RSPCA standards justification

Laying hens

Contents

Introduction

This document provides the rationale underpinning the setting of certain, key standards within the RSPCA Welfare Standards for Laying Hens. As such, this document provides the justification behind the setting of such standards.

Not all standards are covered within this document, as either further explanation is not required, e.g. the justification is clear within the standard itself, or the standard is based on a legal requirement. However, those standards that go above legal minimum requirements and could be set at a range of levels are generally included.

Justifications are not exhaustive, but are typically representative of the evidence base (where this exists) for that issue.

In some cases, a summary of the full standard wording has been provided. Therefore, please refer to the RSPCA Welfare Standards for Laying Hens for the full standard wording.

References to legal requirements relate to domestic legislation.

Food and Water

Food

- **Feeder space: 5cm of (actual) linear track (10cm single side) or 4cm of circular feeding space must be provided and must be accessible for each bird.**

This standard has been in place for over 20 years and was based on a combination of experience and observation at the time of developing the first set of standards for laying hens. The same requirements were introduced into European legislation (1999/74/EC, 1999) (for all alternative (non-cage) systems from 2002. Research (Sirovnik et al., 2018) suggests reduced feed space results in increased competition, reduced feed intake and increased aggressive interactions. As a minimum standard, it is thus expected that producers would review their feeding regime, including feed access where evidence on-farm suggests feed space / access is insufficient.

Water

- **Drinker space: The minimum number of drinkers which must be provided is as follows:**
    - **a) nipples, 1 per 10 hens; cups, 1 per 10 hens; circular trough space (including bells), 1.0cm per hen; linear trough space, 2.5 cm per hen;**
    - **b) never less than 2.**

These standards are in-line with legislation (1999/74/EC, 1999) and practical experience on-farm suggests drinker access is sufficient to allow birds ready access to drinking water. Hens drink at certain times, e.g. prior to egg laying, therefore the position of drinkers may be particularly important; in practice drinkers are often placed directly in front of nest boxes.

Environment

Floor and litter

- **Litter access: Birds must have access to litter within 24 hours of placement.**
- **Litter quality: Litter must be dry, friable and of a suitable particle size.**
- **Litter depth: The litter must be a minimum depth of 5cm, increasing to a minimum of 10cm by 2 months.**

The standard(s) was introduced over 20 years ago.
Good quality litter promotes bird activity and enables some important behavioural needs and priorities including dust-bathing, pecking and scratching (Rodenburg et al., 2005). Frustration and a redirection of foraging behaviour to other birds' feathers (injurious pecking) can be caused when litter access is restricted (Nicol et al., 2003) or the condition of the litter is poor (Green et al., 2000); lack of litter or poor quality litter is therefore a welfare concern. There is evidence that both particle size and litter depth plays an important role in dustbathing behaviour – considered a behavioural need (Weeks & Nicol, 2006) - with smaller particle sizes and deeper substrates resulting in more satisfactory dustbathing behaviour (Moesta et al., 2008). A greater depth of litter may also help to dilute the faecal contamination of litter, helping to maintain it in a hygienic and friable state.

Verandas

- **Verandas must be installed on all barn buildings by no later than 1st May 2030.**

This standard was introduced in 2025.

Verandas provide many benefits for bird welfare by encouraging ranging (in free-range systems), improving litter quality in the main house, providing more space, providing natural light, and providing free-range birds with a more biosecure semi-outdoor area during periods of mandatory confined housing (e.g. during Avian Influenza housing orders). These factors can have indirect positive welfare impacts on flocks, such as reducing injurious pecking.

Exposure to direct natural levels of UVB wavelengths can ensure the production of vitamin D3. This promotes absorption of calcium, which may help improve bone strength.

The RSPCA strongly encourages verandas to be installed on all free-range buildings. The RSPCA Farm Animals Department is currently undertaking an in-depth review of this. Depending on the conclusion of this review, a phase in date for the installation of verandas on all buildings may be set.

See: Veranda justification document.

Lighting

- **Light levels: A minimum illumination of 20 lux is required in the 'activity' areas of the house, including the litter and the feedtracks.**

  The minimum illumination required was increased from a minimum of 10 lux throughout the house to a minimum of 20 lux in activity areas in 2017.

  Visually mediated behaviour such as feeding and exercise are increased in brighter conditions (Boshouwers & Nicaise, 1993; Prescott & Wathes, 2002). The requirements for a minimum of 20 lux in 'activity' areas of the house, therefore encourages these behaviours in areas where they should occur, whilst allowing for lower lighting levels in areas where they are preferred, e.g. the perches for resting and preening behaviour (Davis et al., 1999). This higher light level also allows lighting to be reduced as a management tool in the event of an outbreak of injurious pecking, whilst still maintaining light levels sufficient to encourage foraging behaviours and the maintenance of good eye health.

- **Dusk periods: artificial lighting must be switched off in a stepped or gradual manner to allow the hens to prepare for darkness.**

  The standard(s) is in line with legislation.

  Dusk periods enable birds to locate appropriate roosting spots and stimulates feeding behaviour (Savory, 1980) prior to roosting, preventing hunger during the nighttime period. A short dimming period (less than 15 minutes) is shown to provide sufficient preparation time in experimental studies (March et al., 1990; Olsson & Keeling, 2000). This dimming period is not specified within the RSPCA welfare standards as different periods may be needed in different housing systems; as written, the standards require that a level of outcome assessment takes place to determine what is appropriate on a given unit.

Natural daylight

- **For barn production: natural daylight, corresponding to at least 3% of the total floor area of the house must be installed by no later than 1st May 2032 for existing buildings and in all new houses built from 1st October 2025.**
- **For free-range production: natural daylight openings must:**
  - **a) correspond to at least 3% of the total floor area of the house**
  - **b) be installed at the time of an internal refurbishment**
  - **c) be installed by no later than 1st January 2035**
  - **d) be provided via the installation of windows for buildings that undergo a structural refurbishment or are built from 1st October 2025.**
- **For flocks placed from 1st October 2025, natural daylight must be provided via all popholes within the building when birds need to be housed during the natural daylight period.**

These requirements for natural light were introduced in the 2025 version of the standards, although producers are given a phase-in period to implement this requirement. See natural daylight justification document.

There are numerous benefits to providing laying hens with natural light:

a) Vision - Laying hens have well developed vision and, like ourselves, it is their dominant sense and has evolved for use in brightly lit conditions. In particular, they have well developed colour vision, which has been determined from a variety of behavioural and physiological tests (summarised in Prescott et al., 2003). However, a high light intensity is required for this visual system to work well. The intensity of natural light is many orders of magnitude brighter than the artificially lit environments of poultry houses where the maximum lighting levels are often 20 lux. Further, natural light provides the full spectrum of light, including UV light. Therefore daylight is necessary for chickens to utilise this sense to its full potential.

b) Preference - Recent research has found that hens show a preference for UVA/UVB light compared to white light/commercial lighting (Rana et al., 2021; Wichman et al., 2021). These preferences for light change with age and with the type of behaviour being performed. Usually, behaviours which require visual acuity are performed under bright light and those such as resting and preening in dimmer light. Therefore spatial variation in light provision is also important, which can be provided within houses with windows, whereby the environment naturally becomes darker lit towards the centre of the house.

c) Behaviour - Under UVA lighting conditions laying hens have been found to perform more positive behaviours such as foraging, ground pecking and preening (Maddocks et al., 2001; Rana et al., 2021), especially under lower light intensities. Laying hens provided with supplementary UV lighting (18-72 weeks) were found to have lower stress (determined by CORT levels, bilateral asymmetry and heterophil:lymphocyte ratio) and fear levels (measured using tonic immobility and inversion) (Sobotik et al., 2020).

d) Feather damage and keel fractures - Better plumage cover was also found when natural daylight was provided (M. Bestman et al., 2019) and the absence of daylight between 7 - 17 weeks of age was a predictor of feather loss during the laying period in organic flocks (M. Bestman et al., 2009). Another study identified the absence of daylight as a risk factor for keel bone damage in organic flocks (Jung et al., 2019), this was thought to be a result of increased collisions due to poor visual perception.

e) Range use - Providing windows in the roof or walls of the shed will increase the light intensity inside the house and allow UVA wavelengths, providing hens with more external cues that may promote range use. Bestman et al (2019) reported that a larger amount of daylight inside the house was related to greater range use. In free-range laying hen flocks the range is often not well utilised, with some research reporting range use rarely exceeds 50% of the flock (Pettersson et al., 2016).The importance of promoting laying hens range use has been well studied, Nicol et al (2003) reported a nine-fold reduction in the risk of feather pecking in flocks that utilised the range on sunny days.

f) Stock-keepers - Stock-keepers have reported that they prefer working in a naturally lit environment as they can manage and inspect the birds more clearly. Many also report that natural light helps with the cleaning of the shed at the end of the flock, enabling the operator to inspect more thoroughly whether the house has been effectively cleaned and disinfected.

Space requirements and flock size

- **Stocking density: stocking density must not exceed 9 birds/m².**

  The standard(s) is in line with EU legislation.

  Limiting stocking density helps to ensure birds are able to carry out their normal behavioural repertoire and move around the shed, accessing resources such as perches, feeders, drinkers and nest boxes with minimal difficulty or competition.

  Much of the research regarding the impacts of stocking density on welfare indicators such as plumage condition and mortality - in both commercial and experimental studies – provides mixed results (Huber-Eicher & Audigé, 1999; Nicol et al., 1999, 2006; Zimmerman et al., 2006). It is not clear, therefore, whether stocking densities below the current legal maximum would benefit animal welfare. It is suggested that management may be more important to welfare than lower stocking densities (Nicol et al., 2006). However, this may also be influenced by requirements for different resources, such as environmental enrichment provisions and raised perches, where a lower stocking density allows for greater provision without crowding. A reduced stocking rate can also help to reduce disturbance of key behaviours such as resting and dustbathing and to better enable escape behaviours.

  More recent research shows that providing the birds with additional space, i.e. placing 5, 6 or 7 birds per square metre compared with 10 birds, has been shown to improve many environmental parameters of welfare importance, including litter and air quality (ammonia and carbon dioxide) in the house and a number of production parameters (Kang et al., 2016).

  The RSPCA currently permits a maximum stocking density of 9 birds per square metre but will continue to review this in light of new evidence.

- **Flock and colony size: the maximum flock size for barn hens is 32,000 birds and 16,000 for free-range. In both systems, flocks over 6,000 birds must be split into colonies of not more than 4,000 birds.**

  The standard(s) was introduced over 20 years ago.

  Maintaining smaller colony sizes within a flock helps to ensure even access to resources, such as feeders, drinkers, nest boxes and perches and prevents crowding in areas of the shed. Flock inspections should be facilitated by smaller colony sizes as birds are contained within a smaller area and sick or ailing hens are less likely to be missed by the stock keeper.

  Limiting flock size reduces the impact of any disease incursion in terms of bird numbers affected and research shows that greater flock sizes (>30,000) are more at risk of Salmonella infection. In the case of free-range flocks, limiting the flock size helps to ensure good access to a suitable range, for example by ensuring that the range is within a suitable distance from popholes.

Air quality and thermal environment

- **Aerial contaminants: Aerial contaminants must not reach a level at which they are noticeably unpleasant to a human observer.**
- **Thermal comfort: Hens must have access to a thermally comfortable environment at all times.**

Exposure to dust, gases and airborne pathogens present in laying hen housing can have negative impacts on the health and wellbeing of the hens. Temperature and humidity have direct influences on birds' welfare but also affect levels of aerial contaminants, so it is important that both are monitored and controlled.

Chronic exposure to raised levels of atmospheric ammonia has been shown to reduce levels of certain behaviour including feeding, preening and resting (Kristensen et al., 2000), cause damage to eyes and respiratory tracts, increase susceptibility to disease and secondary infection and increase the risk of keratoconjunctivitis (blind eye) (David et al., 2015; Kristensen & Wathes, 2000). The current chronic exposure limit of ammonia for human health and safety of 25ppm is cited by Defra as a maximum level for poultry (Defra, 1994), although hen preference tests suggest that lower levels are aversive to hens (Kristensen et al., 2000).

The RSPCA therefore recommends that levels are kept below 20ppm.

The human chronic exposure limit for CO2 of 3000ppm is a requirement for broilers in the EU Directive for chickens kept for meat production (EC/2007/, 2007) and is the level recommended in the RSPCA welfare standards for hens. No requirements are provided in the EU legislation for laying hens.

Dust may compromise the health and welfare of hens (David et al., 2015). The RSPCA provides recommendation that inhalable dust levels are below 10mg/m3.

Nest boxes

- **Nest box provision: Hens must be provided with enclosed, draft free nest boxes at a rate of 1 per 5 hens if individual boxes, or 1m2 of nesting substrate per 120 hens for group nesting.**

Hens are highly motivated to lay their eggs in a private, secluded nesting location (Cooper & Appleby, 2003). At least one nest for every seven hens, or at least 1m² of nest space for a maximum of 120 hens for group nesting, must be provided under the EU Directive; the RSPCA goes beyond this in the case of individual nest boxes, where competition may be greater than for group nest boxes.

- **Nest box lighting: Nest box lighting must be limited to the morning and initial nest box training; and may be used only temporarily as a management tool.**

The use of nest box lighting has been associated with both vent pecking and feather pecking (Green et al., 2000) and thus, whilst the standards limit the use of nest box lighting, it is recommended that they are not used at all where possible.

Perches

- **Perch provision: At least 8cm raised perch must be provided per hen, with 15cm per hen recommended.**

  The standard was introduced in 2017.

  Provision of perches for daytime use allows resting birds and subordinate birds to separate themselves from active or aggressive birds, respectively. Provision of perches for daytime use can therefore help to reduce feather loss from injurious pecking. During the day, only a proportion of birds will utilise the perches. The minimum 8cm requirement in existing flat deck systems aims to provide sufficient perching space for the number of birds choosing to perch at any one time during the day. At night, hens are motivated to seek high roosting spots and will do so when given the opportunity. To allow all birds to roost at night, a minimum of 15cm raised perch provision per bird is necessary. Birds provided with this level of provision have been shown to have reduced stress, reduced fearfulness and improved body condition. Therefore, to ensure maximum welfare benefit to the birds, the RSPCA strongly recommends that a minimum of 15cm is provided wherever possible. However, it is recognised that it may be challenging to retro-fit 15cm of well-positioned raised perch space (see below) per bird in some existing systems.

- **Perch positions: Raised perches (retro-fitted after 10th August 2017) must:**
  - **a) be at least 30cm apart from each other in all directions**
  - **b) have no more than 80cm distance between the perch and the next available landing surface/approach aid**
  - **c) have a vertical distance of at least 45cm and not more than 60cm from the slats to the first perch**
  - **d) be positioned no more than 45 degrees to adjacent perches (measured at the horizontal plane)**
  - **e) have at least 45cm clear space above the perch to allow birds to stand in a normal upright position**
  - **f) not be sited directly above one another, i.e. in a vertical plane (ladder formation), unless intermediate perches are provided to allow birds free access**
  - **g) be fixed and not free swinging.**

  This standard was introduced in 2017.

  The design and placement of perches is very important in helping to reduce the risk of keel bone damage.

  The distance between perches/the landing surface/approach aid of between 30-80cm (a & b): the ability of hens to navigate perches is negatively affected by increasing the distance between them (Moinard et al., 2004; Scholz et al., 2014; Scott & Parker, 1994); distances greater than 80cm are associated with increased clumsy landings, misses and refusals to jump (Scholz et al., 2014). Clumsy landings are thought to increase risk of keel bone damage. Legislation requires that perches are at least 30cm apart (1999/74/EC, 1999).

  Minimum distance of 45cm from the first slat (c): this standard represents a balance between meeting the birds' preference for high resting places (Brendler & Schrader, 2016; Schrader & Müller, 2009; Struelens & Tuyttens, 2009), the need to separate resting birds from the rest of the flock (to prevent pecking) (SRUC, 2007) and the birds' ability to access / dismount perches with ease (EFSA, 2015). Poor landings are shown to increase when the vertical distance a hen has to travel between perches is greater than 50cm (Cooper & Appleby, 2003) and both the incidence and severity of keel fractures can increase with increased perch height (Wilkins et al., 2011). EFSA's Panel on Animal

Health and Welfare recommends a minimum perch height of 60cm (Schrader & Müller, 2009), although they suggest that 'small sized steps' of around 40cm will help to make the perches more accessible. SRUC (2007) recommends the vertical height of the first perch is 45-60cm from the surface to which it is secured with perches spaced adequately apart. Perches should be designed to allow birds to perch high enough that birds below cannot peck at them (Brendler & Schrader, 2016).

Angles between perches of less than 45 degrees (d): this helps prevent poor landings and is particularly important for downward jumps (Brendler & Schrader, 2016; Scholz et al., 2014). Several studies and reports (Brendler & Schrader, 2016; Schrader & Müller, 2009; Scott et al., 1997; Scott & Parker, 1994) recommend angles of less than 45 degrees between perches, with the proportion of successful jumps increasing as the angle is reduced (EFSA, 2015; Green et al., 2000).

No ladder formation perches (f): ladder formations (where perches are positioned directly above one another) are difficult for hens to navigate and may increase the risk of poor landings.

Fixed perches (g): free swinging perches may be more difficult to land on and increase the risk of poor landings or falls. Some movement (i.e. where perches are not rigidly fixed) may help to reduce the impact of landings.

Multi-tier

- **Stocking density: The maximum stocking density must not:**
    - **a) not exceed 9 birds/m² usable area;**
    - **b) when calculated at floor level, not exceed 15 birds/m².**

The maximum stocking density (SD) remains 9 birds/m² of usable area in multi-tier systems, as per flat deck systems, however, there is an additional requirement that the SD at floor level is limited to 15 birds/m². This ensures a good balance between the levels of slatted area and litter area provided to each bird and ensures a good number of birds can access the litter at any one time.

By limiting the stocking density on the litter, we prevent overcrowding at certain times of day when hens are most motivated to use the litter. Dustbathing for example has been shown to peak in the late morning and mid afternoon and varies between flocks; crowding on the litter may occur at this time and is a risk factor for piling (Campbell et al., 2016b). More hens have also been observed in the open litter area during the afternoon than at other times of day (Campbell et al., 2016a).

- **Tier heights: Tier heights must not exceed 2m, unless a) a walkway is incorporated enabling a stock person to walk unhindered along the full length of the tier to inspect the birds, and b) intermediate tiers allow hens access to the floor without descending directly from a tier greater than 2m.**

The standard was amended in 2017 to allow higher tiers with walkways.

Tier heights are limited to 2m to ensure birds can be properly inspected and reached in the case of birds requiring further attention, to ensure catching can be carried out safely, and to limit the height from which birds can descend to the floor with the aim of minimising subsequent injury. In 2017 a new standard was introduced to allow tiers higher than 2m but with the proviso that

a) a stock-keeper walkway is included in the design of the system, enabling full access to birds anywhere in the system and
b) that birds cannot directly descend to the floor from this level.

This is also the maximum number of levels that can be provided directly above one another in rearing systems.

- **Number of tiers: The maximum number of tiers directly above one another must not exceed 2.**

In order to achieve a maximum tier height of 2m, with sufficient head height within and underneath the system and perches allowing hens to stand in a normal upright position a maximum of 2 tiers becomes ideal. It may be possible to design a system within these requirements with an additional tier, however it may result in crowding and hindrance of movement through the system. Crowding can result in injury (hens being pushed from the system / perches), injurious pecking and discomfort.

Environmental enrichment

- **Enrichment provision: For every 1,000 birds there must be at least 2 items of environmental enrichment in the house, which must:**
    - **a) be permanently available to the birds;**
    - **b) include some destructible forms of enrichment.**

The standard was strengthened in 2017 to require destructible forms of enrichment. The inclusion of environmental enrichment has been shown to improve hen health and welfare by encouraging activity and decreasing the risk of injurious feather pecking (Featherwel, 2013). A variety of sufficient items, which are safe for bird use, should be appropriately placed throughout the unit to promote activity and interest and provide all birds with an opportunity to explore them. Examples of environmental enrichment include hanging knotted rope/string, pecking blocks, vegetables and plastic bottles with coloured water, straw bales and plastic-wrapped bales of shavings. Supplying a variety of such items and regularly changing them is strongly recommended to help maintain interest. The provision of manipulable or destructible enrichment has been shown to be particularly beneficial in helping minimising injurious feather pecking (Daigle et al., 2014). Breeze blocks are not advisable for pecking due to the nature of the ingredients, but blocks made with feed may be used. Rope/string can be suspended or attached to posts at hen head height and it is recommended to knot it near each end to prevent the entire rope from fraying. Providing safe refuges, resting areas and visual barriers can help further. This can be in the form of perches, straw bales and areas of varied heights.

Acceptable forms of destructible pecking enrichment include: whole small straw bales added to the litter area; suspended haynets filled with: straw, hay, alfalfa blocks, egg trays or other suitable material; pecking blocks; brassicas; knotted rope/string. Adding straw or hay bales to the littered area can provide several benefits in addition to providing foraging opportunities (Campbell et al., 2016a) such as helping to improve litter quality, providing refuge areas, encouraging comfort behaviours and aiding access to popholes.

The range

Management

- **Range management: A range management plan must be in place and reviewed annually. The range area must be actively managed in order to encourage birds outside, away from the popholes and to use the area fully. Poached/muddy/worn areas and any build up of parasites or disease must be managed and prevented.**

  An outdoor range area can add a greater level of complexity to the birds' environment (Knierim, 2006) encouraging natural behaviours, such as foraging and dust-bathing (Gilani et al., 2014). Range provides hens with additional space for activity and movement; exercise has been shown to increase bone strength (N⌀rgaard-Nielsen, 1990; Whitehead, 2004). In addition access to range provides hens with natural light. However, these benefits can only be realised if the range is well managed.

  The range needs to be actively managed to encourage birds to go on to and to make full use of the outdoor area (Featherwel, 2013)(see Shelter, Shade and Natural Cover), and to minimise any health and welfare problems, such as disease and predation. Due consideration should be given to how the shape of the range could affect how evenly the hens use the total range area. More even use of the range will help to spread the manure burden and thus the risk of parasites and infection. Full use of the range also helps to prevent overuse of areas, which may become less attractive to hens.

  Having well-drained areas outside of the popholes is important to help maintain litter quality indoors; litter quality within the house can be affected during wet weather, for example, but this can be managed (Daigle et al., 2014).

Popholes

- **Access to the range: Where birds are intended to be kept for free-range purposes, they must be given access to the range:**
  - **a) within 3 weeks of entering the house at the latest;**
  - **b) in any case from 21 weeks of age at the latest. Popholes must be opened no later than 9am (or no later than 12pm for birds aged under 21 weeks).**

  In order to market eggs as free-range, except during severe weather, hens must have continuous daytime access to the range and the maximum stocking density must not be greater than 2,500 hens per hectare of ground available to the birds or one hen per 4m² at all times (EC589/, 2008). The RSPCA further specifies that birds must have access within three weeks of arriving in the laying shed, and never later than 21 weeks of age. Hens are typically transferred to the laying shed between 15-18 weeks of age. Research suggests the younger birds are when they first have access to the range, the better they will use the range once given access (Janczak & Riber, 2015).

- **Pophole design: For flocks of over 1,200 birds each pophole must be at least 45cm high and 2m wide and must be evenly distributed along the line of access to ensure that all hens have ready access to the range.**

  The range must be readily accessed for birds to make good use of it (for benefits see 'Range management'). Wide popholes, evenly spaced along the length of the shed help to maximise their use. Continuous daytime access complies with legislation for the marketing of free-range eggs, but is also necessary to ensure the range is accessible in a consistent manner; birds with experience of accessing a resources such as the range would experience frustration if this opportunity were taken away.

Natural cover and range enrichment

- **Natural cover: Canopy forming trees, shrubs or other plants must be present on a minimum of 5% of the range increasing to 20% by 1st May 2027.**

  The standards were introduced in 2013 and revised in 2025.

  Research and experience shows that natural cover, particularly trees, can help encourage birds to use the range (Nicol et al., 2003), which in turn can help in range quality management. Use of the range is associated with a reduced risk of injurious pecking (Green et al., 2000) and reduced feather damage at 50+ weeks (M. W. P. Bestman & Wagenaar, 2003). Hens prefer to stay close to structures providing shelter and shade (Nagle & Glatz, 2012; Zeltner & Hirt, 2008) and canopy cover from trees, planted at a rate of 5%, has been shown to help reduce plumage damage (Bright et al., 2011). Natural cover may include trees, shrubs and semi-permanent vegetation that can easily be established and removed, such as artichoke and kale to enable those with mobile sheds and those on rented land to comply with the standards where they have additional restrictions in place.

  The standard has been increased to 20% natural cover by 2027. Following positive feedback from many producers and retailers in providing more natural cover on the range this has been increased. Research shows a correlation between canopy cover and reduced feather pecking (Bright et al., 2011) and improved egg quality with increased canopy cover on the range (Bright & Joret, 2012).

  https://www.woodlandtrust.org.uk/media/1792/role-of-trees-in-poultry-farming.pdf
  https://www.woodlandtrust.org.uk/media/1796/tree-planting-for-poultry.pdf"

- **Range enrichment: facilities to allow dustbathing, foraging and / or perching must be provided on the range in at least 2 areas and at a rate of 1 area per 2000 birds.**

  Free range hens use the range more when the outdoor environment is enriched and enrichments can encourage birds to make use of the whole range area when they are well placed throughout the range. The use of forage sources (including hay bales) were the most successful method on-farm to attract birds into the range followed by shelterbelts and artificial shade (Zeltner & Hirt, 2008)**.**

Management

Inspection

- **Inspection routines: all hens must be inspected at least 3 times per day with work practices and routines designed to ensure hens do not become fearful, i.e. slow and deliberate movements throughout the house.**

Regular and competent inspections of hens better ensures any welfare concerns are rapidly addressed, preventing the escalation of welfare problems whilst also habituating birds to human presence (Barnett et al., 1994; Featherwel, 2013). EU legislation requires hens be inspected at least once a day when they are kept in systems “in which their welfare depends on frequent human attention” (98/58/EC, 1998) but evidence and experience suggests that more frequent inspections are beneficial, with more regular human contact shown to reduce fear and improve production (Barnett et al., 1994; Bryan Jones & Waddington, 1992) which is why the RSPCA requires a minimum of 3 flock inspections per day. Defra recently updated its Code to recommend: “Ideally, there should be three inspections spread out across the day”.

The quality of the inspection is as important as the frequency. Inappropriate interactions such as rough, unpredictable or aversive handling and movement in the shed can lead to increased fear within the flock (Waiblinger et al., 2006). Fearfulness is associated with an increase in severe feather pecking (de Haas et al., 2014; Uitdehaag et al., 2009). Inspections should therefore be calm and deliberate.

Pullets

- **Pullet sourcing: All pullets for an RSPCA Assured laying hen unit must have been reared on an RSPCA Approved rearing unit, with those destined for multi-tier systems, rearing in multi-tier rearing units.**

Conditions at rearing can impact the welfare of the hens both while they are pullets and later as adults during the laying stage (Janczak & Riber, 2015). For example, birds provided with litter during rearing are less likely to feather peck as adults.

Ensuring that the rearing and laying environments match each other as much as possible can reduce stress during the transition to the laying system and can prepare hens for the conditions they will experience during lay. Increased environmental complexity during the rearing period, for example as required by the RSPCA welfare standards for pullets, can reduce the fearfulness of adult laying hens (Brantsæter et al., 2016).

Hens that are to be kept in multi-tier systems during lay must learn how to navigate a complex three dimensional system during the rearing phase (Colson et al., 2005). Poor landings may be more prevalent in adult hens reared without perches and raised platforms than in those provided with perches from an early age. Multi-tier-reared hens use aviary platforms and fly and jump more often as adults than floor-reared hens. RSPCA standards therefore require that hens destined for multi-tier systems have been reared in similar systems and in accordance with RSPCA pullet standards.

See separate Standards Justification Document for Pullets for further information.

Health

Health and welfare monitoring

- **Feather cover: Producers must assess flock feather loss on a monthly basis using the AssureWel protocol, and take remedial action where given thresholds are exceeded.**

The standards were introduced in August 2017.

Feather loss from injurious pecking is a significant and widespread concern. There is a wealth of research demonstrating that a range of management interventions can help to successfully manage or reduce feather loss in a flock. Including a greater range of management interventions is shown to have a more beneficial impact on reducing feather loss.
The standards therefore aim to:

a) create awareness of the issue within a given flock, providing objective data via the use of a standardised protocol and
b) encourage a wide range of interventions to be in place in a flock where an issue is seen.

Mutilations

- **Beak trimming:**

Beak trimming is against the principles of the RSPCA welfare standards. However, it is acknowledged that, at the current time, prohibiting beak trimming could result in a negative impact on welfare in some flocks. Where beak trimming is practised, it must be done so using the most humane method available, which currently includes only infrared beak treatment (IRBT). Research by McKeegan and Philbey (2012) concluded that IRBT does not have chronic adverse neurophysiological consequences unlike hot blade beak trimming, which is no longer permitted in England and Wales.

However, IRBT is still associated with evidence of acute pain and behavioural changes (such as reduced feeding) following the procedure (Janczak & Riber, 2015). We are also concerned that beak trimming deals only with the outcome (damage / feather loss from injurious pecking) rather than dealing with the underlying causes of injurious pecking. Injurious pecking is an abnormal behaviour and we should therefore be seeking to prevent its development rather than simply masking it with a mutilation (as defined by The Mutilations (Permitted Procedures) (England) Regulation 2010).

The RSPCA will therefore continue to work towards a phase-out of beak trimming and will work closely with the industry to help achieve this goal; including giving due consideration to all relevant research and practical aspects of laying hen and pullet rearing, nutrition and breeding that may impact on the issue.

In order to achieve a position where a ban on beak trimming could be implemented without a disproportionate risk to welfare, the underlying problem of injurious pecking will need to be effectively tackled. For this reason, producers placing beak trimmed flocks are required to implement a range of interventions, in addition to the existing management and enrichment standards, to help prevent injurious pecking behaviour.
The RSPCA will continue to monitor levels of feather loss resulting from injurious pecking at a scheme level to assess progress.

Further information on the McKeegan and Philbey study:
The research was funded by Defra in 2008/9 to establish whether IRBT had an impact on the neurophysiology and structure of beaks in treated birds. There were a number of findings to support their conclusion that IRBT does not have chronic adverse neurophysiological consequences, including:

- evidence of regeneration of all nerve types within the beaks at 4 weeks
- no difference in the pain thresholds of these nerves in intact and trimmed birds
- there was no evidence of neuroma formation (abnormal nerve growth), nor of any spontaneous nerve firing (associated with increased pain sensitivity & pain-responses to non-noxious stimuli)
- normal healing of the beak tip

They did however note that there was a trend for a beak step, whereby the lower beak is longer than the upper beak. It is unclear what effect a beak step has on beak function and behaviour, although one 2010 study found that IR birds fed more efficiently than birds whose beaks had been trimmed using a hot blade (there was no control group in this study).

The authors paper also note that their results include only measurements from 4 weeks of age (other than beak measurements) due to difficulties in measuring their other parameters in younger chicks. It is probably most accurate to say there is no evidence of chronic pain in birds whose beaks were infra-red treated at day old, rather than during the procedure itself.

Slaughter / killing

Shackling

- **Shackling: shackling is only permitted where birds are killed on the farm on which they were reared, are not subject to transport and shackling is the only commercially viable means. Where shackling is used, birds must be suspended for no more than 30 seconds and by both legs.**

Shackling a bird causes discomfort and is likely to be very painful (Gentle & Tilston, 2000) so it is important to reduce the shackling period to a minimum. However, for an effective stun, it is considered necessary for the bird to be shackled for a short period to allow it time to relax and reduce wing flapping. Therefore, live birds should not be suspended for more time than is necessary for wing flapping to cease, which has been shown to be around 15 seconds on average (Gregory & Bell, 1987; M. Raj, 1998). Thus, 30 seconds is considered ample time for this to be achieved.

Gas killing

- **Gas killing: birds are required to be killed using controlled atmosphere killing methods, other than in exceptional circumstances.**

The RSPCA welfare standards for: meat chickens; laying hens; and turkeys, have been revised to permit the use of carbon dioxide only (in two phases) gas killing systems. This followed a review of the literature relating to carbon dioxide gas killing and observations of these gas killing systems.

The following outlines the justification behind the key gas killing standards introduced in 2017.

Carbon dioxide only gas killing

Standard:
Carbon dioxide (delivered in two phases) which does not exceed:

i. an *average* maximum concentration of 30%, and

ii. a maximum concentration of 33%, until birds have lost consciousness (Phase 1).

Date standard introduced: Meat chickens – July 2017; Laying hens – August 2017; Turkeys – September 2017

Rationale:
Carbon dioxide is aversive to poultry and has been described as an acidic gas – pungent to inhale at high concentrations and a potent respiratory stimulant – which can cause birds to experience unpleasant sensations (EFSA, 2004; FAWC, 2009; McKeegan et al., 2006; Raj & Tserveni-Gousi, 2000). The degree of aversion to carbon dioxide increases as the concentration rises (McKeegan et al., 2006), with research suggesting that birds start to detect its presence at around 7% (Raj & Gregory, 1991) and aversion being seen in some individuals at 25% (McKeegan et al., 2006). Concentrations of carbon dioxide above 40% are considered to be particularly aversive (EFSA, 2004; FAWC, 2009; McKeegan et al., 2006). However, it has also been suggested that concentrations above 30% are aversive (EFSA, 2004; HSA, 2005). The 2004 European Food Safety Authority opinion on *the welfare aspects of the main systems of stunning and killing the main commercial species of*

animals suggested that discomfort may appear at concentrations of around 25% in chickens and 30% in turkeys. Using carbon dioxide at concentrations of 30% to induce unconsciousness has been recommended by some researchers (Raj & Tserveni-Gousi, 2000) and it has been suggested that using this concentration minimises the gases pungency (Raj et al., 1992).

Prior to the introduction of this standard in 2017, the RSPCA welfare standards for laying hens; meat chickens; and turkeys already permitted exposure of birds to 30% carbon dioxide mixed with inert gases. Research that looked at varying levels of carbon dioxide in air and in nitrogen, suggested that as the behaviours observed were similar (i.e. headshaking rose monotonically and respiratory disruption observed at all concentrations) in both gas mixtures, it is the carbon dioxide causing the response rather than the carrier gas (McKeegan et al., 2006). Further, results from a study by Gerritzen *et al.* (2004) showed that headshaking began at the same carbon dioxide concentration in all the gas mixtures they tested, and therefore suggested it was likely that headshaking is a reaction to increasing carbon dioxide levels. As such, it is reasonable to expect similar behavioural responses to carbon dioxide whether delivered in inert gases or in air, and therefore maintaining a 30% maximum limit in the standards was considered appropriate.

Therefore, the RSPCA welfare standards permit an average maximum concentration of 30% carbon dioxide. However, due to the nature of gas injection systems, it is acknowledged that there will be some variability in the concentration of carbon dioxide within the system. Therefore, a 10% tolerance on this concentration has been applied, i.e. permitting a maximum concentration of 33% carbon dioxide.

Following loss of consciousness by exposure to carbon dioxide gas only, it is a legal requirement to expose poultry to a concentration of carbon dioxide above 40% until death, which is classified as *Phase 2* (EC, 2009).

Gradually increasing carbon dioxide concentrations

Standard:
For processors choosing to use carbon dioxide gas only, new systems installed from 1st January 2018 must be designed and operated to expose birds to a gradually increasing concentration of carbon dioxide until the birds have lost consciousness.

Date standard introduced: Meat chickens – July 2017; Laying hens – August 2017; Turkeys – September 2017

Rationale:
Research suggests that exposure to a gradually increasing concentration of carbon dioxide will result in a smoother transition to unconsciousness and avoid the negative effects of high concentrations of carbon dioxide whilst birds are conscious (Gerritzen et al., 2007; Gerritzen et al., 2004). This is supported by direct observation of different gas killing systems. However, systems that expose birds to a maximum concentration of 30% carbon dioxide on induction until loss of consciousness may be considered acceptable (see rationale for '*Carbon dioxide only gas killing*'), but a gradual increase starting from a low level is preferred. Therefore this standard takes a practical approach to ensure that going forwards any new systems installed gradually increase concentrations of carbon dioxide.

Monitoring birds within the gas killing system

Standard:
There must be a means of clearly visually monitoring in real time the birds throughout the gas killing process, i.e. from start/point of entry to finish/exit.

Date standard introduced: Meat chickens – July 2017; Laying hens – August 2017; Turkeys – September 2017

Rationale:
The *Welfare of Animals at the Time of Killing (England) Regulations 2015* require a means of visually monitoring poultry in the gas stunner. From a practical perspective, it is important to be able to check that induction to unconsciousness is calm and to assess when birds lose consciousness. This is particularly important for systems using carbon dioxide only (in two phases), as it is a legal requirement for conscious birds not to be exposed to concentrations above 40%.

For tunnel systems, the installation of appropriately positioned windows at regular intervals along the entire length of the system can be sufficient to satisfy this standard, provided that the effect of the gas on birds can be clearly seen. Ideally, cameras should be installed, either to follow the birds through the system or at critical monitoring points. Where windows are used to monitor birds it may be necessary for them to be cleaned regularly to ensure visibility of the birds is maintained and thus the requirement is met at all times.

Calm induction to unconsciousness

Standard:
The induction to unconsciousness must be calm, i.e. birds must not show any avoidable signs of fear or excitement, such as wing flapping or escape behaviour.

Date standard introduced: Meat chickens – July 2017; Laying hens – August 2017; Turkeys – September 2017

Rationale:
Gas killing offers a number of potential welfare benefits over conventional water bath systems, including avoiding inversion and the shackling of conscious birds, and the elimination of problems associated with electrical stunning, such as pre-stun electrical shocks and ineffective stunning (EFSA, 2004; FAWC, 2009; HSA, 2005). To maintain this welfare advantage it is important that the induction to unconsciousness is calm. This has been highlighted by the UK's Farm Animal Welfare Council who suggested that as gas killing systems do not render birds immediately unconscious, induction to insensibility (i.e. unconsciousness) without avoidable pain or distress was a key requirement (FAWC, 2009).

During exposure to carbon dioxide poultry exhibit a number of behaviours; it is not clear and opinions vary on how to interpret some of these behaviours and this makes it challenging to understand the welfare impact from observation of these behaviours alone. Such behaviours include head shaking (Gerritzen et al., 2007; McKeegan et al., 2006; Sandilands et al., 2011) and deep breathing and gasping (Gerritzen et al., 2007). However, bird welfare is likely to be improved when these behaviours are performed less frequently. Generally, the presence of such behaviours can be considered of lower welfare concern compared to, for example, escape behaviours and conscious wing flapping, which should not be observed as they are indicative of poor welfare. The Welfare Ranking developed by Grandin (2013) rated gasping with continuous wing flapping from the time birds enter the gas until loss of posture as not acceptable, and where all birds flap continuously or attempt to climb out of the container from entering the gas until loss of posture as a serious problem.

References

98/58/EC. (1998). *COUNCIL DIRECTIVE 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes*. European Directive. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31998L0058&from=EN

1999/74/EC. (1999). *COUNCIL DIRECTIVE 1999/74/EC Laying down minimum standards for the protection of laying hens*.

Barnett, J. L., Hemsworth, P. H., Hennessy, D. P., McCallum, T. H., & Newman, E. A. (1994). The effects of modifying the amount of human contact on behavioural, physiological and production responses of laying hens. *Applied Animal Behaviour Science*, *41*(1), 87–100. https://doi.org/10.1016/0168-1591(94)90054-X

Bestman, M., Koene, P., & Wagenaar, J.-P. (2009). Influence of farm factors on the occurrence of feather pecking in organic reared hens and their predictability for feather pecking in the laying period. *Applied Animal Behaviour Science*, *121*(2), 120–125. https://doi.org/10.1016/j.applanim.2009.09.007

Bestman, M., Verwer, C., van Niekerk, T., Leenstra, F., Reuvekamp, B., Amsler-Kepalaite, Z., & Maurer, V. (2019). Factors related to free-range use in commercial laying hens. *Applied Animal Behaviour Science*, *214*, 57–63. https://doi.org/10.1016/j.applanim.2019.02.015

Bestman, M. W. P., & Wagenaar, J. P. (2003). Farm level factors associated with feather pecking in organic laying hens. *Livestock Production Science*, *80*(1), 133–140. https://doi.org/10.1016/S0301-6226(02)00314-7

Boshouwers, F. M., & Nicaise, E. (1993). Artificial light sources and their influence on physical activity and energy expenditure of laying hens. *British Poultry Science*, *34*(1), 11–19. https://doi.org/10.1080/00071669308417558

Brantsæter, M., Nordgreen, J., Rodenburg, T. B., Tahamtani, F. M., Popova, A., & Janczak, A. M. (2016). Exposure to Increased Environmental Complexity during Rearing Reduces Fearfulness and Increases Use of Three-Dimensional Space in Laying Hens (Gallus gallus domesticus). *Frontiers in Veterinary Science*, *3*. https://doi.org/10.3389/fvets.2016.00014

Brendler, C., & Schrader, L. (2016). Perch use by laying hens in aviary systems. *Applied Animal Behaviour Science*, *182*, 9–14. https://doi.org/10.1016/j.applanim.2016.06.002

Bright, A., Brass, D., Clachan, J., Drake, K. A., & Joret, A. D. (2011). Canopy cover is correlated with reduced injurious feather pecking in commercial flocks of free-range laying hens. *Animal Welfare* , *20*(3), 329–338. https://doi.org/10.1017/S096272860000289X

Bright, A., & Joret, A. D. (2012). Laying hens go undercover to improve production. *The Veterinary Record*, *170*(9), 228. https://doi.org/10.1136/vr.100503

Bryan Jones, R., & Waddington, D. (1992). Modification of fear in domestic chicks, Gallus gallus domesticus, via regular handling and early environmental enrichment. *Animal Behaviour*, *43*(6), 1021–1033. https://doi.org/10.1016/S0003-3472(06)80015-1

Campbell, D. L. M., Makagon, M. M., Swanson, J. C., & Siegford, J. M. (2016a). Laying hen movement in a commercial aviary: Enclosure to floor and back again. *Poultry Science*, *95*(1), 176–187. https://doi.org/10.3382/ps/pev186

Campbell, D. L. M., Makagon, M. M., Swanson, J. C., & Siegford, J. M. (2016b). Litter use by laying hens in a commercial aviary: dust bathing and piling. *Poultry Science*, *95*(1), 164–175. https://doi.org/10.3382/ps/pev183

Colson, S., Arnould, C., Huonnic, D., Michel, V., & Others. (2005). Influence of two rearing systems for pullets, rearing aviaries and furnished floor, on space use and production in laying aviaries. *Animal Science Papers and Reports / Polish Academy of Sciences Institute of Genetics and Animal Breeding, Jastrzebiec*, *23*(Suppl. 1), 85–93. https://www.cabdirect.org/cabdirect/abstract/20053166203

Cooper, J. J., & Appleby, M. C. (2003). The Value of Environmental Resources to Domestic Hens: A Comparison of the Work-Rate for Food and for Nests as a Function of Time. *Animal Welfare* , *12*(1), 39–52. https://doi.org/10.1017/S0962728600025367

Daigle, C. L., Rodenburg, T. B., Bolhuis, J. E., Swanson, J. C., & Siegford, J. M. (2014). Use of dynamic and rewarding environmental enrichment to alleviate feather pecking in non-cage laying hens. *Applied Animal Behaviour Science*, *161*, 75–85. https://doi.org/10.1016/j.applanim.2014.10.001

David, B., Mejdell, C., Michel, V., Lund, V., & Moe, R. O. (2015). Air Quality in Alternative Housing Systems may have an Impact on Laying Hen Welfare. Part II—Ammonia. *Animals*, *5*(3), 886–896. https://doi.org/10.3390/ani5030389

Davis, N. J., Prescott, N. B., Savory, C. J., & Wathes, C. M. (1999). Preferences of Growing Fowls for Different Light Intensities in Relation to Age, Strain and Behaviour. *Animal Welfare* , *8*(3), 193–203. https://doi.org/10.1017/S0962728600021709

DEFRA. (1994). *Poultry litter management*. Poultry Passport. http://www.poultrypassport.org/wp-content/uploads/2013/07/DEFRA-Poultry-Litter-Management-PB1739.pdf

de Haas, E. N., Bolhuis, J. E., de Jong, I. C., Kemp, B., Janczak, A. M., & Rodenburg, T. B. (2014). Predicting feather damage in laying hens during the laying period. Is it the past or is it the present? *Applied Animal Behaviour Science*, *160*, 75–85. https://doi.org/10.1016/j.applanim.2014.08.009

EC. (2009). *COUNCIL REGULATION (EC) No 1099/2009 on the protection of animals at the time of killing*.

EC589/. (2008). *COMMISSION REGULATION (EC) No 589/2008 of 23 June 2008 laying down detailed rules for implementing Council Regulation (EC) No 1234/2007 as regards marketing standards for eggs*. European Regulations. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:163:0006:0023:EN:PDF

EC/2007/. (2007). *Council Directive EC/2007/43*. European Directives. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32007L0043&from=EN

EFSA. (2004). Opinion of the Scientific Panel on Animal Health and Welfare on a request from the Commission related to welfare aspects of the main systems of stunning and killing the main commercial species of animals. *The EFSA Journal*. https://doi.org/ https://doi.org/10.2903/j.efsa.2004.45

EFSA. (2015). *Scientific Opinion on welfare aspects of the use of perches for laying hens*. https://www.efsa.europa.eu/en/efsajournal/pub/4131

FAWC. (2009). *Report on the Welfare of Farmed Animals at Slaughter or Killing: Part 2: White Meat Animals*. https://assets.publishing.service.gov.uk/media/5a7ee1fced915d74e33f3030/FAWC_report_on_the_welfare_of_farmed_animals_at_slaughter_or_killing_part_two_white_meat_species.pdf

Featherwel. (2013). *Improving Feather Cover: A guide to reducing the risk of injurious pecking occurring in non-cage laying hens*. Featherwel. https://www.featherwel.org/featherwel/Portals/3/Documents/advice_guide_V1.2-May-2013.pdf

Gentle, M. J., & Tilston, V. L. (2000). Nociceptors in the Legs of Poultry: Implications for Potential Pain in Pre-Slaughter Shackling. *Animal Welfare* , *9*(3), 227–236. https://doi.org/10.1017/S0962728600022715

Gerritzen, M. A., Lambooij, B., Reimert, H., Stegeman, A., & Spruijt, B. (2004). On-farm euthanasia of broiler chickens: effects of different gas mixtures on behavior and brain activity. *Poultry Science*, *83*(8), 1294–1301. https://doi.org/10.1093/ps/83.8.1294

Gerritzen, M., Lambooij, B., Reimert, H., Stegeman, A., & Spruijt, B. (2007). A note on behaviour of poultry exposed to increasing carbon dioxide concentrations. *Applied Animal Behaviour Science*, *108*(1), 179–185. https://doi.org/10.1016/j.applanim.2006.11.014

Gilani, A.-M., Knowles, T. G., & Nicol, C. J. (2014). Factors affecting ranging behaviour in young and adult laying hens. *British Poultry Science*, *55*(2), 127–135. https://doi.org/10.1080/00071668.2014.889279

Grandin, T. (2013). *Animal Welfare Evaluation of Gas Stunning (Controlled Atmosphere Stunning) of Chickens and other Poultry*. https://www.grandin.com/gas.stunning.poultry.eval.html

Green, L. E., Lewis, K., Kimpton, A., & Nicol, C. J. (2000). Cross-sectional study of the prevalence of feather pecking in laying hens in alternative systems and its associations with management and disease. *The Veterinary Record*, *147*(9), 233–238. https://doi.org/10.1136/vr.147.9.233

Gregory, N. G., & Bell, J. C. (1987). Duration of wing flapping in chickens shackled before slaughter. *The Veterinary Record*, *121*(24), 567–569. https://www.ncbi.nlm.nih.gov/pubmed/3433647

HSA. (2005). *Gas Killing of Chickens and Turkeys*. https://www.hsa.org.uk/downloads/technical-notes/TN12-gas-killing-of-chickens-and-turkeys.pdf

Huber-Eicher, B., & Audigé, L. (1999). Analysis of risk factors for the occurrence of feather pecking in laying hen growers. *British Poultry Science*, *40*(5), 599–604. https://doi.org/10.1080/00071669986963

Janczak, A. M., & Riber, A. B. (2015). Review of rearing-related factors affecting the welfare of laying hens. *Poultry Science*, *94*(7), 1454–1469. https://doi.org/10.3382/ps/pev123

Jung, L., Niebuhr, K., Hinrichsen, L. K., Gunnarsson, S., Brenninkmeyer, C., Bestman, M., Heerkens, J., Ferrari, P., & Knierim, U. (2019). Possible risk factors for keel bone damage in organic laying hens. *Animal: An International Journal of Animal Bioscience*, *13*(10), 2356–2364. https://doi.org/10.1017/S175173111900003X

Kang, H. K., Park, S. B., Kim, S. H., & Kim, C. H. (2016). Effects of stock density on the laying performance, blood parameter, corticosterone, litter quality, gas emission and bone mineral density of laying hens in floor pens. *Poultry Science*, *95*(12), 2764–2770. https://doi.org/10.3382/ps/pew264

Knierim, U. (2006). Animal welfare aspects of outdoor runs for laying hens: a review. *NJAS: Wageningen Journal of Life Sciences*, *54*(2), 133–145. https://doi.org/10.1016/S1573-5214(06)80017-5

Kristensen, H. H., Burgess, L. R., Demmers, T. G., & Wathes, C. M. (2000). The preferences of laying hens for different concentrations of atmospheric ammonia. *Applied Animal Behaviour Science*, *68*(4), 307–318. https://doi.org/10.1016/s0168-1591(00)00110-6

Kristensen, H. H., & Wathes, C. M. (2000). Ammonia and poultry welfare: a review. *World's Poultry Science Journal*, *56*(3), 235–245. https://doi.org/10.1079/WPS20000018

Maddocks, S. A., Cuthill, I. C., Goldsmith, A. R., & Sherwin, C. M. (2001). Behavioural and physiological effects of absence of ultraviolet wavelengths for domestic chicks. *Animal Behaviour*, *62*(5), 1013–1019. https://doi.org/10.1006/anbe.2001.1842

March, T. I., Thompson, L., Lewis, P., & Perry, G. (1990). Sleep and activity behaviour of layers subjected to interrupted lighting schedules. *British Poultry Science*, *31*, 895–896.

McKeegan, D. E. F., McIntyre, J., Demmers, T. G. M., Wathes, C. M., & Jones, R. B. (2006). Behavioural responses of broiler chickens during acute exposure to gaseous stimulation. *Applied Animal Behaviour Science*, *99*(3), 271–286. https://doi.org/10.1016/j.applanim.2005.11.002

McKeegan, D. E. F., & Philbey, A. W. (2012). Chronic neurophysiological and anatomical changes associated with infrared beak treatment and their implications for laying hen welfare. *Animal Welfare* , *21*(2), 207–217. https://doi.org/10.7120/09627286.21.2.207

Moesta, A., Knierim, U., Briese, A., & Hartung, J. (2008). The effect of litter condition and depth on the suitability of wood shavings for dustbathing behaviour. *Applied Animal Behaviour Science*, *115*(3), 160–170. https://doi.org/10.1016/j.applanim.2008.06.005

Moinard, C., Statham, P., Haskell, M. J., McCorquodale, C., Jones, R. B., & Green, P. R. (2004). Accuracy of laying hens in jumping upwards and downwards between perches in different light environments. *Applied Animal Behaviour Science*, *85*(1), 77–92. https://doi.org/10.1016/j.applanim.2003.08.008

N⌀rgaard-Nielsen, G. (1990). Bone strength of laying hens kept in an alternative system, compared with hens in cages and on deep-litter. *British Poultry Science*, *31*(1), 81–89. https://doi.org/10.1080/00071669008417233

Nagle, T. A. D., & Glatz, P. C. (2012). Free range hens use the range more when the outdoor environment is enriched. *Asian-Australasian Journal of Animal Sciences*, *25*(4), 584–591. https://doi.org/10.5713/ajas.2011.11051

Nicol, C. J., Brown, S. N., Glen, E., Pope, S. J., Short, F. J., Warriss, P. D., Zimmerman, P. H., & Wilkins, L. J. (2006). Effects of stocking density, flock size and management on the welfare of laying hens in single-tier aviaries. *British Poultry Science*, *47*(2), 135–146. https://doi.org/10.1080/00071660600610609

Nicol, C. J., Gregory, N. G., Knowles, T. G., Parkman, I. D., & Wilkins, L. J. (1999). Differential effects of increased stocking density, mediated by increased flock size, on feather pecking and aggression in laying hens. *Applied Animal Behaviour Science*, *65*(2), 137–152. https://doi.org/10.1016/S0168-1591(99)00057-X

Nicol, C. J., Pötzsch, C., Lewis, K., & Green, L. E. (2003). Matched concurrent case-control study of risk factors for feather pecking in hens on free-range commercial farms in the UK. *British Poultry Science*, *44*(4), 515–523. https://doi.org/10.1080/00071660310001616255

Olsson, I. A., & Keeling, L. J. (2000). Night-time roosting in laying hens and the effect of thwarting access to perches. *Applied Animal Behaviour Science*, *68*(3), 243–256. https://doi.org/10.1016/s0168-1591(00)00097-6

Pettersson, I. C., Freire, R., & Nicol, C. J. (2016). Factors affecting ranging behaviour in commercial free-range hens. *World's Poultry Science Journal*, *72*(1), 137–150. https://doi.org/10.1017/S0043933915002664

Prescott, N. B., & Wathes, C. M. (2002). Preference and motivation of laying hens to eat under different illuminances and the effect of illuminance on eating behaviour. *British Poultry Science*, *43*(2), 190–195. https://doi.org/10.1080/00071660120121382

Prescott, N. B., Wathes, C. M., & Jarvis, J. R. (2003). Light, vision and the welfare of poultry. *Animal Welfare* , *12*(2), 269–288. https://www.ingentaconnect.com/content/ufaw/aw/2003/00000012/00000002/art00009

Raj, A. B., & Gregory, N. G. (1991). Preferential feeding behaviour of hens in different gaseous atmospheres. *British Poultry Science*, *32*(1), 57–65. https://doi.org/10.1080/00071669108417327

Raj, A. B. M., Wotton, S. B., & Gregory, N. G. (1992). Changes in the somatosensory evoked potentials and spontaneous electroencephalogram of hens during stunning with a carbon dioxide and argon mixture. *The British Veterinary Journal*, *148*(2), 147–156. https://doi.org/10.1016/0007-1935(92)90106-B

Raj, M. (1998). Welfare during stunning and slaughter of poultry. *Poultry Science*, *77*(12), 1815–1819. https://doi.org/10.1093/ps/77.12.1815

Raj, M., & Tserveni-Gousi, A. (2000). Stunning methods for poultry. *World's Poultry Science Journal*, *56*(4), 291–304. https://doi.org/10.1079/WPS20000021

Rana, M. S., Cohen-Barnhouse, A. M., Lee, C., & Campbell, D. L. M. (2021). Preference testing for UV light spectrum and intensity in laying hens. *Poultry Science*, *100*(6), 101063. https://doi.org/10.1016/j.psj.2021.101063

Rodenburg, T. B., Tuyttens, F. A. M., Sonck, B., De Reu, K., Herman, L., & Zoons, J. (2005). Welfare, health, and hygiene of laying hens housed in furnished cages and in alternative housing systems. *Journal of Applied Animal Welfare Science: JAAWS*, *8*(3), 211–226. https://doi.org/10.1207/s15327604jaws0803_5

Sandilands, V., Raj, A. B. M., Baker, L., & Sparks, N. H. C. (2011). Aversion of chickens to various lethal gas mixtures. *Animal Welfare* , *20*(2), 253–262. https://doi.org/10.1017/S0962728600002736

Savory, C. J. (1980). Diurnal feeding patterns in domestic fowls: A review. *Applied Animal Ethology*, *6*(1), 71–82. https://doi.org/10.1016/0304-3762(80)90095-4

Scholz, B., Kjaer, J. B., & Schrader, L. (2014). Analysis of landing behaviour of three layer lines on different perch designs. *British Poultry Science*, *55*(4), 419–426. https://doi.org/10.1080/00071668.2014.933175

Schrader, L., & Müller, B. (2009). Night-time roosting in the domestic fowl: The height matters. *Applied Animal Behaviour Science*, *121*(3), 179–183. https://doi.org/10.1016/j.applanim.2009.09.010

Scott, G. B., Lambe, N. R., & Hitchcock, D. (1997). Ability of laying hens to negotiate horizontal perches at different heights, separated by different angles. *British Poultry Science*, *38*(1), 48–54. https://doi.org/10.1080/00071669708417939

Scott, G. B., & Parker, C. A. L. (1994). The ability of laying hens to negotiate between horizontal perches. *Applied Animal Behaviour Science*, *42*(2), 121–127. https://doi.org/10.1016/0168-1591(94)90152-X

Sirovnik, J., Würbel, H., & Toscano, M. J. (2018). Feeder space affects access to the feeder, aggression, and feed conversion in laying hens in an aviary system. *Applied Animal Behaviour Science*, *198*, 75–82. https://doi.org/10.1016/j.applanim.2017.09.017

Sobotik, E. B., Nelson, J. R., & Archer, G. S. (2020). How does ultraviolet light affect layer production, fear, and stress. *Applied Animal Behaviour Science*, *223*, 104926. https://doi.org/10.1016/j.applanim.2019.104926

SRUC. (2007). *Technical Note: Perch Designs for Extensive Systems*. SRUC. http://www.sruc.ac.uk/downloads/files/1223/tn598_perch_designs_for_extensive_systems

Struelens, E., & Tuyttens, F. A. M. (2009). Effects of perch design on behaviour and health of laying hens. *Animal Welfare* , *18*(4), 533–538. https://doi.org/10.1017/S0962728600000956

Uitdehaag, K. A., Rodenburg, T. B., Bolhuis, J. E., Decuypere, E., & Komen, H. (2009). Mixed housing of different genetic lines of laying hens negatively affects feather pecking and fear related behaviour. *Applied Animal Behaviour Science*, *116*(1), 58–66. https://doi.org/10.1016/j.applanim.2008.06.009

Waiblinger, S., Boivin, X., Pedersen, V., Tosi, M.-V., Janczak, A. M., Visser, E. K., & Jones, R. B. (2006). Assessing the human–animal relationship in farmed species: A critical review. *Applied Animal Behaviour Science*, *101*(3), 185–242. https://doi.org/10.1016/j.applanim.2006.02.001

Weeks, C. A., & Nicol, C. J. (2006). Behavioural needs, priorities and preferences of laying hens. *World's Poultry Science Journal*, *62*(2), 296–307. https://doi.org/10.1079/WPS200598

Whitehead, C. C. (2004). Overview of bone biology in the egg-laying hen. *Poultry Science*, *83*(2), 193–199. https://doi.org/10.1093/ps/83.2.193

Wichman, A., De Groot, R., Håstad, O., Wall, H., & Rubene, D. (2021). Influence of Different Light Spectrums on Behaviour and Welfare in Laying Hens. *Animals : An Open Access Journal from MDPI*, *11*(4). https://doi.org/10.3390/ani11040924

Wilkins, L. J., McKinstry, J. L., Avery, N. C., Knowles, T. G., Brown, S. N., Tarlton, J., & Nicol, C. J. (2011). Influence of housing system and design on bone strength and keel bone fractures in laying hens. *The Veterinary Record*, *169*(16), 414. https://doi.org/10.1136/vr.d4831

Zeltner, E., & Hirt, H. (2008). Factors involved in the improvement of the use of hen runs. *Applied Animal Behaviour Science*, *114*(3), 395–408. https://doi.org/10.1016/j.applanim.2008.04.007

Zimmerman, P. H., Lindberg, A. C., Pope, S. J., Glen, E., Bolhuis, J. E., & Nicol, C. J. (2006). The effect of stocking density, flock size and modified management on laying hen behaviour and welfare in a non-cage system. *Applied Animal Behaviour Science*, *101*(1), 111–124. https://doi.org/10.1016/j.applanim.2006.01.005

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