Welfare of Hens in Cage-free Systems - Summary

The Problem

Barren battery cage, furnished ('enriched') cage and combination ('combi' or convertible) systems reduce hen welfare due to confinement, restricting natural behaviours and exacerbating health problems such as osteoporosis. Cage-free systems, such as barn, free-range and organic systems, have a higher welfare potential. However, welfare problems, such as feather pecking and keel bone fractures, can also occur in these systems. In order to deliver good welfare, cage-free systems need to be well designed and well managed and use a breed able to demonstrate good health and welfare outcomes.

Welfare in cage-free systems

Genetics of the modern laying hen

Genetic selection for production traits has resulted in health and welfare issues for the modern genotype. These issues include plumage loss and feather pecking and poor bone strength and pose significant challenges in cage-free systems. Shifting the focus away from selecting solely for production traits towards improved health and welfare traits is an important part of ensuring good welfare in cage-free systems.

Physical Wellbeing

Mortality

Mortality is caused by different factors and can be reduced by good management, implementing a veterinary health plan, good hygiene and avoidance of stress and overcrowding. Good house and nest box design, early experience of nests during the rearing period can reduce smothering events. In indoor environments, measures including providing dry litter, adequate ventilation and heat exchange, separating hens from their faeces and sealing nest-box fittings (to prevent red mites) improve health. Outdoors, providing high fences and trees encourages activity while protecting against ground and aerial predators.

Skeletal health

To prevent osteoporosis and bone fractures, genetic selection for bone strength and improved house design are needed. Using perches that are soft, round, and have a low-pressure loading is recommended, as well as using ramps connecting the floor, tiers and perches. It is also advisable to have natural light during daytime hours to help birds move around the house more easily. The rearing period is also important for laying hens to learn from pullet stage to use the space and develop a stronger skeletal structure.

Foot health

Common foot problems include foot pad dermatitis, bumble foot and hyperketosis. These are preventable with good perch design (soft and round) and maintaining good hygiene. Litter management is paramount; litter should be kept dry and hygienic. Outdoor access has also been found to reduce foot health issues.

Behavioural Expression

Providing space

Providing sufficient space is required for comfort, maintenance and locomotion behaviours, as well as for bone and muscle health and thermoregulation. Cage-free systems with environmental resources allow naturally motivated behaviours to be expressed, as they provide a spacious, complex environment. Space provided in cage-free systems should account for the total useable space as well as the total amount of

floor space available, as that birds tend to synchronise their behaviours. Outdoor access and verandas provide additional space and a choice of environment.

Nesting
Design of nests is critical to allow nesting behaviour and reduce the risk of eggs laid outside of nests and gregarious nesting which may lead to smothering. To allow nesting behaviour, sufficient nests for all hens to use which are gently sloped, have flaps in the front, be elevated and have loose substrate material should be provided.

Foraging
Hens are highly motivated to forage, scratch and peck to search for food. Restricting this behaviour can lead to frustration resulting in abnormal behaviours, importantly injurious pecking. Opportunities to forage and peck include providing litter with feed scattered throughout, pecking substrates, and outdoor access with grassy ranges, trees or shrubs. Sufficient space is needed to allow birds to carry out these behaviours.

Injurious pecking
Injurious pecking includes feather pecking, vent pecking and toe pecking. Injurious pecking is thought to be the result of redirected pecking at other birds, caused by frustration and stress. Providing opportunities for foraging (e.g., litter, outdoor access) and substrates that birds can peck at (e.g., blocks or pans), good ventilation, natural light and maintaining good health within the flock can reduce injurious pecking outbreaks and therefore also the need to beak trim. Perches should be high enough so that birds cannot be vent pecked from below. Toe pecking is less well understood; it may be more prevalent in white birds, and may result from competition for resources. Injurious pecking can occur in pullets; they should be provided with early access to environmental enrichment, dark brooders and lower stocking densities, which is also found to reduce the risk of outbreaks as adults.

Comfort behaviours
Comfort behaviours include wing flapping, preening and dustbathing. Wing flapping and preening require sufficient space for hens to be able to move around and spread their wings. Hens are highly motivated to dustbathe; it allows them to maintain feather condition, and it is a gregarious behaviour where birds will dustbathe if they see other birds performing it. In the absence of suitable substrate, birds will exhibit sham dustbathing, which isn't sufficient to fulfil the need to carry out this behaviour and can result in frustration. Providing dry, friable litter, additional dustbathing substrate such as sand and sufficient space is crucial to allow birds to express comfort behaviours.

Perching
Providing elevated, well-designed perches is important for hens to feel secure whilst resting during the day and sleeping at night, and to separate active from inactive birds. Optimal perch design and location within the house, with ramps to allow easy access, is crucial for reducing keel bone damage, as well as maintaining good foot health.

Ranging
Free-range systems provide hens with enhanced opportunities to express their behavioural repertoire, including foraging, dustbathing, wing flapping and running. Range access is found to improve feather cover and foot health. Ranging (exploring the outdoor environment) is variable and increases when trees or shelters (including verandas) are provided. These also offer protection from the weather and predators. Providing feed *ad-libitum* and exposing birds to the outdoors at a young age encourages them to use the range when they are older.

Mental Wellbeing

Hens are able to experience subjective states, such as pleasure, fear and stress, which are measured by behavioural and physiological changes. It has been shown that hens are less fearful in outdoor systems. To reduce hens experiencing pain in alternative systems, management methods to minimize injurious pecking and improve skeletal health should be implemented. Positive experiences are equally as important as the absence of negative experiences in order for animals to have a good life. Increased space and provision of environmental enrichment in cage-free systems can reduce frustration and stress and promote positive states in hens by providing opportunities for hens to express foraging, comfort and perching behaviours.

Welfare Outcome Measures

It is important to assess the welfare of animals using animal-based measures to determine their physical and mental wellbeing and behavioural expression. Doing this will identify if there are welfare issues, or where to make improvements to achieve better welfare. The main welfare indicators recommended for laying hens are disease incidence, keel bone fractures, feather cover, mortality and flock behaviour.

CIWF RECOMMENDATIONS FOR LAYING HENS

- **Adequate space** that allows hens to rest undisturbed, move freely and have space for behavioural expression. Bets practice is to provide ≤7 laying hens/m² of usable space and ≤15 laying hens/m² of floor space.
- **Nest boxes** that allow hens to lay their eggs in a secluded area and perform nesting behaviours. Provide 1 nest box per 5 hens or for group nests at least 1m² of nest area per 120 hens.
- **Perches** that give hens 18-22cm each to rest, preen and roost comfortably.
- **Dry, friable litter covering the whole floor area** from day 0 at the layer farm to promote foraging behaviours and reduce the risk of feather pecking outbreaks
- **Pecking substrates with additional areas for dustbathing** to allow hens to perform foraging and dustbathing behaviours.
- **Natural light** including dawn and dusk periods so hens can navigate around their environment and establish their daily rhythm.
- **Additional space and outdoor access** via a veranda/wintergarden with additional enrichments (e.g. perches, dust baths and pecking substrates) and ideally ranges with artificial shelters, trees or bushes.
- **Regular scoring of welfare outcomes** to identify any welfare issues and to set targets for improvements, such as mortality, keel bone fractures, feather cover, cleanliness, pododermatitis, and positive welfare indicators (e.g., dustbathing, ranging outdoors, perching, foraging, positive social interactions).

Welfare of Hens in Cage-free Systems - Scientific review

Contents

1. Laying hen behavioural biology

The laying hens of today originate from the jungle fowl of the Indian Subcontinent. Jungle fowl are found in a variety of habitats and climates, ranging from the Himalaya mountain range in northern India to tropical Southeast Asia. Jungle fowl live in forests, which provide the birds with good roosting sites, adequate opportunities to forage for food sources and cover for protection of their young. Jungle fowl live in small groups usually comprised of a dominant male and hens, and social hierarchies are formed. Jungle fowl are not active at night, and roost in trees to escape predators. Members of the group communicate with each other using vocalisations, such as a "Ku" call that serves to locate each other. Flying is uncommon, with locomotion mainly being walking and running, and flying is used over short distances to escape and immediate threat or to reach a roosting site. [1]

The behaviour of the modern laying hen is not fundamentally different from its jungle fowl ancestor, despite many thousands of years of domestication or more recent intensive selective breeding[2]. Selection for production traits has modified the frequency of behaviours (largely by reducing energy demanding behaviours) rather than adding behaviours to, or eliminating behaviours from, the animals' repertoire[2]. Therefore, the modern laying hen has a number of innate behaviours that they are highly motivated to express, notably roosting (i.e. perching), walking and running, foraging, comfort behaviours including dustbathing and preening and nesting[3].

- In natural conditions, hens roost at night for protection against ground predators, and will compete to secure perch space[4]. Perches are also used in daylight hours for resting, observing their environment[5], preening[6] and to escape or avoid other hens[7].
- In natural conditions hens spend 50-90% of their time foraging, which involves searching and scratching at the ground or litter for potential food items (seeds, earthworms, flying insects, grit), followed by investigation and selection of food items by pecking.
- Dustbathing is a behavioural need for hens as they are highly motivated to perform it[3] to

maintain the function of feathers[8] by dispersing excess lipids[9] and removing parasites[10]. Dustbathing is performed every two days in unrestricted conditions.

- Nesting behaviour includes nest site investigation and selection, pre-laying behaviour (gathering, scraping, crouching, sitting and circling or keel rotation) followed by egg laying and post-lay sitting. The sequence of behaviours takes up to three hours or more and occurs largely in the morning.

2. Overview of commercial production

2.1 Caged production

There were an estimated 7.9 billion laying hens globally in 2020[11]. Globally, it is estimated that 84.2% of laying hens are housed in cages, mostly conventional (often called barren cages)[12]. Furnished ('enriched') cages are used in the EU (44.9% of hens in 2021), UK (35.5% of hens in 2021) and some other countries[12].

Conventional cages provide each hen with only 600cm^2 of space, and lack any resources for nesting, perching, foraging and comfort behaviours.

Furnished ('enriched') cages provide 750cm^2 per hen, and equipment for feeding, drinking, egg collection, manure removal, insertion and removal of hens. In addition, they provide some equipment such as perches, nest boxes, and a pecking and scratching area.

Combination ('combi') systems are multi-tiered structures that have robust doors and internal partitions that convert the unit into a caged system when the doors are closed, and restrict movement through the tier irrespective of doors open or closed. They also operate at high stocking density (~22 birds/m^2 floor area).

Net flooring systems are used in some parts of the world including China. The birds are housed 'off the ground' rather than 'on the ground' on raised netting, so birds have no access to litter, dust-bathing areas and scratching areas.

Legislation

There is a global trend for the phasing out of conventional cages, and some countries have even banned all caged systems (i.e. conventional and enriched cages), such as Austria, Luxemburg, Switzerland, Germany (from 2025), and Czech Republic (from 2027). In the EU, the European Commission has been reviewing its animal welfare legislation in 2023, including Council Directive 1999/74/EC which details the minimum standards protecting laying hens. As part of this review, the Commission requested an independent review by EFSA to provide a view on the protection of laying hens during the different phases of the production cycle. The report, published in early 2023, recommends that **cages should not be used, and that all birds should be housed in cage-free systems at all stages of production**[13]**.** In response to the European Citizen Initiative (ECI) "End the Cage Age", which called for banning the use of cages for laying hens (among other species), the European Commission announced in June 2021 its decision to put forward a legislative proposal to phase out and finally prohibit the use of cages for laying hens and all other farmed species covered in the ECI.

2.2 Cage-free production

Higher welfare systems include cage-free indoor (barn) systems including floor/single tier systems and multi-tier/aviary systems (12.4% of commercial layers globally), and free-range and organic systems (3.4% of commercial layers globally)[12]. Some hens are also kept in backyard flocks, which account for an estimated 7.3% of total global egg production[14].

Single-tier systems are cage-free systems with a maximum of one tier. The floor is covered with litter (typically at least one third of the floor but it can be more) and with partly slatted flooring (made of wire, plastic or wood). The slatted area may contain nest boxes and feeders and drinkers, or nest boxes may be at the sides of the barn above the litter. They usually contain frames with perches.[13]

Multi-tier systems, also called aviary systems, are cage-free systems with tiers of floors, usually with a maximum of four levels (including the ground/ floor level; maximum permitted in the EU). There are a number of designs of multi-tier systems, varying in complexity. In general, each floor consists of a manure belt covered with wire mesh or plastic slats. Drinkers, feeders and perches are located within the tiers – drinkers and feeders are usually located on the lower tiers and most of the perches are located on the top tier, while other perches or platforms are located beside the tiers to enable easier movement through the system. Nest boxes are usually located on one level of the tiered floor, or on several tiers in older designs. All tiers are placed over a littered floor (at least one third of the floor by law in the EU) . The tiers and floor level should be available all the time for the hens, however, some designs (referred to as limited access systems) may not give birds access to the floor under the first tier. Multi-tier systems may include perches and ramps to enable movement between tiers[15].

Outdoor access can be provided in cage-free systems. Both single-tier and multi-tier barn systems can be used as full indoor systems, or they can additionally provide access to a veranda (wintergarden) and/or outdoor access.

- A veranda is an additional, roofed, uninsulated outdoor addition to a building, with an outdoor climate. They have a solid roof and at least one side lacks a solid wall.
- An outdoor range is usually a grass-covered field, sometimes with cover (e.g., trees, shrubs, artificial structures) to promote increased use of the range. Pop-holes are located along the side of the barn and are opened during the daytime allowing the birds to access the range.[13]

3. Cages have a low welfare potential

Cages negatively affect the welfare of hens due to confinement, restricting movement and species specific behaviours. Rearing conditions in cages, including severe space restriction and high stocking densities, have been shown to facilitate the rapid spread of disease, including highly pathogenic avian influenza (HPAI)[16,17].

There is insufficient space in cages, both horizontally and vertically, to perform even the most basic species-specific behaviours. It has been reported that laying hens need on average 1190 cm^2 for dustbathing, 2841cm^2 for wing flapping, 670cm^2 for standing, 25cm^2 for perching[18], 1316cm^2 to turn around and 1693cm^2 for wing flapping[19]. In comparison, a conventional cage only offers 550cm^2 per hen, and a furnished cage 750cm^2 with a height of 45cm. Severe space restriction can have production consequences; restriction of movement below 565cm^2 may increase mortality, reduce egg production and result in lower feed conversion[20–22]. Higher stocking densities are also found to negatively impact immune functioning, and hens were found to show fewer active behaviours and more pecking behaviour when reared at a high stocking density (23 birds/m^2) compared to a lower stocking density (13 birds/m^2)[23].

There is not enough horizontal space for all birds to perch at once in cages[18]; hens are all motivated to perch on elevated structures at night (and to a lesser extent during the day), and they become agitated if roosting is prevented[24]. It is not possible to provide adequately elevated perches in cages, whereas cage-free housing can easily provide elevated structures for hens, in both single- and multi-tier systems. Perches are found to be used more in cage-free systems (53% of the observation period, daytime) than furnished cages (23%)[25].

Dustbathing, foraging behaviour, scratching and searching, are rarely fully expressed in a cage[26–28]. In the absence of any dustbathing substrate and sufficient space in cages, most dustbathing is sham dustbathing[25], taking place on the wire floor without substrate[29] and is therefore insufficient to sate the motivation of the hen for this important behaviour, and leads to feather damage and loss. Hens prefer to lay in nests containing loose material which can be both moulded by their body and feet movements and manipulated with their beaks during nest building[30]. However, nesting material is usually not provided in cages.

Cages have a negative effect on the mental wellbeing of hens. Hens in caged systems are found to be more fearful compared to hens in cage-free systems[31–33]. Due to extreme confinement and high stocking densities in cages, social interactions can be disrupted, with less space for hens to avoid aggressive interactions, competition over resources and a loss of natural hierarchy[34,35]. Hens also experience frustration when unable to express highly motivated behaviours such as foraging, resulting in abnormal behaviours such as feather pecking[3,36].

4. Cage-free systems have a higher welfare potential

Cage-free systems have the potential to provide for the behavioural needs of hens and promote good physical and mental wellbeing. Extensive scientific reviews demonstrate that only cage-free systems provide the possibility for hens to express their full behavioural repertoire[37,38]. The latest EFSA report on the welfare of laying hens recommends that cages should not be used at any stage of production (including pullets and breeders)[13]. However, all systems have welfare risks which need to be managed.

4.1 Genetics of the modern laying hen

Commercial laying hens have been selectively bred to increase egg yield, resulting in laying hen breeds that have earlier sexual maturity, an increased quantity and quality of egg production and decreased feed intake to maintain egg production[39]. Modern hybrids can now produce 320 eggs by 72 weeks of age[40–42] and genetics companies are now working on extending laying cycles[43]; in parts of the world, such as the USA and in Asia, laying hens may be kept longer than 72 weeks, by using artificially induced moulting, and may produce up to 430-470 eggs by 92-100 weeks of age. Forced moulting has severe welfare consequences and is not allowed in the EU or India.

Selecting exclusively for production traits has resulted in health and welfare issues for the modern genotype. These issues, including plumage loss and feather pecking[44–46] and poor bone strength[47], have been somewhat managed in caged systems for decades due to the limited social and environmental opportunities in cages[48]. However, with the market transition towards cage-free egg production, hens are increasingly being housed in systems that offer more complex and varied social and environmental conditions which have the potential to exacerbate the issues associated with commercial breeds such as injurious pecking and keel bone damage[48]. Therefore, shifting the focus away from solely production traits towards improved health and welfare traits is an important part of ensuring good welfare in cage-free systems[43,49,50].

Dual-purpose breeds, where females are kept for egg production while the males are reared for meat, have more moderate levels of production of both eggs and meat due to a more balanced breeding, which can address many of the welfare issues associated with high egg production. They also offer an acceptable alternative to culling day-old male chicks and allow to make use of spent hens at the end of lay. Dual-purpose hybrid Lohmann Dual hens housed in an organic system were found to have a calm temperament[51] and a lower prevalence of feather loss compared to the hybrid Lohmann Brown-Plus breed[52,53]. This suggests that dual-purpose breeds may have a benefit of improving key welfare issues such as feather pecking in commercial breeds[54].

4.2 Physical wellbeing

4.2.1 Mortality

Mortality was generally regarded as being higher in cage-free systems compared to cages[25,55]. However, recent research shows that there is no longer a significant difference in mortality between cage-free and furnished cage systems[56]. It is to be expected that mortality in a new system may be higher due to lack of experience[57] and mortality in cage-free systems declines with time as knowledge and management practices, housing design and genetics improve[56,58–60]. It is worth noting that not all regions are represented in data or studies on mortality; most available data is from Europe and North America, and no data was identified for some of the biggest egg producers in the world (e.g., China, India, Mexico and Brazil)[56]. Therefore, many findings can only be generalised to other regions. Primary causes of mortality in cage-free systems include smothering[61], predation in free-range flocks, injuries such as feather pecking and cannibalism, sickness and disease[13], and infestations of red mites[25].

4.2.1.1 Endo and ectoparasites

Hens in free-range systems may have higher levels of helminths through access to the outdoor range [62]. A meta-analysis including data on layers, broilers and indigenous breeds[63] found that the pooled prevalence of helminth infections in free-range systems was 85% and was 71% in deep litter systems without outdoor access. However, this does not necessarily reflect the impact of helminth infections on welfare in these systems, as infections leading to low worm burdens generally do not cause welfare problems[64].

Flies, beetles and permanent ectoparasites were considered least problematic in cage-free systems as the hens ingested and groomed away the organisms; red mite infestations, however, were considered more problematic[65]. Red mites are a blood-feeding ectoparasite that reside in cracks and crevices in perches, nest boxes and on the undersides of ledges and perches[66]. Mite infestations affect production as well as welfare, reducing egg production, egg size and result in economic losses (e.g., €231million per year in Europe)[67]. Red mites are found globally, for example, infestation rates in China were 88% in 2010[68]. General disinfection and good hygiene, avoidance of stress and overcrowding, good ventilation and temperature control are all methods to reduce infestations[69]. The design of the nest boxes and fittings are also important for the control of red mite; properly sealing structures prevents the mites hiding in cracks and crevices.

4.2.1.2 Air quality

Dust and ammonia levels may be higher in cage-free systems due to provision of litter material and higher levels of bird activity[70]. Dust is composed of inorganic and organic compounds and high levels can compromise the health and welfare of birds[70,71], for example, through bacterial and fungal infections spreading among the flock[25,72]. Good ventilation and heat exchange systems are important to extract air pollutants and keep the litter relatively dry. Many producers maintain a separation of the hens from their faeces with the use of manure belts under drinkers, nest boxes and perches.

4.2.1.3 Predation

Predation can occur on organic and free-range farms, mostly due to foxes and birds of prey gaining access to the outdoor range. One study in the Netherlands estimated that across 27 organic/ free-range farms, 3.7% of hens were lost due to predation[73]. Mortality due to predation poses an economic loss for farmers, for example, an estimated €6700 in an average (25,000 hen) free-range farm[73]. Predation can be effectively minimised by using high, electric fencing, dug into the ground and nightly indoor housing, whilst the provision of trees and shelters protects can against some aerial predators[74,75].

4.2.1.4 Smothering

Crowding (or piling) in corners and other parts of the housing area can lead to smothering (death by suffocation), however, it is unpredictable and the causes are not well understood[76]. Smothering is prevalent in cage-free systems; in a study representing 35% of the UK free-range egg supply, nearly 60% of farm managers experienced smothering, with on average 25.5% of birds lost in each incidence [76]. It is believed that there are different categories of smothering, with distinct causes[77]. Panic smothers are caused by sudden disturbances (e.g., by predators or loud noises), and are isolated incidences involving large numbers of hens[77]. Nest box smothers occur in nest boxes, triggered by one hen entering and other hens following her into the same nest[77]. This behaviour is thought to be related to gregarious nesting behaviour[78], which may occur due to inexperienced hens mimicking more experienced hens[79]. Recurring smothers occur throughout lay, and usually involve small numbers of birds[77]. Smothering can be reduced by the separation of flocks into smaller colonies and giving pullets early experience of the environment in which they will lay to reduce fear. Also, house and nest box design may be important to promote appropriate nesting behaviours and reduce the risk of nest box smothers, although more research is needed to fully decipher an optimal design[78]. Full coverage of the floor with high quality litter and enrichment to promote foraging, such as grit or feed scattered through the litter could also reduce the risk of abnormal behaviours, including smothering[78].

The primary causes of mortality in cage-free systems can be mitigated through good management. Management systems and an appropriate veterinary health plan (including vaccination and worming programmes) are vital to good health status and low mortality and both are very much determined by a positive producer attitude to the system they operate. Twelve years of Swiss commercial data in litter systems showed a consistent fall in the incidence of viral disease, parasites, cannibalism and feather pecking as a result of better management[80]. For example, vaccination against Marek's disease and increased education of producers was effective in decreasing its prevalence[80]. Bacterial infections rose however, probably due to dust, bacteria, and ammonia loading[80].

4.2.2 Skeletal health

Wing and keel bones are found to be stronger in hens from cage-free systems compared to caged systems[25] as caged hens are more prone to osteoporosis due to low activity levels[81]. However, fractures of the keel bone are a serious welfare issue in cage-free systems[43,82], and their prevalence is found to be high (>50%) in a number of studies (50-78% of the flock in free-range and barn systems[83]; 69.1% of the flock in barns and 59.8% of the flock in free-range systems,[84]; >80% of flocks housed with multi-level perches,[85]; up to 83% of the flock in an aviary system,[86]; 97% of the flock had at least one keel bone fracture in a barn system,[87]; average 82.5% of the flock housing in aviaries,[15]; >95% of barn/aviary flocks and > 93% of organic/free range flocks in Denmark,[88]; it should be noted that estimates of prevalence have several limitations such as diagnostic technique and lack of standardisation of reporting, meaning it is very difficult to reliably estimate[89]).

4.2.2.1 Keel bone damage

Keel bone fractures are described as breaks in the bone that form a callus around the fracture and may also cause deviations or bending in the bone[90]. All moderate and severe keel bone deformities are likely to be painful[86,91]. The bones undergo a period of healing of around 35 days[92] during which time the hen's behaviour is modified. Laying hens with keel bone fractures showed less time spent engaging in highly motivated behaviours (including perching, nesting and locomotion), indicating reduced mobility and negative affective states compared to birds without fractures[93]. Individual hen's egg production and egg quality were also negatively affected by the presence of keel fractures[91] (Nasr et al., 2012). Hens with healed keel fractures showed a conditioned place preference for an environment where they received butorphanol treatment, suggesting that keel fractures are a source of chronic pain for hens[94].

In cage-free systems, birds are thought to break the anatomically exposed keel bone in falls or collisions with perches and other obstacles, as they jump and fly between structures at different heights[85,95]. Also, the occurrence of new fractures is temporally linked to egg production, with more new fractures occurring when laying rates are highest[96], and age of onset of lay[88]. Also, one study found that >96% of fractures occurred at the caudal end of the keel bone, suggesting that these fractures may be instead due to depletion of the bird's reserves due to breeding for higher egg quality[88]. Genetic selection for bone strength and improved house and perch design are needed to improve the welfare of the laying hen, especially in cage-free systems[43,47,85,97].

Optimal house and perch design needs to take account of the physical attributes of the hen, including trajectory requirements for jumping and flying on and off perches and nest boxes; proximity of fixtures and walls; low pressure loading perches, and to provide experience and training for pullets for moving in a three-dimensional space as well as developing a strong bone structure in a cage-free system.

Recommendations include:

- Portal-type (stepwise design) aviaries which are associated with a lower risk of keel fractures compared with row-type aviaries[15,98].
- Ramps should be provided to connect the floor, tiers and perches[15,99–101]. Ramps should ensure that birds do not have to jump more than 80cm vertically, horizontally or diagonally, or more than an angle of 45^{o} [13,99].
- A perch width of 3 to 6cm is recommended to reduce peak force under the keel bone and foot pads[13,99]. Using softer material for perches or soft coverings (e.g. rubber, polyurethane) on metal perches[99,102,103].
- The house layout should ensure easier movement throughout the house by providing[13,99]:
    - a vertical space between tiers of >50cm - <100cm;
    - a distance between rows of tiers of at least 80cm;
    - a horizontal distance between perches of at least 30cm, and;
    - a horizontal distance between the perch and the wall of at least 20cm.
- Adequate natural daylight in the hen house, allowing safer maneuvering and orientation through the system[104].
- Providing elevated structures, for example perches and platforms, in pullet housing aids in the development of pullets' motor skills and strength before they move to the cage-free system for lay[90,105–107].

4.2.3 Foot health

Housing conditions, including litter quality, are important factors for foot health[108]. Hens in cage-free systems have been found to have a higher prevalence and severity of foot disorders compared to hens in caged systems[109,110]. Foot pad dermatitis, bumble foot and hyperketosis are the most common foot problems of laying hens in cage-free systems[98].

4.2.3.1 Foot pad dermatitis and bumble foot

Foot pad dermatitis (discoloration, necrosis and ulceration of the epidermis) is caused by wet litter and high ammonia content of the litter, as well as feed and genetic components[108]. Infection with *Staphylococcus aureus* in deep litter systems leads to bumble foot, a localised bulbous lesion in the ball of the foot, which causes pain and severe lameness[65]. Contact with wet, dirty litter can result in poorer foot pad hygiene and increased foot pad dermatitis and bumble foot[111,112]. Litter maintenance is therefore of paramount importance in all systems, particularly in deep litter systems. Bumble foot is also associated with poor perch design and perch hygiene[113]; optimizing perch design can reduce the prevalence of bumble foot within the flock[111]. Provision of ramps is also found to improve aspects of foot pad health in cage-free systems[15].

4.2.3.2 Hyperkeratosis

Hyperkeratosis occurs due to adaptation growth caused by long-term or repeated exposure to pressure[114]. Floor surfaces and perches can cause an abnormal pressure load on hens' feet, causing skin proliferation[115,116]. Outdoor access may reduce the risk of hyperkeratosis; Heerkens et al.[98] found that free-range flocks had a lower prevalence of hyperkeratosis. Similarly, Riber and Hinrichsen[117] found that barn hens were more likely to have foot pad lesions compared to organic hens. Perch design is important for reducing hyperkeratosis due to compression loading while perching. Prototype perches (soft, round polyurethane perches) produced a lower peak force on the foot pad than commercially available steel perches, whilst commercially available square perches produced higher peak forces than standard oval and round perches while standing[118]. Therefore, perches with a soft surface may reduce the incidence of hyperkeratosis and improve foot pad health[118].

Table 2. Summary of recommendations to address the most common welfare issues related to laying hens' physical health in cage-free housing systems.

Welfare consequence		Housing system	Recommendation
Mortality and disease	Ectoparasite infestation	Single-tier, multi-tier, free-range	Avoid wooden perches, seal crack and crevices of nest boxes, disinfection and good hygiene practices
	High dust and ammonia levels	Single-tier, multi-tier, free-range	Good ventilation and heat exchange systems, separate hens from faeces using manure belts under drinkers, nest boxes and perches
	Predation	Free-range	Use of high, electric fencing, housing birds at night, trees/ shelters
	Smothering	Single-tier, multi-tier, free-range	Smaller colonies, early experience of nest boxes, optimal nest box design
Skeletal health	Keel bone damage	Multi-tier, free-range	Good perch and house design
Foot health	Footpad dermatitis and bumble foot	Single-tier, multi-tier, free-range	Dry friable litter, good perch design and hygiene, provision of ramps, outdoor access
	Hyperkeratosis	Single-tier, multi-tier, free-range	Perch design (soft and round)

4.3 Behavioural expression

4.3.1 Space for behavioural expression

Provision of adequate space is vital to allow hens to perform comfort and maintenance behaviours (including dustbathing, perching and wing-flapping; see table 3) and locomotion (including running, walking, flying), and not be restricted in movement which can result in negative states such as stress, discomfort and frustration[22]. For example, hens showed a rebound in wing flapping and stretching, feather raising, tail wagging and leg stretching after moving into a large cage (2310 cm^2) following housing in a small cage (847cm^2) for four weeks, showing that hens are highly motivated to perform these behaviours during confinement[26]. Engel[119] found that there was a 64% reduction in locomotion, a 36% reduction in floor and object pecking and a 17% reduction in preening when brown hens were stocked at 542cm^2 versus 1648cm^2 per hen in a cage. Savory et al.[120] concluded a space allowance <5000cm^2 per hen imposed at least some constraint to behavioural expression, but that this amount of space provided in a free-range environment with complex resources allowed a full range of natural behaviour. A lack of space also negatively impacts physical health; confinement results in hens not being able to exercise fully which contributes to osteoporosis and weak muscles[121], and adequate space is important for thermoregulation e.g., to avoid overheating[122].

Table 3. Summary of space requirements for the expression of normal behaviours in brown and white hybrid laying hens (Riddle et al., 2018).

Behaviour	Space required (cm^2)	
	Brown birds	White birds
Standing	670	572
Lying	631	558
Perching	25	20
Dustbathing	1190	1028
Wing flapping	2841	3446

It is important to point out that the space required for a single movement by a single hen is not sufficient to base recommendations on space requirements, because hens have a tendency to synchronise their behaviours, and space requirements also include longer distance movements (e.g., running and flying) to access resources such as food, water, perches and nest boxes[19].

Multi-tier barn systems provide an increased space allowance per hen, including functional areas, but it is important to consider space allowance as both the total useable space (defined as at least 30cm wide with a floor slope not exceeding 14% and 45cm headroom; Council Directive 1999/74/EC) and the total floor space (length x width of the shed) available so that all hens can access the floor area without the stocking density becoming too high. The latest EFSA recommendation for a maximum stocking density for adult laying hens is four birds per m^2 (compared to the legal maximum in the EU of nine birds per m^2) based on an 'expert knowledge elicitation' (a quantitative assessment modelling the effect of space allowance on plumage damage the ability of hens to walk, scratch and peck) and a behavioural space model (a quantitative approach to determine how stocking densities are relates to motivated behaviours)[13]. This stocking density was determined to effectively reduce the risk of plumage damage and allow unconstrained performance of motivated behaviours – including those which take up the most space e.g. wing flapping[13]. It is recommended that in multi-tier systems birds have access to all of the tiers, including the space underneath the first tier, at all times. In addition, providing a covered veranda (wintergarden) for birds (in appropriate climates) will reduce the indoor stocking density during daytime periods – which is when hens are the most active – and allows birds to have the choice between different temperatures and light conditions[13]. In order to maximize the welfare benefits associated with the additional space it provides, the area of the veranda should not be included in the stocking density calculation. Free-range systems provide even greater additional outdoor space for hens (typically $4m^2$ per hen).

4.3.2 Nesting

Generally, hens prefer to lay in a discrete enclosed nest[123,124] with loose material such as straw[125]. The nest must be perceived as attractive and there must be sufficient numbers to service the number of hens in the house. The absence of nest boxes, or preventing hens from expressing nesting behaviour has negative effects on the welfare of hens, including frustration and vent pecking[126,127].

Commercially, group nests are enclosed on three sides with front curtains and a plastic grid or perch in front; there is a roof, and the floor is sloped (12 to 18%) and covered usually with Astroturf[R] or simple rubber matting. Front curtains are an important component of group nests[128]; more settled pre-laying behaviour and nest-building was found to be carried out in nests with flaps[129] and curtains allowed for hen investigation along the length of the nest[130]. A floor slope of 12% was recommended[130] as more hens were observed in the nests, with more sitting events and better alignment (back to rear of nests for egg roll away) than in nests with slopes of 18%. Additionally, a greater number of visits led to egg laying[130]. Integration of nests into the aviary (in the centre of the building as opposed to against a wall) led to a more even use of nests[131]; hens tended to prefer nests high up when mounted against the wall and facing the walkway when integrated onto an aviary. Corner nests and nests closest to the entrance were preferred and the authors recommended the platforms in front of the nests be more than 30cm wide to promote use of nests[131].

Nest site attractiveness, such as a preference for nest boxes in corners[132] and nest boxes on the ends of rows[133], and social facilitation (hens observing other hens carrying out the behaviour) can lead to gregarious nesting (where hens choose a nest that is already occupied even when there are other empty nests available)[134]. This is problematic as it can lead to smothering[134] and aggression between hens[135]. It can also result in hens not being able to perform pre-lay behaviours and increase the number of eggs laid outside of the nest[136]. Nests that are in elevated locations are preferred to nests on the ground floor[79]. Enhancement of nests in less preferred locations, for example, the addition of preferred nesting material (e.g., straw[125]) has been suggested as a possible solution to achieve increased utilisation of nest boxes. Hens are found to prefer nests with soft, deformable flooring[30]. Group nests should not be too large to ensure they provide a sense of enclosure to cater for the egg-laying preferences of hens[137]. The addition of a central partition to commercial group nests can make the nests more attractive to hens[138].

Introducing nest boxes into the latter stages of pullet rearing helps to train the young hens to use the nest box and is vital to reduce the number of eggs laid on the floor, which can be an issue in cage-free systems. Floor eggs create additional work for farmers collecting them by hand and are a source of economic loss as they are usually dirty or broken, meaning fewer saleable eggs[139–141]. The prevalence of floor egg laying is variable in prevalence across systems, flocks and individuals[142–147]. Factors contributing to floor egg laying include individual preferences, strain, design of the housing system, management of the system and pullet training (reviewed in [148]). Non-optimal nest use results in floor eggs, with hens trying to lay in occupied nests (gregarious nesting) that are more attractive, such as more secluded nests, corner nests or the higher nests[79,133]. The incidence of floor eggs can be mitigated by improving the attractiveness of nests, as discussed above.

4.3.3 Foraging

Hens are highly motivated to forage even when provided with adequate food[149]. Foraging behaviour was performed significantly less in furnished cages than in barn systems (5.4% of the time compared to 16.6%, respectively[25]), indicating opportunities to forage are inadequate in furnished cages. Cage-free systems can provide opportunities for hens to forage, by providing dry, friable litter, and the range in free-range systems.

Designing and managing systems that allow hens to fulfil their behavioural need to forage are crucial in reducing the risk of injurious pecking and the need for beak trimming (detailed in the next section).

4.3.4 Injurious pecking

Injurious pecking refers to forms of pecking that cause injuries, including feather pecking, vent pecking, and toe pecking. Injurious pecking can result in overall plumage loss, damage to skin, poor thermoregulation, increased risk of infection and increased mortality[150–153]. The prevalence of injurious pecking has been estimated to be 23.8% at 61 weeks of age in free-range flocks in France[154]. However, injurious pecking is highly variable between systems, husbandry conditions and countries, ranging from 15-95% of birds affected during an outbreak[36].

4.3.4.1 Feather pecking

Severe feather pecking involves hens pulling, removing and sometimes ingesting the feathers of other hens[155]. It is thought to be the result of redirected pecking due to frustration at not being able to fully express normal foraging, comfort and exploratory behaviours[3,36]. For example, there is an inverse relationship between foraging and feather pecking[156,157]. Other factors which contribute to feather pecking include high light intensities[158], poor air quality[158,159], use of bell drinkers rather than nipple drinkers[150] and infection with red mite[146].

4.3.4.2 Vent pecking

Vent pecking occurs often in flocks with a high prevalence of feather pecking and cannibalism[160,161] and can result in serious injury and death. It is associated with feather pecking and egg laying when hens lay outside of nest boxes or at elevated positions with their cloaca region exposed to other birds[160,161].

4.3.4.3 Toe pecking

Toe pecking can be a self-directed behaviour or directed towards other birds. It is directed at toes, leading to wounds and in serious cases the loss of toes[162] and mortality[163]. Toe pecking has been found to increase stress responses in the victims and increase fearfulness, causing toe-pecked birds to reduce their use of elevated structures[164]. It can be seen more often in white hybrids than brown and therefore may have some relationship to the strain/ hybrid[117]. The causes are not yet understood and are likely multi-factorial, but aggression results from competition for resources, which includes for females in breeder flocks[13].

4.3.4.4 Beak trimming

Due to the serious consequences of injurious pecking, beak trimming is widely employed as a management technique to reduce the prevalence and severity of damage caused. Injurious pecking is less prevalent within beak-trimmed flocks and performed at lower rates when compared with intact-beak flocks[165,166]. However, beak trimming is likely acutely painful for hens, evidenced by increased heart rate[167], discharge from peripheral trigeminal afferent nerve fibres during and after trimming[168] and changes in behaviour, such as decreased activity and food intake[169]. Therefore, beak trimming is a welfare concern of its own as the mutilation causes soft tissue damage resulting in pain and loss of function[13]. Preventative methods to reduce injurious pecking outbreaks should instead be used and remove the need to beak trim.

4.3.4.5 Preventative methods to reduce injurious pecking

The provision of substrates to promote foraging and exploratory behaviours and reduce frustration, for example, hay bales, pecking substrates and blocks and dry litter on the floor with feed scattered throughout are recommended[170–173]. in order to reduce injurious (feather and vent) pecking outbreaks[152,153]. To avoid vent pecking, perches must be high enough[161] and there should be a sufficient number of attractive nests provided to reduce birds laying eggs outside of the nest. Multi-tier systems and systems with a veranda[174] and outdoor range access[171,175–177] provide more opportunities for hens to avoid and move away from birds that are trying to peck, improving plumage and reducing the likelihood of feather pecking.

Injurious pecking may occur during the rearing period as well as during laying[154,178,179]. Rearing pullets at lower stocking densities, providing sufficient fibre, early access to perches, dry litter and continuous provision of quality environmental enrichment items are found to reduce the risk of pecking developing early in life[151,171,180–189]. Also, provision of dark brooders (panels suspended above the floor equipped with heating elements, and surrounded with black, plastic fringes to block out the light) is found to effectively reduce injurious pecking both during rearing and adulthood[190–193]. Lastly, matching pullet housing to the laying system to allow early adjustment to the laying environment prior to the onset of lay also reduces injurious pecking[194,195].

4.3.5 Comfort behaviours

Hens prefer fine particles like sand in which to dustbathe[196]. Hens require between 1000-1190cm^2 to be able to perform dustbathing[18]. Hens are motivated to dustbathe when they observe other hens dustbathing (i.e., social facilitation)[197,198]. Therefore, it is important in cage-free systems to provide sufficient space for hens to dustbathe simultaneously, as well as providing an optimal substrate. Dustbathing involves the hen lying down and tossing loose substrate onto her back and wings, rubbing the substrate into her feathers and shaking it out. This combined with preening removes grease and dirt from the feathers and helps keep the plumage in good condition[199]. Preening is considered to be a comfort behaviour and is performed when birds are in a relaxed state[200]. A longer duration of preening is an indicator of positive welfare associated with a preferred environment[201], and is positively associated with high feed efficiency[202], and reduced aggression[203]. Wing flapping can occur during dustbathing, and it is associated with a positive emotional state as hens are found to show more wing flapping in anticipation of a reward[204].

In the absence of a suitable substrate in sufficient quantity or due to a lack of early experience of substrate, hens are found to perform sham-dustbathing[205]. While hens can exhibit 'going-through-the-motions' of a bathing routine, sham-dustbathing is not considered effective or particularly rewarding for the hen[206] as it does not fulfill the functions of dustbathing[207]. For example, hens performed similar amounts of dustbathing and preening in furnished cages (7% preen, 2.5% dustbathe) as they did in floor and aviary housing systems (6% preen, ~4% dustbathe), however, most of the dustbathing in furnished cages was sham-dustbathing[25]. Therefore, it is vital to provide optimal substrate that is dry and friable, such as sand, to support dustbathing.

4.3.6 Perching

Hens are strongly motivated to seek elevated structures for sleeping or resting[24,208–212] and they become agitated if roosting is prevented[24]. Elevated structures for perching can reduce fearfulness and promote resting behaviour[213]. Provision of aerial perches in commercial free-range houses has been found to reduce levels of aggression and fearfulness and improve body condition[213].

In cage-free systems, perches can be provided, however, issues can arise. Perches should be elevated from the floor so that birds cannot peck perching birds from below and resting birds are not disturbed by active birds below. For night-time roosting, birds show a preference for perches higher than 60cm[99]. Hens prefer perches on the higher tiers for roosting at night, which can result in welfare risks from overcrowding of the higher tiers even when the total amount of perching space available is deemed sufficient e.g., by legislation[212,214]. It is recommended to provide a minimum of 18cm per layer and layer breeder (compared to the EU legal minimum requirement of 15cm per bird which is likely not sufficient[18]), and 14cm per pullet[13] and preferably 22cm (e.g. [18,215]). Perch design is important for keel bone integrity and foot health (see previous sections). Also, it is important to consider strain when designing perches as there is evidence that different strains (e.g. conventional versus dual-purpose) have differing preferences for heights of perches and location within the house[53].

4.3.7 Ranging

Free-range systems provide hens with enhanced opportunities to express their behavioural repertoire, including foraging, dustbathing, wing flapping and running[120,216]. Ranging behaviour is affected by time of day, age, feeding system, weather conditions, previous experience, genetic strain, and importantly the quality of the outdoor environment provided. Extensive locomotion is observed in aviaries and free-range systems, with birds moving 1800m and 2500m per day, respectively[217]. The variations in the use of the outdoor area between farms can be explained by climatic conditions, range design (in particular the presence of natural or artificial cover) or stocking density, while intra-flock differences appear to be related to personality and experience of the hens[218]. Although range use differs considerably between individuals within a flock[219,220], a very large percentage of hens go outside at least some of the time (>95%[219,221–223]).

Ranging decreased with increasing wind speed and precipitation[224,225]. Studies in northern/western Europe typically report an average proportion of birds observed on the range of 9-13%[224,226,227] but higher levels have been reported in more favourable climatic conditions, e.g., 32.6% of the flock in a study of three farms located on the north coast of the Basque Country in Spain[228] and an average 35% of the flock located in Germany[229]. Heat and cold stress need to be carefully monitored in a free-range system. Hens may be susceptible to thermal stress due to being exposed to variable weather conditions and pop holes disrupting the indoor climate of the house. On the other hand, the range may reduce thermal stress by offering choice between different climatic conditions and reducing the stocking density within the house[218].

The proportion of hens on the range is found to decrease with increasing flock size[226,227,230] and this effect is particularly marked when looking at flock sizes in the hundreds compared with those in the thousands, e.g. 42% with a flock size of 490 compared with <12% for flock sizes of 1500-2500[231]. Ranging was reduced with increasing stocking density indoors[226] and outdoors[232]. Small flock sizes may promote greater use of the range[218].

Hens may prefer to remain close to the house; one study found that a high proportion (~70%) of the hens outside tended to stay close to the house[233]. However, for hens that venture >50m from the shed, they engage in more walking and foraging behaviour and may have better feather condition[227]. Rodriguez- Aurrekoetxea and Estevez[228] reported improved feather condition and lower levels of footpad dermatitis in hens with a higher frequency of range use. Access to an outdoor range is found to improve footpad health[98,117] and reduce the risk of injurious pecking outbreaks[171,175,177,234].

Range use is enhanced with the provision of trees, bushes, and artificial shelters with a sand floor for dustbathing[177,233]. Shelter provides shade and protection from wind, rain and overhead predators, and provides a more favourable environment for the hens than just an open grassy area. Similarly, verandas can provide a useful intermediate zone between the indoor and outdoor environment, reducing thermal and sensory contrast, encouraging hens to venture outside. Provision of tree cover on the range may also have economic benefits by improving certain production traits[235].

Hens that use the range more frequently are found to be less fearful than those using the range less frequently or not at all[221,236]. Regular exposure to an outdoor environment at an early age reduced fearfulness in laying hens, and those birds seen frequently outdoors were less fearful than those staying indoors[237,238]; providing free-range experience is therefore important for pullets destined for free-range laying systems.

Table 3. Summary of recommendations to address the most common welfare issues related to laying hens' behavioural expression in cage-free housing systems.

Welfare consequence		Housing system	Recommendation
Sufficient space		Single-tier, multi-tier	Increased space allowance, taking into account total useable space and total floor space e.g., 7 hens/m^2 of total useable space, 15 hens/m^2 of total floor area, functional areas, outdoor access (free-range system)/ veranda
Ability to nest		Single-tier, multi-tier, free-range	Enclosed nests, flaps at the front of nests, elevated nests, sloped (12%) floors, nesting material (e.g., straw), enough nests for the flock
Expressing foraging behaviour		Single-tier, multi-tier, free-range	Dry friable litter at least ideally >560cm^2 available per hen, pecking substrates, outdoor access/ veranda
Injurious pecking	Feather pecking	Single-tier, multi-tier, free-range	Dry friable litter, outdoor range/ veranda, pecking substrates, natural light, good ventilation, feeding mash and fibre, dark brooders (pullets)
	Vent pecking	Single-tier, multi-tier, free-range	Dry friable litter, outdoor range/ veranda, pecking substrates, perch design (high so perching birds cannot be pecking from below), nest design and number (to encourage laying in nests), feeding mash and fibre, dark brooders (pullets)
	Toe pecking	Single-tier, multi-tier, free-range	More research is needed, but dry friable litter, pecking substrates, natural light, good ventilation, feeding mash and fibre, dark brooders (pullets) are advisable for other forms of injurious pecking
Expressing perching behaviour		Single-tier, multi-tier, free-range	Sufficient space (minimum 18cm, preferably 22cm per hen), optimal perch design (>60cm high, soft, round perches, width 3-6 cm, step-wise design)
Expressing ranging behaviour		Free-range	Lower stocking densities and flock sizes, shelter and shade (e.g., trees or verandas), grass covered range

4.4 Mental wellbeing

Hens are able to experience complex negative and positive emotional states, which are measured by behavioural and physiological changes[239,240]. Most of the work on hens has concentrated on negative states such as frustration, pain, stress and physical restrictions (as discussed in earlier sections). However, positive experiences, such as pleasure, play and social bonding, are equally as important as the absence of negative experiences in order for animals to have a good life[241–243].

4.4.1 Negative emotional states

Chickens likely experience pain[244] as nociceptors are expressed throughout their body[245,246] and they elicit a behavioural response to painful stimuli such as feather removal[247]. Most work investigating pain in hens has been associated with beak trimming[169,244,248,249] and osteoporosis and bone breaks, including keel bone damage[81,86] (as discussed in earlier sections). To reduce hens experiencing pain in cage-free systems, management methods to minimize injurious pecking and improve skeletal health (discussed earlier) should be implemented.

Stress negatively affects the mental wellbeing of hens, as well as impacting productivity, for example, heat stress is found to decrease egg production[250–252], and stressed chicks went on to have more feather damage and injuries as adults[253]. Common environmental stressors that should be considered in cage-free systems include high stocking density, changes in management practices, changes in social interactions or changes to resource access, and can result in increased corticosterone concentrations and behavioural changes[232,254–256].

In cage-free systems, providing good quality environmental enrichment can reduce negative states. Enrichment can improve hens' ability to cope with stressors; hens housed in an enriched environment had reduced startle responses compared to control hens[257]. Also, early enrichment was found to increase visits to the range and reduced corticosterone concentrations indicating improved adaptation to environmental stressors[232].

Table 4. Summary of recommendations to address the most common welfare issues related to laying hens' mental wellbeing in cage-free housing systems.

Welfare consequence	Housing system	Recommendation
Frustration	Single-tier, multi-tier, free-range	Sufficient space, environmental enrichment (perches, pecking substrates, litter, outdoor access/ verandas)
Fear	Single-tier, multi-tier, free-range	Early exposure to the housing system/ range, environmental enrichment
Pain (beak trimming, bone fractures)	Single-tier, multi-tier, free-range	Environmental enrichment, breeding for better bone health, optimal perch and house design
Stress	Single-tier, multi-tier, free-range	Lower stocking densities, sufficient space allowance, environmental enrichment

4.4.2 Positive emotional states

Exploratory behaviour (foraging and feeding behaviour in poultry) is thought to be one of the best indicators of positive welfare in various species and it is rewarding[258]. Perching likely induces positive emotional states and represents a positive cognitive enrichment for hens[259]. Comfort behaviour is rewarding and associated with positive affective states in multiple species including laying hens[258]. Different comfort behaviours are often synchronized such as dustbathing (e.g., in hens with outdoor access)[197] and preening[260]. Synchronisation is proposed as an indicator of positive welfare in group-housed, gregarious animals[258,261,262], and it is important as it can promote positive welfare throughout an entire group by using a few individuals[258,262].

4.5 Measuring welfare of laying hens

It is important to assess the welfare of animals using animal-based outcomes to determine their physical and mental wellbeing and behavioural expression[263]. Animal-based outcomes are measures made directly on the animal or from farm records[264]. The provision of certain resources (e.g. outdoor access, environmental enrichment) in cage-free systems can increase the welfare potential of that system, but these systems also need to be well managed in order to deliver good welfare. Therefore, to ascertain that cage-free systems with a higher welfare potential actually result in good welfare, welfare must be measured using animal-based indicators. A robust welfare outcomes monitoring programme will help identify any welfare issues and drive continuous improvement. Recently EFSA have identified important animal-based measures for laying hens, including 'iceberg indicators' which are welfare outcomes which can have multiple causes, such as injurious pecking, plumage damage, and wounds[13].

Assessment protocols, such as the Welfare Quality® (WQ®) project, have been developed based on animal welfare frameworks (e.g. the Five Freedoms or Five Domains), to provide a detailed overview of animal welfare as well as indicating the causes of the welfare state measured[265]. However, such extensive welfare assessment protocols can be time consuming and require specific training. Other protocols have been developed to require fewer measures and be more practical, such as the AssureWel project. Qualitative Behaviour Assessment (QBA)[266] is another assessment protocol and is used in the Welfare Quality Assessment protocol for laying hens, as an indicator of both negative and positive welfare[267].

The main welfare measures recommended for laying hens are disease incidence, keel bone fractures, feather cover, mortality and flock behaviour (e.g. fearfulness). Other measures include feather cleanliness, foot pad dermatitis and beak trimming. These measures can be scored using AssureWel[268], and LayWel[269] protocols. Behavioural measures can be made, including dustbathing, ranging, perching, foraging (indicators of positive emotional states) and aggressive and injurious pecking and smothering (indicators of negative emotional states)[270].

4.6 Conclusion

While cage-free housing systems for laying hens have a higher welfare potential compared to caged systems, there are still welfare problems, such as disease outbreak, feather pecking and keel bone fractures, which can occur in these systems. Ensuring good welfare in cage-free systems requires the right combination of house design, genetics, rearing conditions and management to allow hens to express their behavioural preferences (e.g. perching, dustbathing and foraging), support good health and normal biological functioning (e.g. providing clean, dry litter and sheds designed to minimise injuries) and promote positive mental states (e.g. through exploration of an outdoor range) while minimising negative experiences (e.g. reducing stressors).

4.7 References

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