13:313-320.

Bell, D. D. 2002. Cage management for layers. Pages 1007-1040 in Commercial chicken meat and egg productionSpringer.

Bestman, M., P. Koene, and J.-P. Wagenaar. Influence of farm factors on the occurrence of feather pecking in organic reared hens and their predictability for feather pecking in the laying period. Appl. Anim. Behav. Sci., 2009. 121, 2: p. 120-125 https://doi.org/10.1016/j.applanim.2009.09.007.

Blatchford, R., and J. Mench. 2014. The utilization of feeder space by hens housed in enriched colony cages. Poult. Sci. 93:71.

Bozkurt Z. , Bayram I., Bülbül A., Aktepe O.C. Effects of strain, cage density and position on immune response to vaccines and blood parameters in layer pullets 2008. Kafkas Universitesi Veteriner Fakultesi Dergisi, Volume 14, Issue 2, Pages 191 - 204

Briese, A., and B. Spindler. 2013. Discussion of actual legal minimum requirements for feeder space and perch length in laying hen husbandry in the light of the body widths measured in Lohmann Selected Leghorn and Lohmann Brown laying hens. Berl. Munch. Tierarztl. Wochenschr. 126:163-168.

Broom, D., and A. Fraser. 2007. Domestic animal behaviour and welfare. CAB International. Reading.[Google Scholar].

Chew, J.A.; Widowski, T.; Herwig, E.; Shynkaruk, T.; Schwean-Lardner, K. The Effect of Light Intensity, Strain, and Age on the Behavior, Jumping Frequency and Success, and Welfare of Egg-Strain Pullets Reared in Perchery Systems. Animals 2021, 11, 3353. https://doi.org/10.3390/ani11123353

Council Directive 1999/74/EC. Laying down minimum standards for the protection of laying hens. Off. J. Euro. Communities 203:53-57.

Cooper, J. J., and M. C. Appleby. 1996. Demand for nest boxes in laying hens. Behav. Processes 36:171-182.

Davami, A., M. Wineland, W. Jones, R. Ilardi, and R. Peterson. 1987. Effects of population size, floor space, and feeder space upon productive performance, external appearance, and plasma corticosterone concentration of laying hens. Poult. Sci. 66:251-257.

Dawkins, M.S. and S. Hardie. Space needs of laying hens. Br. Poult. Sci., 1989. 30: p. 413-416.

De Haas E., Newberry R., Edgar J., Riber A., Estevez I., Ferrante V., Hernandez C., Kjaer J., Ozkan S., Dimitrov I., Rodenburg B., Janczak A. 2021. Prenatal and Early Postnatal Behavioural Programming in Laying Hens, With Possible Implications for the Development of Injurious Pecking. Frontiers in Veterinary Science, Vol.8, 10.3389/fvets.2021.678500.

Faure, J.-M. 1986. Operant determination of the cage and feeder size preferences of the laying hen. Appl. Anim. Behav. Sci. 15:325-336.

Fawcett DL, Casey-Trott TM, Jensen L, Caston LJ, Widowski TM. Strain differences and effects of different stocking densities during rearing on the musculoskeletal development of pullets. Poult Sci. 2020 Sep;99(9):4153-4161. doi: 10.1016/j.psj.2020.05.046. Epub 2020 Jun 24. PMID: 32867958; PMCID: PMC7598119.

Frankenhuis, M.T., M.H. Vertommen, and H. Hemminga. Influence of claw clipping, stocking density and feeding space on the incidence of scabby hips in broilers. Br. Poult. Sci., 1991. 32: p. 227-230.

Garner, J., A. Kiess, J. Mench, R. Newberry, and P. Hester. 2012. The effect of cage and house design on egg production and egg weight of White Leghorn hens: An epidemiological study. Poult. Sci. 91:1522-1535.

Giersberg, M. F., B. Spindler, and N. Kemper. 2019. Linear space requirements and perch use of conventional layer hybrids and dual-purpose hens in an aviary system. Frontiers in veterinary science 6:231.

Giersberg, M., N. Kemper, J. Hartung, L. Schrader, and B. Spindler. 2017. Determination of body width in brown and white layer pullets by image analyses. Br. Poult. Sci. 58:230-235.

Grebey T.C., Ahmed B.A. Ali, Janice C. Swanson, Tina M. Widowski, Janice M. Siegford, Dust bathing in laying hens: strain, proximity to, and number of conspecifics matter, Poultry Science, Volume 99, Issue 9, 2020, Pages 4103-4112, ISSN 0032-5791, https://doi.org/10.1016/j.psj.2020.04.032.

Hansen I., Braastad B. 1994. Effect of rearing density on pecking behaviour and plumage condition of laying hens in two types of aviary, Applied Animal Behaviour Science, Volume 40, Issues 3–4, Pages 263-272, https://doi.org/10.1016/0168-1591(94)90067-1.

H&N International, 2019. Nueva Guia de Manejo, Brown nick – Ponedora de Huevo marron. Editor H&N international GmbH, Cuxhaven, Germany. 08/2019 - Accessible: HN-ES.pdf (hnpeninsular.com)

Hofmann T, Schmucker S, Grashorn M, Stefanski V. Short- and long-term consequences of stocking density during rearing on the immune system and welfare of laying hens. Poult Sci. 2021;100(8):101243. doi:10.1016/j.psj.2021.101243

Huber-Eicher, B. and L. Audigé. Analysis of risk factors for the occurence of feather pecking in laying hen growers. Br. Poult. Sci., 1999. 40: p. 599-604.

Hughes, B. 1971. Allelomimetic feeding in the domestic fowl. Br. Poult. Sci. 12:359-366.

Hughes, B. O., and P. Dun. 1983. A Comparison of Laying Stock Housed Intensively in Cages and Outside on Range: Years 1981-83. West of Scotland Agricultural College.

Huon, F., M.-C. Meunier-Salaün, and J.-M. Faure. 1986. Feeder design and available feeding space influence the feeding behaviour of hens. Appl. Anim. Behav. Sci.

Hy-line Brown, 2019. Hy-Line Brown alternative systems management guide. Hy-Line International. Accessible: https://www.hyline.com/filesimages/Hy-Line-Products/Hy-Line-Product-PDFs/Brown/Brown%20Alt/BRN%20ALT%20COM%20UK.pdf

Hy-Line, 2017. Guide de gestion en systèmes alternatifs. Brown rural. Hy-line International. Accessible: Hy-Line-Brown-Rural-Guide-FR3.pdf (hyline-france.com).

ISA Brown, 2019. Guide d'élevage général des pondeuses commerciales. Institut de Sélection Animale B.V. The Netherlands https://sansdents.com/wp-content/uploads/2019/02/ISA-BROWN-GUIDE-D%E2%80%99%C3%89L%C3%89VAGE-GENERAL-DES-PONDEUSES-COMMERCIALES.pdf

ISA Brown, Isa Brown commercial product guide North American version. Hendrix Genetics. The Netherlands – EU. Accessible: https://www.isa-poultry.com/documents/302/ISA_Brown_cs_product_guide_North_America_L8110-2-NA.pdf

ISA White, ISA White product guide – cage housing. Hendrix Genetics. The Netherlands – EU. Accessible: https://www.isapoultry.com/documents/1398/ISA_White_CS_product_guide_cage_EN_L1211-2a.pdf

Janczak, A.M. and A.B. Riber. Review of rearing-related factors affecting the welfare of laying hens. Poult. Sci., 2015. 94, 7: p. 1454-1469 https://doi.org/10.3382/ps/pev123.

Joice & Hills, 2015. Isa brown – UK management guide. Accessible: https://www.joiceandhill.co.uk/documents/1362/ISA_Brown_Management_Guide_071021.pdf

Keeling, L. J., R. C. Newberry, and I. Estevez. 2017. Flock size during rearing affects pullet behavioural synchrony and spatial clustering. Appl. Anim. Behav. Sci. 194:36-41. doi 10.1016/j.applanim.2017.04.002

Kjaer, J., and W. Bessei. 2013. The interrelationships of nutrition and feather pecking in the domestic fowl. Arch Geflügelk 77:1-9.
Knierim, U. 2000. Investigations on the degree of synchronous feeding behaviour of two types of laying hybrids in battery cages with a feeder space of 12 cm per hen. Dtsch. Tierarztl. Wochenschr. 107:459-463.
Krause, E.T.; Schrader, L. Suggestions to Derive Maximum Stocking Densities for Layer Pullets. Animals 2019, 9, 348. https://doi.org/10.3390/ani9060348
Leone, E. H., and I. Estevez. 2008. Space use according to the distribution of resources and level of competition. Poult. Sci. 87:3-13. doi 10.3382/ps.2007-00026
Liebers, C.J., A. Schwarzer, M. Erhard, P. Schmidt, and H. Louton. The influence of environmental enrichment and stocking density on the plumage and health conditions of laying hen pullets. Poult. Sci., 2019. 98, 6: p. 2474-2488 10.3382/ps/pez024.
Lohmann Brown - Classic, N/A. Management guide cage housing. Lohmann Breeders. Accessible: https://lohmann-breeders.com/media/strains/cage/management/LOHMANN-Brown-Classic-Cage.pdf
Lohmann Brown Classic & Lite, N/A. Free Range Management Guide. Lohmann GB Limited. Accessible: https://www.lohmanngb.co.uk/uploadedImages/1559732867-lb_free_range_management_guide_with_cover.pdf
Mench, J.A. and R.A. Blatchford. Determination of space use by laying hens using kinematic analysis. Poult. Sci., 2014. 93, 4: p. 794-798.
Møller, A.P.; Sanotra, G.S.; Vestergaard, K.S. Developmental stability in relation to population density and breed of chicken Gallus Gallus. Poult. Sci. 1996, 74, 1761–1771.
National Farm Animal Care Council. 2017. Codes of practice for the care and handling of pullets and laying hens.
Niedersachsen, M. 2013. Empfehlungen zur Verhinderung von Federpicken und Kannibalismus zum Verzicht auf Schnabelkürzen bei Jung-und Legehennen des Niedersächsischen Ministeriums für Ernährung, Landwirtschaft und Verbraucherschutz(aktualisierte Fassung vom 30.02. 2013). URL: http://www. ml. niedersachsen. de/portal/live. php.
Novogen, 2019. Guide d'élevage des pondeuses commerciales – NOVOgen WHITE. NOVOGEN S.A.S - MAUGUERAND - LE FOEIL - BP 265 - 22800 QUINTIN – France. www.novogen-layers.com. Accessible : https://www.novoponte.fr/wp-content/uploads/2019/03/NovoWhite-Guide-Elevage.pdf
Oliveira, J., H. Xin, and H. Wu. 2019. Impact of feeder space on laying hen feeding behavior and production performance in enriched colony housing. animal 13:374-383.
Patterson, P.H. and H.S. Siegel. Impact of cage density on pullet performance and blood parameters of stress. Poult. Sci., 1998. 77: p. 32-40.
Riddle, E. R., A. B. Ali, D. L. Campbell, and J. M. Siegford. 2018. Space use by 4 strains of laying hens to perch, wing flap, dust bathe, stand and lie down. PLoS One 13:e0190532.
RSPCA, 2018. Food and water; Environment. In: welfare standards for pullets (laying hens), pp.2. URL: https://science.rspca.org.uk/sciencegroup/farmanimals/standards/pullets.
Savory, C.J., M.C. Jack, and V. Sandilands. Behavioural responses to different floor space allowances in small groups of laying hens. Br. Poult. Sci., 2006. 47, 2: p. 120-124.
Schreiter, R., K. Damme, and M. Freick. 2021. Relation between Feed Particle Size Distribution and Plumage Condition in Laying Hens on Commercial Farms. Animals 11:773.
Sirovnik, J., H. Würbel, and M. J. Toscano. 2018. Feeder space affects access to the feeder, aggression, and feed conversion in laying hens in an aviary system. Appl. Anim. Behav. Sci. 198:75-82.
Spindler, B., M. Clauss, A. Briese, and J. Hartung. [Planimetric measurement of floor space covered by pullets]. Berliner und Münchener tierärztliche Wochenschrift, 2013. 126, 3-4: p. 156-162.
Thogerson, C., P. Hester, J. Mench, R. Newberry, C. Okura, E. Pajor, P. Talaty, and J. Garner. 2009a. The effect of feeder space allocation on productivity and physiology of Hy-Line W-36 hens housed in conventional cages. Poult. Sci. 88:1793-1799.
Thogerson, C., P. Hester, J. Mench, R. Newberry, E. Pajor, and J. Garner. 2009b. The effect of feeder space allocation on behavior of Hy-Line W-36 hens housed in conventional cages. Poult. Sci. 88:1544-1552.
UEP. 2017. Animal husbandry guidelines for US egg-laying flocks. Guidelines for cage-free housing. United Egg Producers, Johns Creek, GA, USA. Available at: https ….
Voluntary initiative group for the welfare of pullets, 2021. Guide on best management practice for the welfare of pullets (meant for production of eggs for human consumption). Under the EU Platform on Animal Welfare. Reference number DOC/2021.07128 Rev1. 12 p. Accessible: https://ec.europa.eu/food/system/files/2021-06/aw_platform_plat-conc_guide-welfare-pullets_0.pdf
von Eugen, K.; Nordquist, R.E.; Zeinstra, E.; van der Staay, F.J. Stocking Density Affects Stress and Anxious Behavior in the Laying Hen Chick During Rearing. Animals 2019, 9, 53. https://doi.org/10.3390/ani9020053
Webster, A. B., and J. F. Hurnik. 1994. Synchronization of behavior among laying hens in battery cages. Appl. Anim. Behav. Sci. 40:153-165. doi 10.1016/0168-1591(94)90079-5

Widowski, T., L. Caston, T. Casey-Trott, and M. Hunniford. 2017. The effect of space allowance and cage size on laying hens housed in furnished cages, Part II: Behavior at the feeder. Poult. Sci. 96:3816-3823.

Zepp, M., H. Louton, M. Erhard, P. Schmidt, F. Helmer, and A. Schwarzer. The influence of stocking density and enrichment on the occurrence of feather pecking and aggressive pecking behavior in laying hen chicks. J. Vet. Behav., 2018. 24: p. 9-18 10.1016/j.jveb.2017.12.005.