# Welfare issues with furnished cages for egg-laying hens

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# Contents

# Abstract

**FURNISHED CAGES** were developed in response to criticisms about conventional battery-cage confinement of laying hens in commercial egg production. Battery cages—small, barren, wire enclosures—restrictively confine the birds, depriving them of the opportunity to display many important patterns of behavior. In contrast, furnished cages are typically equipped with a nest box, perch, and dustbathing area, thereby providing more behavioral outlets than conventional cages. However, similar to conventional battery cages, furnished cages provide an unacceptably limited amount of space per bird; prevent many important locomotory activities, including running, jumping, flying, and wing-flapping; and constrain perching, dustbathing, and nesting. The severe locomotory restriction of cages also prevents hens from obtaining normal amounts of exercise, which in turn leads to poor skeletal strength and other pathologies. While allowing for some natural behavior denied in conventional cages, furnished cages remain unable to adequately provide for an acceptable level of welfare for hens kept in commercial egg production.

# Egg Production Systems

Battery cages are small wire enclosures that afford each hen as little as 432.3 $cm^2$ (67 $in^2$),[1] an amount of space smaller than a single sheet of letter-sized paper. These cages are placed side by side in rows and stacked in tiers commonly 4-8 levels high in industrial egg production operations. Each cage may hold 5-10 birds,[2] and hundreds of thousands of hens may be confined within a single building. Battery cages are barren and invariant environments,[3] and the welfare of caged hens is severely comprised.

**Battery Cages**

Although battery cages have been sharply criticized by scientists for many reasons,[4] among the most significant is their severe restriction of movement. Battery-caged hens are not only unable to display many of their natural behavior patterns, such as nesting, perching, dustbathing, scratching, foraging, exploring, and engaging in comfort movements, including wing-flapping, they are also prevented from receiving adequate exercise. This relative inactivity compounds the severe osteoporosis and accompanying propensity for bone fractures that most egg-laying hens endure.*

**Furnished Cages**

Furnished cages (also known as enriched, colony,[5,6] or modified cages) were developed as an attempt to improve conventional cages by providing outlets for known strong behavioral priorities.[7] Furnished cages are similar to battery cages except they typically include a nest box, perch, litter area for dustbathing, and greater height. While they do allow caged hens to engage in more natural behavior, furnished cages do not enable hens the freedom of movement and environmental conditions necessary to achieve an acceptable level of welfare. Specifically, in a study requested by the European Parliament, the inability to forage and perform dust bathing were listed as two of the main factors to consider in the transition to cage-free systems.[8]

Furnished cages were common in Europe, including the United Kingdom, Denmark, Sweden, Norway, and Germany,[9,10,11] but their use is declining in many EU member countries.[12] In 2023, the number of laying hens in the European Union was 387 million and from those, 39.2% were hens housed in furnished cages with a range of variability in use from 0% in Austria and Luxembourg to 97.2% in

* For more information, see "An HSUS Report: A Comparison of the Welfare of Hens in Battery Cages and Alternative Systems" by Drs. Shields and Duncan at www.hsus.org/farm/resources/research/practices/comparison_hen_welfare_cages_vs_cage_free.html.

Malta.[13] Furnished cages are not commonly used in the United States.[14] As of April 2024, 62.9% of the U.S. laying hen flock was caged birds,[15] but these are primarily battery cages. The remainder are kept in cage-free aviary, free-range and pastured range systems. In Canada, in the first half of 2023, 34% of laying hens were kept in furnished cages, increasing by 16% since 2019.[16]

Size and design of furnished cages vary, with 10-12 birds in smaller models, 15-30 in medium cages, and 60 in the largest.[17] Although the arrangement of furnishings varies between different cage models, the nest box is usually situated to one side or in a corner, and the dustbath—typically a box or mat with added litter—is placed to one side or on top of the nest box.[18] There may be one perch running parallel to the feed trough, multiple parallel perches, a T-shaped perch arrangement, or perches running cross-wise, both parallel and perpendicular to the cage front.[19] Directive 1999/74/EC of the European Union stipulates that each bird in a furnished cage be given at least 600 $cm^2$ (93 $in^2$) of usable space in addition to the space within the nest box itself, totaling 750 $cm^2$ (116.3 $in^2$ or 0.81 $ft^2$) of space per hen.[20]

**Cage-Free Aviary**

Cage-free alternatives already in use worldwide include barns and free-range systems. In barns, hens are not afforded outdoor access, but are provided with nest boxes and often perches and areas with loose substrate (litter) for natural dustbathing, scratching, and foraging behavior. Structurally, they may be single or multi-level. Multi-level barns are also known as aviaries. The different levels in aviary systems utilize vertical space within the building and enable hens to move between multiple different tiers. Stocking densities vary—e.g., the EU legal directive stipulates that each bird should be given 1,111$cm^2$ (172.2 $in^2$ or 1.2 $ft^2$) of space per hen[21] and U.S. egg industry guidelines require 929-1,393.5 $cm^2$ (144-216 $in^2$ or 1-1.5 $ft^2$) per bird, depending on the space provided on perches and elevated levels within the barn.[22] Free-range systems, whether small, backyard flocks or large-scale production operations, generally provide both a protected indoor shelter or barn area, as well as outdoor access.

Conventional, unenriched cages became illegal in the European Union in 2012.[23] Under this legislation (Council Directive 1999/74/EC), furnished cages are still permitted; however, the "End of the Cage" petition initiated in 2018, supported by over 170 animal welfare organizations and 1.4 million citizens[24] seeks to forbid all types of caged systems for farmed animals, including furnished cages.[25] Several EU countries have already banned furnished cages, along with several U.S. states (see Annex).

# Welfare Concerns with Furnished Cages

Compared with cage-free barn, aviary, and free-range systems, furnished cages are inadequate. Space allowance in both the horizontal and vertical dimensions of the enclosure impedes movement, limiting important natural behavior. As well, the restrictive design of furnished cages prevents the hens from exercising, leading to disuse osteoporosis, liver pathology, and skeletal weakness, which leaves hens prone to skeletal fractures during depopulation, when they are removed from the cages. Further, scientific evidence suggests that birds kept in cages are more fearful of other birds and of

employees, compared to hens in cage-free environments. Though there are very few studies that directly compare furnished cages to cage-free systems,[26] many studies demonstrate that sizable problems related to cage confinement are unaddressed by modifying cages with additional furnishings.

## Lack of Space

While slightly more spacious than typical battery cages, the amount of space allocated to each hen in a furnished cage is still deficient. Furthermore, despite official space requirements, there is evidence that some egg producers are not in compliance. In 2021, the European Commission's Directorate for Health and Food Audits and Analysis evaluated the effectiveness of official animal welfare controls for lying hens. This was the first audit after the ban of unenriched cages. During this project it was found that the main weakness in the official welfare controls for laying hens is the miscalculation of the maximum stocking density of cages, causing regular overstocking in farms. This was attributed to several causes including calculating stocking density with the birds present, but disregarding the initial number of birds; relying on the operator's declaration regarding housing plans without checking for further changes; and officials including the nesting area and other features as usable space when they are not continuously accessible.[27] Despite official space requirements it is highly likely that birds living in furnished cages have lower space availability than intended.

Even if each bird has access to 600 $m^2$ as required by the EU regulations, this space is insufficient for most birds. A study calculated the amount of space needed by four of the most popular laying hen strains to perform basic behavior. It was found that Hy-Line, W36 and DeKalb White birds needed between 573 to 567 $cm^2$ (88.8 to 87.8 $in^2$) to stand normally, whereas Hy-Line Browns and Bovan Browns needed between 649 to 670 $cm^2$ (100.6 to 103.8 $in^2$). Likewise, white birds needed between 538 to 559 $cm^2$ (83.4 to 86.6 $in^2$) to lay down (defined as sternal sitting or recumbency on the floor with the head held above the level of the body in relaxed position) whereas browns needed between 630 to 632 $cm^2$ (97.6 to 97.9 $in^2$).[28] Thus, although 600 $cm^2$ (93 $in^2$) of usable space per bird seems to be enough for white birds to stand and lay, it is not enough for brown strain to comfortably adopt basic body postures.

Lack of space can a negative impact on feather coverage. Poor feather coverage reduces hens' ability to thermoregulate and increases susceptibility to further injury.[29,30] A 2019 study that compared hens raised in furnished cages at different stocking densities found that at industry typical space allowances, birds had poorer feather coverage in the keel and back body regions. Keel feather loss was attributed to cage abrasion during feeding, sitting, and entering the nest box.[31] Similarly, another study comparing feather condition and other welfare indicators in conventional and large and small furnished cages found that birds in larger furnished cages had better feather condition as well as better gait score, which was attributed to the opportunity to perform more preening, walking and other activities. In this study, the space per bird (645 $cm^2$ or 99.9 $in^2$) and the height of the enclosure in larger furnished cages was higher compared to small furnished cages (600 $cm^2$ vs 645 $cm^2$ floor space and 100 cm vs 45 cm high / 93 $in^2$ vs 99.9 $in^2$ floor space and 39.3 in vs 17.7 in).[32]

The dynamics of crowding and space utilization in large-scale, commercial production are complex. However, critical thinking by scientists about the space needs of hens and other animals has revealed interesting insights about space availability in various enclosure sizes. Because animals can time-share space (i.e., use the same spatial locations at different times) in large enclosures, there is more functional area for the display of behavior, although local crowding may occur in floor systems.[33,34] Further, hens are not stocked as densely on cage-free operations,[35,36] so the overall space allowance is far more generous than in conventional or furnished cages. This allows more freedom of movement for behavioral expression and movements that serve to provide exercise.

## Constraints on Behavior

Cages of all types prevent the full expression of many critical natural behavior patterns. Walking and exploring are reduced;[37,38] perching is constrained by the cage height,[39] and locomotory behavior such as running, jumping, flying, and wing-flapping are prevented completely. There are also concerns about whether dustbathing can be fully accommodated in the limited space provided in a furnished cage[40] and whether the EU directive's requirements for nesting space in furnished cages is adequate.[41] In contrast, cage-free facilities allow hens to move over greater distances and often between different levels,[42] provide more choices for nesting space, and usually feature larger littered areas. As such, cage-free operations better accommodate the behavioral needs of hens than conventional as well as furnished cages.

### *Perching and Roosting*

Birds require both vertical and horizontal space for behavioral expression, particularly at night when, under natural conditions, chickens perch in trees.[43,44] Roosting, an ancient behavior pattern shared by ancestral Jungle Fowl,[45] is thought to protect birds from predation during resting hours.[46] Studies have shown that hens prefer perches that are placed higher off the ground than those that are closer to the floor.[47,48,49,50] In a cage, however, this is severely limited by the distance from the floor to the ceiling, while in cage-free facilities, there is much more vertical space to include elevated perches. In a furnished cage, perches are generally situated only 6-8 cm (2.36-3.15 in) above the cage floor.[51] The cage height requirement in EU legislation is a minimum of 45 cm (17.7 in); however, research has shown that when caged hens were tested, they "shunned" any cage height of less than 46 cm (18.1 in).[52] The cage height requirement was debated during drafting of EU directive 1999/74/EC, and some scientists and political leaders argued for a higher minimum than what was legislated.[53] Feather pecking is an abnormal behavior performed by laying hens that may result in injury.[54] The etiology of feather pecking is complex, and numerous factors are thought to influence its prevalence, but it is related to frustrated foraging attempts.[55] To reduce injurious pecking in commercial egg production systems, the end 1/3-1/2 of the birds' beaks are routinely cut off with a heated blade[56] or infrared laser treatment[57] shortly after the birds hatch. If positioned high enough, perches can protect hens from feather damage caused by injurious pecking, as hens standing on the floor are unable to reach those who are perching.[58] In contrast, perches in furnished cages are not elevated off the cage floor high enough to offer the same protection. As a result, feather pecking can lead to vent cannibalism and subsequent high mortality in hen flocks with intact beaks.[59]

Hens use perches of different heights for different types of behavior, tending to stand or walk on lower perches, while sitting or sleeping on higher ones. Both lower and higher perches can be offered in cage-free environments to accommodate this behavioral differentiation, whereas furnished cages can provide only low perches.[60] In one study, hens in non-cage systems with both low and high roosting locations made use of the perches more during the day compared to hens in furnished cages.[61] This suggests that the proximity of the perches to the cage floor in furnished cages may make them less attractive.

Perching linear space provided in furnished cages has also been contested. According to the European Union Council Directive 1999/74/EC, a minimum of 15 cm (6 inches) of perching space in furnished cages is required.[62] However, a recent study found that some popular white and brown laying hen strains use between 18 and 22 cm (7 to 8.6 in) on average to perch comfortably. The narrowest hens in this study were DeKalb Whites and the widest were Hy-Line Brown. If 15 cm/hen (6 in) were provided, only 83% of the DeKalb White hens and 68.5% of the Hy-Line birds would be able to perch simultaneously.[63] This was considered a potential welfare problem, since 90 to 94 % of birds prefer to perch at night in furnished cages.[64]

### *Exploratory Behavior*

Hens are naturally inquisitive, curious animals, but furnished cages do not allow the full expression of exploratory behavior,[65] an activity scientists have identified as important to animals in many ways. Exploration creates opportunities to express agency and improve competency, satisfies the motivation to acquire information about the surrounding environment, and is also an end in itself.[66,67,68] It has been suggested that exploratory behavior is a behavioral need of hens.[69]

Complexity in cage-free systems offers more opportunities for hens to engage in exploratory behavior,[70] and this is particularly true of free-range facilities, as the day-to-day changes in an enriched outdoor environment offer a degree of diversity and novelty that indoor conditions cannot provide. The rich outdoor environment stimulates exploratory behavior and elicits pecking and scratching,[71] satisfying the biological drive to investigate, manipulate, and interact daily with a variety of natural stimuli. In contrast, cage confinement can lead to greater inactivity: Hens confined in furnished cages spend more time simply standing and sitting than birds in non-cage systems.[72]

### *Dustbathing and Foraging*

In the European Union, cage-free systems must supply litter over at least one-third of the floor space.[73] This requirement, coupled with the stocking density requirement discussed above, provides more litter availability[74] and room for the display of scratching, pecking, and dustbathing behavior compared to furnished cages in which litter is sparse.[75] The total floor space available for these activities is variable but often quite limited.

Studies of dustbathing in furnished cages have reported a variety of results. In one study, only 26.7% of dustbaths were actually performed in the area provided within the enclosure, with the rest displayed on the wire cage floor. When access to the dustbath was restricted during the peak egg-laying period, the percentage dropped to 8.3%.[76] Conversely, in another study of the same type of furnished cage, all dustbathing occurred in the dustbath.[77] A 2008 study of litter types in furnished cages found that the use of the dustbathing area was highly variable, with some hens visiting the dustbath a great deal and others not at all.[78] This may indicate that for some hens, the dustbath provided in furnished cages is somehow inadequate.

One possibility is that there may be competition for the limited dustbathing area in a furnished cage. Dustbathing is normally a social activity, and the sight and sound of dustbathing hens are triggers for other birds who observe the behavior.[79] In a furnished cage, where there may be space for only one[80] or two[81] individuals, multiple birds attempting to gain access at the same time can lead to crowding in the dustbath.[82] A recent study evaluating the amount of space a bird needs to dustbathe found that four popular strains of laying hens needed between 1,003 to 1,191 $cm^2$ (155.4 to 184.6 $in^2$) with an average width and length of 25 to 28 cm (9.8 to 11 in) and 39 to 44 cm (15.3 to 17.3 in), respectively. Evaluation was made using still photos, thus the authors noted that the space used to dustbathe could be greater than the area reported since birds extend their wings and legs and change the position of their bodies frequently, as well as move around the litter areas when the dustbath bout is completed.[83] If the minimum average area required for dust bathing is 1,003 $cm^2$ (about 155.46 $in^2$) any litter space provided below this number would not be adequate. Furnished cages have a usable area of 600 $cm^2$ (93 $in^2$) per bird, thus providing insufficient space to perform dust bathing, even for the bird strains that occupy smaller areas for this behavior.

Hens may attempt to dustbathe on the wire cage floor if they do not have access to the dustbath.[84] Dustbathing bouts are shorter and more frequent when performed on wire flooring as compared to loose litter and differ qualitatively, with less scratching, vertical wing-shaking, and rubbing. Scientists studying "sham" dustbathing have proposed that these behavioral patterns may indicate frustrated attempts at more complete dustbathing bouts.[85]

Additionally, even when dustbathing does occur in the dustbath provided in a furnished cage, the behavior is excessive compared to dustbaths in deeply bedded, cage-free systems. In floor housing, dustbaths typically occur once every other day and last 20-30 minutes; in furnished cages, hens dustbathe in short, frequent, incomplete bouts, with more than 80% of hens dustbathing daily. Scientists have concluded that the shorter dustbaths are due to disturbance by other birds, and, as it is impossible to supply a thick layer of litter in cages, "dust bathing in cages will never be optimal."[86]

There are few direct comparisons of dustbathing in cage and cage-free systems. In a 2006 study, hens displayed more dustbathing behavior in furnished cages than in an aviary; however the observation period was short (two weeks) and began immediately after the birds were introduced from battery cages into the multi-level cage-free system, prompting the researchers to suggest that birds in the aviary may have adjusted slowly to the new, more complex environment.[87] In a 2008 study of multiple farms, there was no difference in the amount of dustbathing behavior observed in furnished cages and a cage-free system, but most of the dustbathing that did occur in furnished cages was sham dustbathing on the wire cage floor.[88] In a 2009 German study, the complete dustbathing behavior of aviary hens was expressed in a natural circadian pattern, but in contrast, hens in furnished cages displayed incomplete dustbathing patterns in the absence of the normal diurnal rhythm. The length of the dustbathing bouts was also different: In furnished cages, dustbaths lasted 4.62-4.77 minutes while in the aviary the median value for the length of a dustbath was 14.87 minutes. The study authors concluded that normal behavior was "highly restricted" in the furnished cages.[89]

Dustbaths are also difficult to manage in furnished cages. The substrate, often sand or wood shavings, may get displaced by vigorous body movements during normal dustbathing and scratching activities, and it can be time-consuming to replenish the litter manually. Dust in the atmosphere can also interfere with the bearings of drive units operating doors to the nest box and dust bath,[90] and sawdust can become lodged in automated systems.[91]

Dustbathing activity often occurs in synchronicity. In one study evaluating dustbathing in Lohmann White hens kept in aviaries, high occupancy of the litter area combined with a high percentages of hens dustbathing indicated that at some time points, large groups of birds engaged in synchronous behavior, covering most of the litter area. Therefore, it was proposed that crowding in the litter area may occur with behavior that requires space to be executed and is simultaneous.[92] In furnished cages, synchronous dustbathing is impossible, as the dustbathing space is so limited. This may be particularly problematic for white hen strains, which have been shown to be more highly motivated to dustbathe than brown birds. In one study, Dekalb White hens were more likely to dustbathe in synchronicity than birds from brown strains. In this experiment, birds had access to litter from 11:30 to 01:00, and white birds usually started to dustbathe immediately after the doors of the aviary were open, whereas brown birds were less likely to begin immediately.[93] Therefore, white bird strains might be more frustrated when access to litter in furnished cages is restricted and they are unable to perform the behavior when there is not enough space for multiple birds.

Foraging is another behavior that is vitally important to hens, as it is to many animals. Hens spend more than 50% of their daily time budget in foraging-related behavior when they are given outdoor access[94,95] and continue to forage for food even when the exact same feed is freely available in a trough.[96,97] Hens in non-cage systems display more foraging behavior and walking in the littered area compared to hens confined in furnished cages.[98] Lack of loose substrate for pecking and manipulation in certain furnished cage designs has been implicated as a causal factor in the development of abnormal feather-pecking behavior.[99] Ground-scratching, a component of natural foraging behavior, serves to wear down the claws, but the claws of hens kept on wire floors can become overgrown in cages.[100] An abrasive strip attached to the egg guard behind the food trough at the front of a cage can enable hens to maintain an appropriate nail length,[101] but is not an adequate substitute for natural foraging behavior.

### *Nesting Behavior*

Nesting behavior is so important to the laying hen that it is often used as a prime example of a behavioral need.[102] Decades of scientific evidence show that hens are frustrated, distressed, and that they suffer in conventional battery cages because there is no outlet for normal nesting behavior.[103, 104, 105, 106, 107, 108, 109] To address this need, furnished cages are equipped with nest boxes. However, the degree to which nest boxes in cages adequately satisfy the needs of hens is questionable. Hens normally remain on the nest for 1-2 hours during egg-laying under natural conditions.[110] They also usually lay their egg early in the morning, and nest box use is proportionally greater during this time period.[111] This situation may create competition for the nest box[112] when all hens need lengthy access during the same short time period.

The nest space requirement for furnished cages set forth in the EU directive stipulates that the total area per hen including the nest box is 750 $cm^2$ (116.3 $in^2$),[113] as discussed above. However, since 600 $cm^2$ (93 $in^2$) must be "usable space," this leaves only 150 $cm^2$ (23.3 $in^2$) per hen for the nesting area.[114] This space allowance may not be large enough, as crowding can occur when multiple birds try to use the nest box at the same time. When this happens, birds may struggle as they move into or out of the nest, and push or climb over each other, possibly causing feather damage.[115]

Nest site selection is also important. Hens examine several different potential nesting locations before choosing a final nesting site. In cage-free housing systems, hens are able to select from many different nest boxes, and studies have shown that hens will inspect several before making a choice.[116, 117] Hens vary in their individual preferences for different nest types.[118] They may show considerable ingenuity in accessing alternative nesting sites, sometimes even prying open the closed door to the dustbath to lay their egg in an area they find more suitable.[119] In a furnished cage, hens are highly limited in their choice of nesting sites, whereas in a cage-free system, they have much greater opportunity to lay their egg in a location they find attractive.

## Inability to Exercise and Bone Fractures

One of the most important welfare problems with cages is that they severely restrict locomotion,[120] limiting exercise. A 2018 study found that hens need between 2,823 to 3,446 $cm^2$ (437.5 to 534.1 $in^2$) to move their wings properly for wing-flapping behavior, with white birds requiring a larger area than brown birds. These numbers were greater than what was previously reported, which was attributed to the birds' younger age (28 weeks) and the fact that this study evaluated this variable in a commercial-style aviary, whereas other studies were performed in restricted testing areas.[121] Nonetheless, the smaller area reported for this activity in previous work was 1,693 $cm^2$ (262.4 $in^2$)[122] which is still much larger than the 600 $cm^2$ (93 $in^2$) of usable space required per bird in furnished cages in the European Union.

Laying hens are prone to osteoporosis. Poor skeletal bone mass of laying hens is thought to have occurred as a consequence of selective breeding to maximize egg production,[123, 124] as calcium needed for shell formation is diverted from bone.[125] The chronic lack of exercise in cages compounds problems with osteoporosis[126] and leads to bone fragility and impaired bone strength.[127, 128, 129, 130] Skeletal weakness can also lead to bone fractures.[131, 132, 133]

Although the opportunity to perch[134, 135] and the provision of added space in furnished cages improve bone strength compared to conventional battery cages,[136, 137, 138, 139] hens in cage-free systems are able to exercise more fully and subsequently have stronger wing and keel bones than hens confined in furnished cages.[140, 141, 142, 143] Scientists have found that while hens in modified cages execute more leg movements compared to those in battery cages, wing movements may still be inhibited.[144] Although one study found that bone strength of hens in furnished cages was "partly comparable" to aviary and free-range systems,[145] another study noted that any exercise caged hens are able to perform is "insufficient to prevent bone degeneration."[146]

The inability to exercise also increases the risk of developing disuse osteoporosis,[147] that is, bone loss generated by low mechanical pressure or stress on bones.[148] The development of this kind of osteoporosis due to restricted movement can lead to weaker bones and keel bone fractures.[149] In fact, when the prevalence of keel bone fractures in four system types (free-range, organic, barn and furnished cage) was investigated, it was observed that, although birds in furnished cages had the lowest prevalence of keel bone damage (36%), they also had the weakest bones when measured as peak breaking strength, particularly for the humerus.[150]

In commercial egg operations, hens are "depopulated"—removed and killed—at the end of what egg producers consider to be their productive life and replaced with new, younger birds. Hens removed from conventional cages break bones with alarming frequency. Studies report that 16-25% of hens have newly broken bones when handled and removed from cages at the end of the laying period.[151,152,153] It is thought that the incidence of bone fractures is worsened by lack of exercise,[154] because only slightly more than 10% of hens from barn and free-range housing systems suffer bone breaks when they are caught during depopulation.[155]

Despite the greater bone strength of hens in cage-free systems, they can experience bone fractures during the laying period, which are identified as old bone breaks when the hens' carcasses are examined after depopulation. Though it was thought that hens in barn and aviary systems can break bones due to collisions and falls,[156,157] as they miss a perch,[158] or as they fly down between levels, even birds in conventional and furnished cages, as well as single-level cage-free systems (where the risk of crash landings would be expected to be low) can have old bone fractures.[159,160,161] A study published in 2008 comparing furnished cages to cage-free systems found high levels of fractures of the keel bone in all systems, with greater numbers and more severe fractures in non-cage systems.[162] However, more recent research published in 2020 and 2021 compared the prevalence of keel bone fractures in Danish laying hens from furnished cages, aviaries, and free-range systems and found a similar prevalence in non-caged systems and furnished cages, with 53-100% and 50-98%,[163] respectively. More than 96% of these fractures were localized at the distal end of the keel bone,[164] which was not the expected result if bone injuries were due to collisions.

Because trauma seems to be a poor explanation for keel bone fractures, a recent study used CT scanning and histopathology to characterize these injuries in 32-week-old birds and in birds older than 75 weeks from both non-caged (deep litter) and caged (furnished cages) systems. The fractures were strikingly similar in both housing systems and the authors concluded that there is no evidence to support fractures due to external trauma since there was no soft tissue damage, which is commonly developed along with fractures.[165] Alternatively, it was proposed that the caudally located fractures may be related to the late ossification of the keel bone, which in addition to the selection for smaller birds with increased egg production could result in an increased internal biomechanical pressure on the caudal tip during the egg-laying process, creating the fracture lines observed in both systems. Furthermore, although fractures were similar in localization and appearance, macroscopical observations found that keel bone damage from birds in deep litter tended to have more substantial callus formation, whereas fractures from birds in furnished cages resembled stress fractures with no osteoblast or other elements related to healing along the fracture lines. Because of this, palpation (as used in many previous studies) would be of little use in finding these stress fractures in caged laying hens,[166] and could be why previous studies using palpation reported bone fractures in hens kept in cage-free housing systems. The study concluded that fractures in both types of housing systems may originate by a common pathogenesis (late ossification of the keel bone) and that the mobility of birds in alternative systems requires more callus formation to repair fractures compared to furnished cages.[167]

Further research investigated the difference between fracture healing in non-cage and cage systems. Thøfner and colleagues (2021) observed the keel bones and some production parameters such as body weight and egg size from 4,794 birds from 40 Danish flocks at end of lay. They found that birds in furnished cages had almost a total absence of callus along fracture lines, whereas non-caged birds

presented callus as a typical finding. Likewise, they investigated flocks of parent birds in non-caged systems and found that half of the birds from parent stock flock had ≤ 1 fracture per hen at 60 weeks old. Additionally, it was observed that greater hen body weight and later age at onset of egg laying reduced the risk of developing keel bone fractures, whereas the daily egg size at onset of lay increased such risk.Thus, it is important to recognize that bone fractures are related to factors other than housing system, such as genetic selection for smaller hens bred to produce larger eggs and an earlier onset of lay.[168] Selective breeding for improved bone strength is possible,[169,170] and would greatly improve the welfare of hens in any type of housing system.

The inability of highly productive hens to exercise, combined with the high-energy diet they receive, can lead to fatty liver hemorrhagic syndrome—an increase in adiposis, fat deposition around organs and tissues. Fatty deposits in the abdomen and around the heart can lead to hernia and circulatory disorders, respectively. In severe cases, as pressure builds up in the cells of the liver, the organ may rupture, causing the hen to bleed to death. In a direct comparison of furnished cages and an aviary system, it was found that, in agreement with previous studies, laying hens with more freedom of movement in the cage-free system were less affected by abdominal and cardiac (heart) fat mass and fatty liver.[171]

## Fearfulness

Using a variety of behavioral tests, several studies have found that hens confined in both conventional battery cages[172,173,174] and furnished cages[175] are more fearful than those kept in cage-free housing. In one study of battery-caged hens, the researchers found lower overall fear levels in an aviary system compared to conventional cages and concluded that cage-free systems would offer a higher level of welfare.[176] In another study, the scientists noted that hens can escape from barn staff and other birds in cage-free systems, and distance themselves from potential threats, whereas in furnished cages, there is limited space for avoidance of people or cage-mates.[177] This observation is key. In cages, it is nearly impossible for hens to avoid an aggressive hen or one who feather-pecks, while in cage-free systems, hens have more options for hiding or escape.[178] The opportunity for a prey animal such as a hen to exhibit a flight response when feeling threatened is likely a very important feature of their welfare.

## Potential for Injury

Complexity in artificial environments, such as furnished cages, creates more opportunity for hens to get stuck in or injured by enclosure fittings, especially if there are moving parts, such as timed doors, and as the cages deteriorate with age. Although newer cage designs have overcome some of the previous design flaws that were common in conventional cages,[179] the possibility that hens could become trapped in furnished cages is extremely troubling and unacceptable. Trapped birds who cannot extricate themselves may suffer from severe trauma or death. Scientists have noted that the trapping of body parts in this way is almost always due to cage housing.[180]

Cages may also contribute to bone malformations. For instance, keel bone deviations, which are variations from the normal straight line of keel bone development that can be horizontal or vertical and are formed over a long period of time as a response to regular loading pressures.[181,182,183] Rorvang and colleagues (2018) found that keel bone deviations increased with the age of hens housed in small furnished cages assessed at 32, 62 and 77 weeks of age.[184] The furnished cages examined had 8-10 birds and provided 750 $cm^2$ (116.2 $in^2$) In a separate study with comparable methods, laying hens housed in multitier cage-free systems had fewer keel bone deviations.[185] Thus, researchers have reasoned that the combination of weaker bones and inactivity in a roosting position is likely causing a higher prevalence of keel-bone deviations in furnished cages.[186]

## Mortality

Mortality rate is one clear and obvious indicator of hen well-being in various egg production systems, but early research reported conflicting results. For instance, while a 2008 study of six flocks in furnished cages and seven flocks in cage-free systems in the Netherlands, Belgium, and Germany found higher rates of mortality in cage-free systems,[187] as did a German study comparing floor pens to enriched cages published in 2003,[188] a 2009 dissertation found that the mortality rate was 14-15% in enriched cages, but only 7% in an aviary system.[189] The LayWel project, a collaborative research effort among working groups in seven different European countries including data from 230 different flocks with special emphasis on furnished cages, found no overall statistical effect, only that differences in mortality rate depended on whether or not the study was carried out under commercial production conditions or in an experimental study.[190] A comprehensive analysis of mortality in conventional cages and cage-free systems has shown that the genetic strain of the hens is important.[191] Indeed, in the 2008 study mentioned above, two bird strains (ISA Brown and Bovans Goldline hens) had lower mortality compared to others observed in non-cage systems. Among the study's conclusions was the statement that "[t]hese hybrids may be better suited for non-cage systems than other hybrids used."[192]

In addition to the appropriate selection of hen strains, good management in cage-free systems is very important to keep mortality rates low. In this regard, knowledge and experience are essential. A meta-analysis published in 2021 compiled information from previous studies published between 2000 and 2020 with comparisons of conventional cages, furnished cages, and indoor aviary systems. The analysis included data from 16 countries, 6,040 flocks and over 176 million hens. The study found that each year of new experience managing cage-free production was associated with an average drop in mortality of 0.4 to 0.6%, accumulating 4-6% over a decade. Furthermore, there were no differences in mortality between caged and cage-free systems over a recent time period, with mortality rate ranging from 3 to 5%. These results contradict the common notion that high mortality rates are inherent in cage-free systems and highlight the importance of the maturity of a system, as well as the resources available for the dissemination of knowledge, proper training, and the implementation of best practices such as vaccination programs and preventive strategies against feather pecking.[193]

# Group Size, Space Allowance, and Injurious Pecking Behavior

Part of the rationale for developing furnished cages was that smaller group sizes in cages might reduce the likelihood of an outbreak of abnormal feather-pecking behavior. Some sources contend that there is a higher risk for the development of injurious pecking that can lead to cannibalism in large group sizes.[194,195] This is in part because there is greater potential for birds to imitate the injurious pecking behavior of other hens in a large group[196] and because individual birds who learn to feather-peck will have many more potential victims.[197,198]

Under experimental conditions, feather pecking has been shown to increase with group size among flocks varying between 4-368 birds.[199,200,201,202] However, in a study of egg production facilities with group sizes ranging from 225-9954, there was no correlation between the number of hens in the group and the incidence of cloacal cannibalism.[203] This suggests that the group size effect may have an upper limit,[204] and thus may not apply to larger, commercial-sized flocks. A systematic review of multiple studies found that cannibalism rates were not different between beak-trimmed hens of the same strain raised in cage (small group) and cage-free (large group) conditions.[205] According to the scientists of the LayWel project, the ideal group size is still a matter of much intense research, as the optimal and maximal number of birds per group has not yet been elucidated.[206]

Furnished cages for large groups, up to 60 birds,[207] are used despite the fact that this contradicts the purported benefit of small group size in cages, reduced cannibalism and feather-pecking. In a comparison of two furnished cage types, more hens died in groups of 60 compared to in groups of 40 in one cage design, and over 50% of the mortality in this study was related to cannibalism.[208] In another study of furnished cages, more hens died in groups of 40 or 60 hens compared to groups of 10 or 20, largely due to cannibalism.[209] However, cannibalism can also be very high in groups of 10-20 birds in furnished cages, if birds are not beak-trimmed.[210] To help prevent injurious pecking behavior and to reduce its impact, commercial egg operations routinely sear off 1/3-1/2[211,212] of the end of hens' beaks,[213] as discussed above.

Feather-pecking and cannibalism should not be confused with aggressive behavior,[214] as feather-pecking is thought to be redirected foraging pecks.[215] Studies have demonstrated that aggressive behavior appears to be lowest at either end of the spectrum, in both small, tightly confined groups and in large, crowded flocks. One study of small groups (3 or 6 hens housed at approximately the same stocking density) found more aggression in experimental floor pens, where birds had more space per bird than in cages. The researchers postulated that crowding affects the social behavior of the birds and that aggressive behavior is constrained in cages because reducing the space available for agonistic encounters reduces the social triggers that lead to aggression.[216] However, in another study of group sizes ranging from 72-368 birds, aggression was lowest in the largest group sizes with higher stocking densities, prompting the scientists to write that the hens adopted a "non-social, non-aggressive" social strategy in these conditions.[217] A 2006 study found that in the first two weeks after being introduced to the new system, aggression was higher in an aviary compared to furnished cages when hens were transferred there after being reared in battery cages,[218] which may have been due in part to the once restricted birds' attempts to establish their social order with new flock mates in an enlarged area.

Indeed, research has shown that the social dynamics are very different in cages and cage-free systems. In a large group, there are more potential aggressors to peck at subordinate hens, but conversely, there is also more opportunity to hide in a large group, and in a crowded environment, a single individual is less conspicuous. At least one study has demonstrated that submissive hens prefer large groups even more strongly than hens classified by the authors as aggressive individuals, which led the researchers to suggest this may be due to the opportunity to avoid persecutors in a larger flock.[219]

Research has also shown that hens tend to choose a large flock given a greater space allowance over a small group in a more confined area. In a preference testing experiment, there was a tendency for hens to choose to join a large group (120 hens) in a large space (9 $m^2$ or 96.9 $ft^2$) compared to a small group (5 hens) in a small, enclosed space (1 $m^3$ or 35.3 $ft^3$), and a small group in a large space was significantly preferred. The authors noted that the hens seemed to have an aversion to the small space used in the study, prompting the scientists to propose that their research "provides strong evidence in favour of alternative non-cage systems."[220]

# Conclusion

While an improvement over conventional, barren, battery cages, furnished cages still severely restrict movement and do not provide the standard of welfare that well-managed cage-free systems can provide. The behavior of hens in furnished cages is highly constrained, and exercise is severely limited. Low levels of exercise contribute to osteoporosis and can lead to liver pathology and keel bone deviations. Hens in furnished cages are more fearful. Problems with furnished cages have already prompted several European countries to phase out their use completely including Austria, Luxemburg, and Switzerland[221] Several additional countries such as Germany and Czechia have set phase out periods. In the United States, legal bans that include furnished cages are in force, including in Oregon California, Washington, Arizona, Colorado, Nevada, Utah, and Rhode Island (see Annex).

The welfare potential of a given housing system is increasingly being seen as a more meaningful way of characterizing the adequacy of an animal production operation. Although some scientific evaluations find furnished cages acceptable,[222, 223, 224] the shortfalls of cage confinement are not and cannot be fully addressed by these modified cages and research to date has shown that even with substantial additional modifications, there will still be inherent welfare problems with such cages. It is entirely possible to house hens commercially in a way that affords them much more freedom of movement, and it is important that the industry strives for a system in which all of the behavioral and physical needs of the hens can be met. The inherent lack of space in furnished cages makes this impossible.

# ANNEX: Legislation prohibiting or phasing out furnished cages

Some individual European countries have already enacted legislation regarding furnished cages. Austria and Luxemburg have prohibited the use of all cages.[225] Switzerland banned battery cages in 1992 and furnished cages were not authorized as an alternative system following the findings of the Federal Veterinary Office in 1993.[226] In Belgium, the Flanders region issued a draft decree in 2023 which aims to ban all cages for egg production and will enter in force on January 1, 2036.[227] In the Wallonia region of Belgium, enriched cages will be banned starting in 2028.[228] In Germany, while battery cages have been banned since 2008, existing colony and enriched cages are to be phased out by the end of 2025, with a possible extension of maximum three years in cases of extreme need.[229,230] In Czechia, a ban on enriched cages will come into force in 2027 and in Slovakia by 2030. Finally, France has banned new or retrofitted enriched cages.[231]

Around the world, other countries have taken measures against cage systems, but not all of them include furnished cages. For instance, Australia has required a phase out of battery cages by 2036,[232] which, depending on the market, could lead farmers to use furnished cages, although the Australian Capital Territory has already banned all caged systems for lying hens in its entirety.[233] In Canada, a phase out of conventional battery cages by 2036 has been put in place,[234] but enriched cages are still used. New Zealand completed its phase out for battery cages in 2023; however, furnished cages remain legal.[235,] Israel enacted in 2022 a phase out of battery cages by 2038, which also bans cages in any new laying hen facility.[236] In Bhutan, the Ministry of Agriculture and Forests prohibited cage confinement in 2012, declaring that any bird kept for egg production should not be confined in cages that prevented the expression of natural behavior.[237]

In the United States, there are no restrictions at the federal level regarding the use of cages for laying hens, but 11 states ban or are phasing out the use of battery cages and some of them include furnished cages. In 2010, Ohio imposed a moratorium on the construction of new battery cage facilities. This legislation prohibits permits for new battery cage operations starting in year 2011, but allows established farms to continue using them and to expand their existing production using cages.[238] In Michigan, battery cages were effectively prohibited since 2009 by requiring one square foot of space per hen,[239] but in 2019 a new law prohibiting all cages (including furnished cages) and the sale of caged eggs passed with a phase out date by the end of 2024.[240] Oregon banned battery cages in 2012[241] and in 2019 approved a law requiring eggs produced and sold in the state to be cage-free by 2024.[242] California enacted a prohibition on battery cages in 2008 through Proposition 2. Subsequently, in 2018, Proposition 12 was passed, requiring that only cage-free eggs shall be produced and sold in California. This law took full effect in 2024.[243,244] Massachusetts residents passed a referendum in 2016 outlawing battery cages, which took effect in 2022 and requires that each hen must have at least 1.5 square feet of usable floor space, requiring a de facto change to cage-free systems.[245] In 2019, Washington passed a bill requiring eggs produced and sold in the state to be cage free by 2024.[246,247] In Arizona, laying hens must be housed in cage-free systems with at least one square foot of available space and all eggs sold in the state must come from cage-free hens by 2025.[248] Colorado passed a bill in 2020 requiring that all eggs produced and sold in the state must be cage free by 2025, leaving a two-year transition period.[249] In 2021, Nevada passed legislation that requires eggs sold and produced in the state to be cage free, with a phase out period by 2024.[250,251] Also in 2021, Utah passed a bill to ban the production and sale of caged eggs, which will come in full effect in 2025.[252] Rhode Island approved a ban of caged hens (including furnished) in 2018 with a phase out period by 2026.[253,254]

# References


[1] United Egg Producers. 2024. 2025 Cage Housing UEP Animal Welfare Guidelines for U.S. Egg Laying Flocks. https://uepcertified.com/wp-content/uploads/2024/01/2025-UEP-Cage-Guidelines-Final.pdf. Accessed May 23, 2024.
[2] Bell DD and Weaver WD. 2002. Commercial Chicken Meat and Egg Production, 5th Edition (Norwell, MA: Kluwer Academic Publishers, p.1009).
[3] Blokhuis HJ, Van Niekerk TF, Besse W, et al. 2007. The LayWel project: welfare implications of changes in production systems for laying hens. World's Poultry Science Journal 63:101-14.
[4] Baxter MR. 1994. The welfare problems of laying hens in battery cages. The Veterinary Record 134(24):614-9.
[5] Short W. 2008. What to consider when investing in enriched cages. Farmers Weekly Interactive, May 15. www.fwi.co.uk/Articles/2008/05/16/110500/What-to-consider-when-investing-in-enriched-cages.htm. Accessed May 23, 2024.
[6] Big Dutchman. 2013. Modern egg production with enriched colony systems. www.bigdutchman.com/en/news-stories/article/modern-egg-production-with-enriched-colony-systems/. Accessed May 23, 2024.
[7] Hughes BO. 1994. Origins and development of modified cages for laying hens. In: Sherwin CM (ed.), Modified Cages for Laying Hens. Proceedings of a Symposium Held at Nobel House (London, U.K.: Universities Federation for Animal Welfare, pp. 1-9)
[8] Rodenburg TB. 2020. End the cage age: Looking for alternatives. www.europarl.europa.eu/RegData/etudes/STUD/2020/658539/IPOL_STU(2020)658539_EN.pdf. Accessed May 23, 2024.
[9] Rodenburg TB, Tuyttens FAM, and Sonck B. 2005. Welfare, health, and hygiene of laying hens housed in furnished cages and in alternative housing systems. Journal of Applied Animal Welfare Science 8(3):211-26.
[10] Tauson R. 2005. Management and housing systems for layers - effects on welfare and production. World's Poultry Science Journal 61(3):477-90.
[11] European Union. Laying hens by way of keeping 2011-2020 dataset. https://agriculture.ec.europa.eu/document/download/3611ba2e-ad9f-4b39-83db-00be67dc4022_en?filename=laying-hens-keeping-2011-2020_en.xlsx. Accessed May 23, 2024.
[12] European Union. Laying hens by way of keeping 2011-2020 dataset. https://agriculture.ec.europa.eu/document/download/3611ba2e-ad9f-4b39-83db-00be67dc4022_en?filename=laying-hens-keeping-2011-2020_en.xlsx. Accessed June 7, 2024.
[13]Eggs – Market Situation – Dashboard. 2024, Last update: 22/05/2024. https://agriculture.ec.europa.eu/document/download/9bdf9842-1eb6-41a2-8845-49738b812b2b_en. Accessed May 28, 2024.
[14] Bell DD. 2002. Cage management for layers. In: Bell DD and Weaver WD (eds.), Commercial Chicken Meat and Egg
Production, 5th Edition (Norwell, MA: Kluwer Academic Publishers, p. 1009).
[15] U.S. Department of Agriculture National Agricultural Statistics Service. 2024. Egg Markets Overview, April 26, 2024. https://mymarketnews.ams.usda.gov/filerepo/sites/default/files/3725/2024-04-26/824884/ams_3725_00019.pdf. Accessed May 28, 2024.
[16] Egg Farmers of Canada. 2023 Annual Report. eggfarmers.ca/wp-content/uploads/2024/03/2023_Egg-Farmers-of-Canada_Annual-Report.pdf. Accessed on May 23, 2024.
[17] LayWel. 2006. Description of housing systems for Laying hens. www.laywel.eu/web/pdf/deliverable%2023.pdf. Accessed May 23, 2024.
[18] LayWel. 2006. Description of housing systems for Laying hens. www.laywel.eu/web/pdf/deliverable%2023.pdf. Accessed May 23, 2024.
[19] Struelens E and Tuyttens FAM. 2009. Effects of perch design on behaviour and health of laying hens. Animal Welfare 18:533-8.
[20] Council Directive 1999/74/EC of 19 July 1999 laying down minimum standards for the protection of laying hens. http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=31999L0074&model=guichett. Accessed May 23, 2024.
[21] Council Directive 1999/74/EC of 19 July 1999 laying down minimum standards for the protection of laying hens. http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=31999L0074&model=guichett. Accessed May 23, 2024.

[22] United Egg Producers. 204. 2024 Cage-Free Housing Animal Welfare Guidelines for U.S. Egg Laying Flocks. https://uepcertified.com/wp-content/uploads/2023/10/CF-UEP-Guidelines_2024.pdf. Accessed June 4, 2024.
[23] Council Directive 1999/74/EC of 19 July 1999 laying down minimum standards for the protection of laying hens. http://eurlex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=31999L0074&model=guichett. Accessed May 28, 2024.
[24] Rodenburg TB. 2020. End the cage age: Looking for alternatives. www.europarl.europa.eu/RegData/etudes/STUD/2020/658539/IPOL_STU(2020)658539_EN.pdf. Accessed May 28, 2024.
[25] European Commission. End the Cage Age. https://citizens-initiative.europa.eu/initiatives/details/2018/000004/end-cage-age_en. Accessed on May 28, 2024.
[26] Rodenburg TB, Tuyttens FAM, de Reu K, Herman L, Zoons J, and Sonck B. 2008. Welfare assessment of laying hens in furnished cages and non-cage systems: an on-farm comparison. Animal Welfare 17:363-73.
[27] European Commission. 2023. Overview report on the protection of the welfare of laying hens at all stages of production. https://ec.europa.eu/food/audits-analysis/overview/download/1878. Accessed on May 28, 2024.
[28] Riddle ER, Ali AB, Campbell DL, and Siegford JM. 2018. Space use by 4 strains of laying hens to perch, wing flap, dust bathe, stand and lie down. PLoS One. 13(1):e0190532.
[29] Sarica M, Boga S, and Yamak US. 2008. The effects of space allowance on egg yield, egg quality and plumage condition of laying hens in battery cages. Czech Journal of Animal Science 53(8):346-53.
[30] McAdie TM and Keeling LJ. 2000. Effect of manipulating feathers of laying hens on the incidence of feather pecking and cannibalism. Applied Animal Behaviour Science. 68(3):215-29.
[31] Weimer SL, Robison CI, Tempelman RJ, Jones DR, and Karcher DM. 2019. Laying hen production and welfare in enriched colony cages at different stocking densities. Poultry science 98(9):3578-86.
[32] Meng F, Chen D, Li X, Li J, and Bao J. 2014. Effects of large or small furnished cages on performance, welfare and egg quality of laying hens. Animal Production Science 55(6):793-8.
[33] Petherick JC. 2007. Spatial requirements of animals: Allometry and beyond. Journal of Veterinary Behavior 2:197-204.
[34] Appleby MC. 2004. What causes crowding? Effects of space, facilities and group size on behaviour, with particular reference to furnished cages for hens. Animal Welfare 13(3):313-20.
[35] Appleby MC and Hughes BO. 1991. Welfare of laying hens in cages and alternative systems: environmental, physical and behavioural aspects. World's Poultry Science Journal 47:109-28.
[36] Rodenburg TB, Tuyttens FAM, and Sonck B. 2005. Welfare, health, and hygiene of laying hens housed in furnished cages and in alternative housing systems. Journal of Applied Animal Welfare Science 8(3):211-26.
[37] Albentosa MJ and Cooper JJ. 2002. Effects of cage height and stocking density on the behaviour, perch use and distribution of laying hens in furnished cages. British Poultry Science 43(Supplement 1): S16-6.
[38] Cooper JJ and Albentosa MJ. 2003. Behavioural priorities of laying hens. Avian and Poultry Biology Reviews 14(3):127-49.
[39] Struelens E, Tuyttens FAM, Duchateau L, et al. 2008. Perching behaviour and perch height preference of laying hens in furnished cages varying in height. British Poultry Science 49(4):381-9.
[40] Lindberg AC and Nicol CJ. 1997. Dustbathing in modified battery cages: Is sham dustbathing an adequate substitute? Applied Animal Behaviour Science 55:113-28.
[41] Appleby MC. 2003. The European Union ban on conventional cages for laying hens: history and prospects. Journal of Applied Animal Welfare Science 6(2):103-21.
[42] Rodenburg TB, Tuyttens FAM, and Sonck B. 2005. Welfare, health, and hygiene of laying hens housed in furnished cages and in alternative housing systems. Journal of Applied Animal Welfare Science 8(3):211-26.
[43] McBride G, Parer IP, and Foenander F. 1969. The social organization and behaviour of the feral domestic fowl. Animal Behaviour Monographs 2:127-81.
[44] Wood-Gush DGM, Duncan IJH and Savory CJ. 1978. Observations on the social behaviour of domestic fowl in the wild. Biology of Behaviour 3:193-205.
[45] Collias NE and Collias EC. 1967. A field study of the Red Jungle Fowl in North-central India. The Condor 69:360-86.
[46] Appleby MC, Mench JA, and Hughes BO. 2004. Poultry Behaviour and Welfare (Wallingford, U.K.: CABI Publishing, p. 67).
[47] Blokhuis HJ. 1984. Rest in poultry. Applied Animal Behaviour Science 12:289-303.
[48] Appleby MC and Duncan IJH. 1989. Development of perching in hens. Biology of Behaviour 14:157-68.
[49] Olsson IAS and Keeling LJ. 2000. Night-time roosting in laying hens and the effect of thwarting access to perches. Applied Animal Behaviour Science 68:243-56.
[50] Struelens E and Tuyttens FAM. 2009. Effects of perch design on behaviour and health of laying hens. Animal Welfare 18:533-8.

[51] Struelens E, Tuyttens FAM, Duchateau L, et al. 2008. Perching behaviour and perch height preference of laying hens in furnished cages varying in height. British Poultry Science 49(4):381-9.
[52] Dawkins MS. 1985. Cage height preference and use in battery-kept hens. The Veterinary Record 116:345-7.
[53] Struelens E, Tuyttens FAM, Duchateau L, et al. 2008. Perching behaviour and perch height preference of laying hens in furnished cages varying in height. British Poultry Science 49(4):381-9.
[54] Zeltner E, Klein T and Huber-Eicher B. 2000. Is there social transmission of feather pecking in groups of laying hen chicks? Animal Behaviour 60:211-6.
[55] Dixon LM. 2008. Feather pecking behaviour and associated welfare issues in laying hens. Avian Biology Research 1(2):73-87.
[56] Cheng H. 2006. Morphopathological changes and pain in beak trimmed laying hens. World's Poultry Science Journal 62(1):41-52.
[57] Kuenzel WJ. 2007. Neurobiological basis of sensory perception: welfare implications of beak trimming. Poultry Science 86:1273-82.
[58] Welchsler B and Huber-Eicher B. 1998. The effect of foraging material and perch height on feather pecking and feather damage in laying hens. Applied Animal Behaviour Science 58:131-41.
[59] Moinard C, Morisse JP, and Faure JM. 1998. Effect of cage area, cage height and perches on feather condition, bone breakage and mortality of laying hens. British Poultry Science 39:198-202.
[60] Struelens E, Tuyttens FAM, Duchateau L, et al. 2008. Perching behaviour and perch height preference of laying hens in furnished cages varying in height. British Poultry Science 49(4):381-9.
[61] Rodenburg TB, Tuyttens FAM, de Reu K, Herman L, Zoons J, and Sonck B. 2008. Welfare assessment of laying hens in furnished cages and non-cage systems: an on-farm comparison. Animal Welfare 17:363-73.
[62] Council Directive. 1999/74/EC of 19 July 1999. Laying down minimum standards for the protection of laying hens. https://eur-lex.europa.eu/eli/dir/1999/74/oj. Accessed May 28, 2024.
[63] Riddle ER, Ali ABA, Campbell DLM, Siegford JM (2018) Space use by 4 strains of laying hens to perch, wing flap, dust bathe, stand and lie down. PLoS ONE 13(1): e0190532.
[64] Appleby MC, Smith SF, and Hughes BO. 1993. Nesting, dust bathing and perching by laying hens in cages: effects of design on behaviour and welfare. British Poultry Science 34(5):835-47.
[65] Cooper JJ and Albentosa MJ. 2003. Behavioural priorities of laying hens. Avian and Poultry Biology Reviews 14(3):127-49.
[66] Mench JA. 1998. Environmental enrichment and the importance of exploratory behavior. In: Shepherdson DJ, Mellen JD, and Hutchins M (eds.), Second Nature (Washington, DC: Smithsonian Institution Press, pp. 30-46).
[67] Wemelsfelder F and Birke L. 1997. Environmental challenge. In: Appleby MC and Hughes BO (eds.), Animal Welfare (Wallingford, U.K.: CABI Publishing, pp. 35-47).
[68] Wood-Gush DGM and Vestergaard K. 1989. Exploratory behavior and the welfare of intensively kept animals. Journal of Agricultural Ethics 2:161-9.
[69] Wemelsfelder F and Birke L. 1997. Environmental challenge. In: Appleby MC and Hughes BO (eds.), Animal Welfare (Wallingford, U.K.: CABI Publishing, pp. 35-47).
[70] Rodenburg TB, Tuyttens FAM, and Sonck B. 2005. Welfare, health, and hygiene of laying hens housed in furnished cages and in alternative housing systems. Journal of Applied Animal Welfare Science 8(3):211-26.
[71] Knierim U. 2006. Animal welfare aspects of outdoor runs for laying hens: a review. Wageningen Journal of Life Sciences 54(2):133-45.
[72] Rodenburg TB, Tuyttens FAM, de Reu K, Herman L, Zoons J, and Sonck B. 2008. Welfare assessment of laying hens in furnished cages and non-cage systems: an on-farm comparison. Animal Welfare 17:363-73.
[73] Council Directive 1999/74/EC of 19 July 1999 laying down minimum standards for the protection of laying hens. http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=31999L0074&model=guichett. Accessed May 28, 2024.
[74] Rodenburg TB, Tuyttens FAM, de Reu K, Herman L, Zoons J, and Sonck B. 2008. Welfare assessment of laying hens in furnished cages and non-cage systems: an on-farm comparison. Animal Welfare 17:363-73.
[75] Rodenburg TB, Tuyttens FAM, and Sonck B. 2005. Welfare, health, and hygiene of laying hens housed in furnished cages and in alternative housing systems. Journal of Applied Animal Welfare Science 8(3):211-26.
[76] Lindberg AC and Nicol CJ. 1997. Dustbathing in modified battery cages: Is sham dustbathing an adequate substitute? Applied Animal Behaviour Science 55:113-28.
[77] Appleby MC and Hughes BO. 1995. The Edinburgh modified cage for laying hens. British Poultry Science 36:707-18.
[78] Wall H, Tauson R, and Elwinger K. 2008. Effects of litter substrate and genotype on layers' use of litter, exterior appearance, and heterophil:lymphocyte ratios in furnished cages. Poultry Science 87(12):2458-65.
[79] Duncan IJH, Widowski TM, Malleau AE, Lindberg CA, and Petherick CJ. 1998. External factors and causation of dustbathing in domestic hens. Behavioural Processes 43:219-28.

[80] Van Niekerk ThGCM. and Reuvekamp BFJ. 2000. Hens make good use of litter in enriched cages. World Poultry 16(2):34-7.
[81] Appleby MC and Hughes BO. 1995. The Edinburgh modified cage for laying hens. British Poultry Science 36:707-18.
[82] Van Niekerk ThGCM. and Reuvekamp BFJ. 2000. Hens make good use of litter in enriched cages. World Poultry 16(2):34-7.
[83] Riddle ER, Ali AB, Campbell DL, and Siegford JM. 2018. Space use by 4 strains of laying hens to perch, wing flap, dust bathe, stand and lie down. PLoS One 13(1):e0190532.
[84] Van Niekerk ThGCM. and Reuvekamp BFJ. 2000. Hens make good use of litter in enriched cages. World Poultry 16(2):34-7.
[85] Merrill RJN and Nicol CJ. 2005. The effects of novel floorings on dustbathing, pecking and scratching behaviour of caged hens. Animal Welfare 14(3):179-86.
[86] Van Niekerk ThGCM. and Reuvekamp BFJ. 2000. Hens make good use of litter in enriched cages. World Poultry 16(2):34-7.
[87] Shinmura T, Eguchi Y, Uetake K, and Tanaka T. 2006. Behavioral changes in laying hens after introduction to battery cages, furnished cages and an aviary. Animal Science Journal 77(2):242-9.
[88] Rodenburg TB, Tuyttens FAM, de Reu K, Herman L, Zoons J, and Sonck B. 2008. Welfare assessment of laying hens in furnished cages and non-cage systems: an on-farm comparison. Animal Welfare 17:363-73.
[89] Platz S, Heyn E, Hergt F, Weigl B, and Erhard M. 2009. Comparative study on the behaviour, health and productivity of laying hens in a furnished cage and an aviary system. Berl Munch Tierarztl Wochenschr. 122(7/8):235-40.
[90] Appleby MC, Walker AW, Nicol CJ, et al. 2002. Development of furnished cages for laying hens. British Poultry Science 43(4):489-500.
[91] Van Niekerk ThGCM. and Reuvekamp BFJ. 2000. Hens make good use of litter in enriched cages. World Poultry 16(2):34-7.
[92] Campbell DL, Makagon MM, Swanson JC, and Siegford JM. 2016. Litter use by laying hens in a commercial aviary: dust bathing and piling. Poultry science 95(1):164-75.
[93] Grebey TC, Ali AB, Swanson JC, Widowski TM, and Siegford JM. 2020. Dust bathing in laying hens: strain, proximity to, and number of conspecifics matter. Poultry Science 99(9):4103-12.
[94] Savory CJ, Wood-Gush DGM, and Duncan IJH. 1978. Feeding behaviour in a population of domestic fowls in the wild. Applied Animal Ethology 4:13-27.
[95] Dawkins MS. 1989. Time budgets in Red Junglefowl as a baseline for the assessment of welfare in domestic fowl. Applied Animal Behaviour Science 24:77-80.
[96] Dawkins MS. 1989. Time budgets in Red Junglefowl as a baseline for the assessment of welfare in domestic fowl. Applied Animal Behaviour Science 24:77-80.
[97] Duncan IJH and Hughes BO. 1972. Free and operant feeding in domestic fowls. Animal Behaviour 20:775-7.
[98] Rodenburg TB, Tuyttens FAM, de Reu K, Herman L, Zoons J, and Sonck B. 2008. Welfare assessment of laying hens in furnished cages and non-cage systems: an on-farm comparison. Animal Welfare 17:363-73.
[99] Weitzenbürger D, Vits A, Hamann H, and Distl O. 2006. Evaluation of small group housing systems and furnished cages as regards particular behaviour patterns in the layer strain Lohmann Selected Leghorn. Archiv für Geflügelkunde 70(6):250-60.
[100] Tauson R. 1986. Avoiding excessive growth of claws in caged laying hens. Acta Agriculturae Scandinavica 36:95-106.
[101] LayWel. 2006. Description of housing systems for Laying hens. www.laywel.eu/web/pdf/deliverable%2023.pdf. Accessed May 28, 2024.
[102] Petherick CJ and Rushen J. 1997. Behavioural restriction. In: Appleby MC and Hughes BO (eds.), Animal Welfare (Wallingford, U.K.: CABI Publishing, pp. 89-105).
[103] Appleby MC, Hughes BO, and Elson HA. 1992. Poultry Production Systems: Behaviour, Management and Welfare (Wallingford, U.K.: CAB International, p. 186).
[104] Sherwin CM and Nicol CJ. 1992. Behaviour and production of laying hens in three prototypes of cages incorporating nests. Applied Animal Behaviour Science 35(1):41-54.
[105] Hughes BO. 1983. Space requirements in poultry. In: Baxter SH, Baxter MR, and MacCormack JAD (eds.), Farm Animal Housing and Welfare (Boston, MA: Martinus Nijhoff Publishers, pp. 121-8).
[106] Duncan IJH. 1970. Frustration in the fowl. In: Freeman BM and Gordon RF (eds.), Aspects of Poultry Behaviour (Edinburgh, Scotland: British Poultry Science Ltd, pp. 15-31).
[107] Baxter MR. 1994. The welfare problems of laying hens in battery cages. The Veterinary Record 134(24):614-9.
[108] Wood-Gush DGM. 1972. Strain differences in response to sub-optimal stimuli in the fowl. Animal Behaviour 20(1):72-6.

[109] Yue S and Duncan IJH. 2003. Frustrated nesting behaviour: relation to extra-cuticular shell calcium and bone strength in White Leghorn hens. British Poultry Science 44(2):175-81.
[110] Duncan IJH, Savory CJ, and Wood-Gush DGM. 1978. Observations on the reproductive behaviour of domestic fowl in the wild. Applied Animal Ethology 4:29-42.
[111] Cooper JJ, Albentosa MJ, and Redgate SE. 2004. The 24 hour activity budgets of hens in furnished cages. British Poultry Science 45:S38-40.
[112] Guesdon V and Faure JM. 2004. Laying performance and egg quality in hens kept in standard or furnished cages. Animal Research 53:45-57.
[113] Council Directive 1999/74/EC of 19 July 1999 laying down minimum standards for the protection of laying hens. http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=31999L0074&model=guichett. Accessed May 24, 2024.
[114] Appleby MC. 2003. The European Union ban on conventional cages for laying hens: history and prospects. Journal of Applied Animal Welfare Science 6(2):103-21.
[115] Appleby MC. 1998. The Edinburg Modified Cage: effects of group size and space allowance on brown laying hens. Journal of Applied Poultry Research 7:152-61.
[116] Meijsser FM and Hughes BO. 1989. Comparative analysis of pre-laying behaviour in battery cages and in three alternative systems. British Poultry Science 30:747-60.
[117] Wood-Gush DGM. 1963. The control of the nesting behaviour of the domestic hen. 1. The role of the oviduct. Animal Behaviour 11:293-9.
[118] Kruschwitz A, Zupan M, Buchwalder T, and Huber-Eicher B. 2008. Nest preference of laying hens (*Gallus gallus domesticus*) and their motivation to exert themselves to gain nest access. Applied Animal Behaviour Science 112:321-30.
[119] Guesdon V and Faure JM. 2004. Laying performance and egg quality in hens kept in standard or furnished cages. Animal Research 53:45-57.
[120] Weitzenbürger D, Vits A, Hamann H, and Distl O. 2006. Evaluation of small group housing systems and furnished cages as regards particular behaviour patterns in the layer strain Lohmann Selected Leghorn. Archiv für Geflügelkunde 70(6):250-60.
[121] Riddle ER, Ali AB, Campbell DL and Siegford JM. 2018. Space use by 4 strains of laying hens to perch, wing flap, dust bathe, stand and lie down. PLoS One 13(1):e0190532.
[122] Mench JA and Blatchford RA. 2014. Determination of space use by laying hens using kinematic analysis. Poultry science 93(4):794-8.
[123] Bishop SC, Fleming RH, McCormack HA, Flock DK, and Whitehead CC. 2000. Inheritance of bone characteristics affecting osteoporosis in laying hens. British Poultry Science 41(1):33-40.
[124] Gregory NG. 2009. Exercise restriction and the laying hen: A welfare issue and no bones about it. The Veterinary Journal 183(2):123.
[125] Riddell C. 1992. Non-infectious skeletal disorders of poultry: an overview. In: Whitehead CC (ed.), Bone Biology and Skeletal Disorders in Poultry. Poultry Science Symposium Number Twenty-three (Oxfordshire, U.K.: Carfax Publishing Company, pp. 137-8).
[126] LayWel. 2006. Overall strengths and weaknesses of each defined housing system for laying hens, and detailing the overall welfare impact of each housing system. www.laywel.eu/web/pdf/deliverable%2071%20welfare%20assessment.pdf. Accessed May 28, 2024.
[127] Hughes BO. 1983. Space requirements in poultry. In: Baxter SH, Baxter MR, and MacCormack JAD (eds.), Farm Animal Housing and Welfare (Boston, MA: Martinus Nijhoff Publishers, pp. 121-8).
[128] Rowland LO and Harms RH. 1970. The effect of wire pens, floor pens and cages on bone characteristics of laying hens. Poultry Science 49(5):1223-5.
[129] Wabeck CJ and Littlefield LH. 1972. Bone strength of broilers reared in floor pens and in cages having different bottoms. Poultry Science 51(3):897-9.
[130] Meyer WA and Sunde ML. 1974. Bone breakage as affected by type housing or an exercise machine for layers. Poultry Science 53(3):878-85.
[131] Gregory NG, Wilkins LJ, Eleperuma SD, Ballantyne AJ, and Overfield ND. 1990. Broken bones in domestic fowls: effect of husbandry system and stunning method in end-of-lay hens. British Poultry Science 31(1):59-69.
[132] Gregory NG and Wilkins LJ. 1991. Broken bones in hens. The Veterinary Record 129(25-26):559.
[133] Budgell KL and Silversides FG. 2004. Bone breakage in three strains of end-of-lay hens. Canadian Journal of Animal Science 84(4):745-7.
[134] Walker AW, Alvey DM, and Tucker SA. 1997. Effect of cage height and perch provision on bone strength and ease of catching of laying hens. British Poultry Science 38:S15-16.
[135] Abrahamsson P and Tauson R. 1993. Effect of perches at different positions in conventional cages for laying hens of two different strains. Acta Agriculturae Scandinavica. Section A, Animal Science 43(4):228-35.

[136] LayWel. 2006. Overall strengths and weaknesses of each defined housing system for laying hens, and detailing the overall welfare impact of each housing system. www.laywel.eu/web/pdf/deliverable%2071%20welfare%20assessment.pdf. Accessed May 28, 2024.
[137] Leyendecker M, Hamann H, Hartung J, et al. 2005. Keeping laying hens in furnished cages and an aviary housing system enhances their bone stability. British Poultry Science 46(5):536-44.
[138] Moinard C, Morisse JP, and Faure JM. 1998. Effect of cage area, cage height and perches on feather condition, bone breakage and mortality of laying hens. British Poultry Science 39:198-202.
[139] Tactacan GB, Guenter W, Lewis NJ, Rodriguez-Lecompte JC, and House JD. 2009. Performance and welfare of laying hens in conventional and enriched cages. Poultry Science 88:698-707.
[140] LayWel. 2006. Overall strengths and weaknesses of each defined housing system for laying hens, and detailing the overall welfare impact of each housing system. www.laywel.eu/web/pdf/deliverable%2071%20welfare%20assessment.pdf. Accessed May 28, 2024.
[141] Rodenburg TB, Tuyttens FAM, de Reu K, Herman L, Zoons J, and Sonck B. 2008. Welfare assessment of laying hens in furnished cages and non-cage systems: an on-farm comparison. Animal Welfare 17:363-73.
[142] Leyendecker M, Hamann H, Hartung J, et al. 2002. Analysis of the egg shell stability and the bone strength of laying hens in three different hen housing systems. Züchtungskunde 74(2):144-55.
[143] Scholz B, Rönchen S, Hamann H, et al. 2008. Evaluation of bone strength, keel bone deformity and egg quality of laying hens housed in small group housing systems and furnished cages in comparison to an aviary housing system. Archiv für Tierzucht 51(2):179-86.
[144] Lindberg AC. 1997. Leg and wing movements by hens in enriched modified cage systems. British Poultry Science 38:S10-11.
[145] Vits A, Weitzenbürger D, Hamann H, and Distl O. 2005. Influence of different small-group-systems on performance traits, egg quality and bone breaking strength of laying hens. 2nd Communication: Bone breaking strength. Züchtungskunde 77(5):355-66.
[146] Leyendecker M, Hamann H, Hartung J, et al. 2005. Keeping laying hens in furnished cages and an aviary housing system enhances their bone stability. British Poultry Science 46(5):536-44.
[147] Whitehead CC and Fleming RH. 2000. Osteoporosis in cage layers. Poultry Science 79(7):1033-41.
[148] Takata S and Yasui N. 2001. Disuse osteoporosis. Journal of Medical Investigation. 48(3/4):147-56.
[149] Rørvang MV, Hinrichsen LK, and Riber AB. 2019. Welfare of layers housed in small furnished cages on Danish commercial farms: the condition of keel bone, feet, plumage and skin. British Poultry Science 60(1):1-7.
[150] Wilkins LJ, McKinstry JL, Avery NC, et al. 2011. Influence of housing system and design on bone strength and keel bone fractures in laying hens. Veterinary Record 169(16):414.
[151] Gregory NG and Wilkins LJ. 1989. Broken bones in domestic fowl: handling and processing damage in end-of-lay battery hens. British Poultry Science 30(3):555-62.
[152] Gregory NG, Wilkins LJ, Eleperuma SD, Ballantyne AJ, and Overfield ND. 1990. Broken bones in domestic fowls: effect of husbandry system and stunning method in end-of-lay hens. British Poultry Science 31(1):59-69.
[153] Sandilands V, Sparks N, Wilson S, and Nevison I. 2005. Laying hens at depopulation: the impact of the production system on bird welfare. British Poultry Abstracts 1:23-4.
[154] LayWel. 2006. Overall strengths and weaknesses of each defined housing system for laying hens, and detailing the overall welfare impact of each housing system. www.laywel.eu/web/pdf/deliverable%2071%20welfare%20assessment.pdf. Accessed May 28, 2024.
[155] Sandilands V, Sparks N, Wilson S, and Nevison I. 2005. Laying hens at depopulation: the impact of the production system on bird welfare. British Poultry Abstracts 1:23-4.
[156] Newberry RC. 2006. Welfare of poultry in non-cage housing systems. 95th Annual Meeting of the Poultry Science Association, Edmonton, Canada, University of Alberta. Poultry Science Poscal 85(Supplement 1):144.
[157] LayWel. 2006. Overall strengths and weaknesses of each defined housing system for laying hens, and detailing the overall welfare impact of each housing system. www.laywel.eu/web/pdf/deliverable%2071%20welfare%20assessment.pdf. Accessed May 28, 2024.
[158] Rodenburg TB, Tuyttens FAM, and Sonck B. 2005. Welfare, health, and hygiene of laying hens housed in furnished cages and in alternative housing systems. Journal of Applied Animal Welfare Science 8(3):211-26.
[159] Scientific Panel on Animal Health and Welfare. 2005. Opinion of the Scientific Panel on Animal Health and Welfare on a request from the Commission related to the welfare aspects of various systems of keeping laying hens. The EFSA Journal 197:1-23. https://efsa.onlinelibrary.wiley.com/doi/pdf/10.2903/j.efsa.2005.197. Accessed May 28, 2024.
[160] Nicol CJ, Brown SN, Glen E, et al. 2006. Effects of stocking density, flock size and management on the welfare of laying hens in single-tier aviaries. British Poultry Science 47(2):135-46.
[161] Rodenburg TB, Tuyttens FAM, de Reu K, Herman L, Zoons J, and Sonck B. 2008. Welfare assessment of laying hens in furnished cages and non-cage systems: an on-farm comparison. Animal Welfare 17:363-73.

[162] Rodenburg TB, Tuyttens FAM, de Reu K, Herman L, Zoons J, and Sonck B. 2008. Welfare assessment of laying hens in furnished cages and non-cage systems: an on-farm comparison. Animal Welfare 17:363-73.
[163] Thøfner I, Hougen HP, Villa C, Lynnerup N, Christensen JP. 2020. Pathological characterization of keel bone fractures in laying hens does not support external trauma as the underlying cause. PLoS ONE 15(3):e0229735.
[164] Thøfner IC, Dahl J, and Christensen JP. 2021. Keel bone fractures in Danish laying hens: prevalence and risk factors. PLoS ONE 16(8):e0256105.
[165] Thøfner I, Hougen HP, Villa C, Lynnerup N, Christensen JP. 2020. Pathological characterization of keel bone fractures in laying hens does not support external trauma as the underlying cause. PLoS ONE 15(3):e0229735.
[166] Thøfner I, Hougen HP, Villa C, Lynnerup N, and Christensen JP. 2020. Pathological characterization of keel bone fractures in laying hens does not support external trauma as the underlying cause. PLoS ONE 15(3):e0229735.
[167] Thøfner I, Hougen HP, Villa C, Lynnerup N, and Christensen JP. 2020. Pathological characterization of keel bone fractures in laying hens does not support external trauma as the underlying cause. PLoS ONE 15(3):e0229735.
[168] Thøfner IC, Dahl J, Christensen JP. 2021. Keel bone fractures in Danish laying hens: prevalence and risk factors. PLoS ONE 16(8):e0256105.
[169] Fleming RH, McCormack HA, McTeir L, and Whitehead CC. 2006. Relationships between genetic, environmental and nutritional factors influencing osteoporosis in laying hens. British Poultry Science 47(6):742-55.
[170] Bishop SC, Fleming RH, McCormack HA, Flock DK, and Whitehead CC. 2000. Inheritance of bone characteristics affecting osteoporosis in laying hens British Poultry Science 41(1):33-40.
[171] Rönchen S, Scholz B, Hamann H, and Distl O. 2008. Fat status in Lohmann Silver and Lohmann Tradition laying hens kept in modified small group housing systems, small group housing systems, furnished cages and an aviary system. Berliner und Münchener Tierärztliche Wochenschrift 121(1/2):11-8.
[172] Hansen I, Braastad BO, Storbråten J and Tofastrud M. 1993. Differences in fearfulness indicated by tonic immobility between laying hens in aviaries and in cages. Animal Welfare 2:105-12.
[173] Jones RB and Faure JM. 1981. Tonic immobility ("righting time") in laying hens housed in cages and pens. Applied Animal Ethology 7:369-72.
[174] Colson S, Michel V, and Arnould C. 2006. Welfare of laying hens housed in cages and in aviaries: what about fearfulness? Archiv für Geflügelkunde 70(6):261-9.
[175] Rodenburg TB, Tuyttens FAM, de Reu K, Herman L, Zoons J, and Sonck B. 2008. Welfare assessment of laying hens in furnished cages and non-cage systems: an on-farm comparison. Animal Welfare 17:363-73.
[176] Hansen I, Braastad BO, Storbråten J and Tofastrud M. 1993. Differences in fearfulness indicated by tonic immobility between laying hens in aviaries and in cages. Animal Welfare 2:105-12.
[177] Rodenburg TB, Tuyttens FAM, de Reu K, Herman L, Zoons J, and Sonck B. 2008. Welfare assessment of laying hens in furnished cages and non-cage systems: an on-farm comparison. Animal Welfare 17:363-73.
[178] Rodenburg TB, Tuyttens FAM, and Sonck B. 2005. Welfare, health, and hygiene of laying hens housed in furnished cages and in alternative housing systems. Journal of Applied Animal Welfare Science 8(3):211-26.
[179] Tauson R. 1985. Mortality in laying hens caused by differences in cage design. Acta Agriculturae Scandinavica 35:165-74.
[180] Appleby MC and Hughes BO. 1991. Welfare of laying hens in cages and alternative systems: environmental, physical and behavioural aspects. World's Poultry Science Journal 47:109-28.
[181] Riber AB, Casey-Trott TM, and Herskin MS. 2018. The influence of keel bone damage on welfare of laying hens. Frontiers in Veterinary Science 5:6.
[182] Käppeli S, Gebhardt-Henrich SG, Fröhlich E, Pfulg A, and Stoffel MH. 2011. Prevalence of keel bone deformities in Swiss laying hens. British Poultry Science 52(5):531-6.
[183] Stratmann A, Fröhlich EK, Harlander-Matauschek A, Schrader L, Toscano MJ, Würbel H, Gebhardt-Henrich SG. 2015. Soft perches in an aviary system reduce incidence of keel bone damage in laying hens. PloS one.10(3):e0122568.
[184] Rørvang MV, Hinrichsen LK, and Riber AB. 2018. Welfare of layers housed in small furnished cages on Danish commercial farms: the condition of keel bone, feet, plumage and skin. British Poultry Science 60(1):1-7.
[185] Riber AB and Hinrichsen LK. 2016. Keel-bone damage and foot injuries in commercial laying hens in Denmark. Animal Welfare. 25(2):179-84.
[186] Rørvang MV, Hinrichsen LK, Riber AB. 2018. Welfare of layers housed in small furnished cages on Danish commercial farms: the condition of keel bone, feet, plumage and skin. British poultry science. 60(1):1-7.
[187] Rodenburg TB, Tuyttens FAM, de Reu K, Herman L, Zoons J, and Sonck B. 2008. Welfare assessment of laying hens in furnished cages and non-cage systems: an on-farm comparison. Animal Welfare 17:363-73.

[188] Weber RM, Nogossek M, Sander I, Wandt B, Neumann U, and Glünder G. 2003. Investigations of laying hen health in enriched cages as compared to conventional cages and a floor pen system. Wiener Tierärztliche Monatsschrift 90(10):257-66.
[189] Fischer, VS. 2009. Evaluation of small group housing systems and an aviary system with the layer lines Lohmann Brown (LB) and Lohmann Selected Leghorn (LSL). Doctorate of Veterinary Medicine, Tierärztliche Hochschule Hannover, pp. 136-9.
[190] LayWel. 2006. Overall strengths and weaknesses of each defined housing system for laying hens, and detailing the overall welfare impact of each housing system. www.laywel.eu/web/pdf/deliverable%2071%20welfare%20assessment.pdf. Accessed May 28, 2024.
[191] Aerni V, Brinkhof MWG, Wechsler B, Oester H, and Fröhlich E. 2005. Productivity and mortality of laying hens in aviaries: a systematic review. World's Poultry Science Journal 61(1):130-42.
[192] Rodenburg TB, Tuyttens FAM, de Reu K, Herman L, Zoons J, and Sonck B. 2008. Welfare assessment of laying hens in furnished cages and non-cage systems: an on-farm comparison. Animal Welfare 17:363-73.
[193] Schuck-Paim C, Negro-Calduch E, Alonso WJ. 2021. Laying hen mortality in different indoor housing systems: a meta-analysis of data from commercial farms in 16 countries. Scientific Reports. 11(1):3052.
[194] Petherick JC. 2007. Spatial requirements of animals: Allometry and beyond. Journal of Veterinary Behavior 2:197-204.
[195] Appleby MC. 2004. What causes crowding? Effects of space, facilities and group size on behaviour, with particular reference to furnished cages for hens. Animal Welfare 13(3):313-20.
[196] Appleby MC, Hughes BO, and Elson HA. 1992. Poultry Production Systems: Behaviour, Management and Welfare (Wallingford, UK: CAB International, p.154).
[197] Rodenburg TB, Tuyttens FAM, and Sonck B. 2005. Welfare, health, and hygiene of laying hens housed in furnished cages and in alternative housing systems. Journal of Applied Animal Welfare Science 8(3):211-26.
[198] Newberry RC. 2004. Cannibalism. In: Perry GC (ed.), Welfare of the Laying Hen. Poultry Science Symposium Series 27 (Wallingford, U.K.: CABI Publishing, pp. 239-58).
[199] Bilcík B and Keeling LJ. 2000 Relationship between feather pecking and ground pecking in laying hens and the effect of group size. Applied Animal Behaviour Science 68:55-66.
[200] Appleby MC. 1993. Should cages for laying hens be banned or modified? Animal Welfare 2:67-80.
[201] Nicol CJ, Gregory NG, Knowles TG, Parkman ID, and Wilkins LJ. 1999. Differential effects of increased stocking density, mediated by increased flock size, on feather pecking and aggression in laying hens. Applied Animal Behaviour Science 65:137-152.
[202] Hughes BO and Duncan IJH. 1972. The influence of strain and environmental factors upon feather pecking and cannibalism in fowls. British Poultry Science 13:525-47.
[203] Gunnarsson S, Keeling LJ, and Svedberg J. 1999. Effects of rearing factors on the prevalence of floor eggs, cloacal cannibalism and feather pecking in commercial flocks of loose housed laying hens. British Poultry Science 40:12-8.
[204] Newberry RC. 2004. Cannibism. In: Perry GC (ed.), Welfare of the Laying Hen. Poultry Science Symposium Series 27 (Wallingford, U.K.: CABI Publishing, pp. 239-58).
[205] Aerni V, Brinkhof MWG, Wechsler B, Oester H, and Fröhlich E. 2005. Productivity and mortality of laying hens in aviaries: a systematic review. World's Poultry Science Journal 61(1):130-42.
[206] LayWel. 2006. Description of housing systems for Laying hens. www.laywel.eu/web/pdf/deliverable%2023.pdf. Accessed May 28, 2024.
[207] LayWel. 2006. Description of housing systems for Laying hens. www.laywel.eu/web/pdf/deliverable%2023.pdf. Accessed May 28, 2024.
[208] Fischer, VS. 2009. Evaluation of small group housing systems and an aviary system with the layer lines Lohmann Brown (LB) and Lohmann Selected Leghorn (LSL). Doctorate of Veterinary Medicine, Tierärztliche Hochschule Hannover, pp. 136-9.
[209] Weitzenbürger D, Vits A, Hamann H, and Distl O. 2005. Mortality and causes of death in layer strains Lohmann Selected Leghorn and Lohmann Brown kept in small group housing systems and furnished cages. Züchtungskunde 77(5):367-81.
[210] Guesdon V, Ahmed AMH, Mallet S, Faure JM, and Nys Y. 2006. Effects of beak trimming and cage design on laying hen performance and egg quality. British Poultry Science 47(1):1-12.
[211] Fraser D, Mench J, and Millman S. 2001. Farm animals and their welfare in 2000. In: Salem DJ and Rowan AN (eds.), State of the Animals 2001 (Washington, DC: Humane Society Press, pp. 87-99).
[212] Cheng H. 2006. Morphopathological changes and pain in beak trimmed laying hens. World's Poultry Science Journal 62(1):41-52.
[213] Dennis R, Fahey AG, and Cheng HW. 2009. Infrared beak treatment method compared with conventional hot-blade trimming in laying hens. Poultry Science 88:38-43.

[214] Newberry RC. 2004. Cannibalism. In: Perry GC (ed.), Welfare of the Laying Hen. Poultry Science Symposium Series 27 (Wallingford, U.K.: CABI Publishing, pp. 239-58).
[215] Dixon LM, Mason GJ, and Duncan IJH. 2007. What's in a peck? A comparison of the motor patterns involved in feather pecking, dustbathing and foraging. In: Galindo F and Alvarez L (eds.), Proceedings of the 41st International Congress of the ISAE (Merida, Mexico: International Society for Applied Ethology, p. 47). www.applied-ethology.org/res/2007%20isae%20in%20merida_%20mexico.pdf. Accessed May 28, 2024.
[216] Hughes BO and Wood-Gush DGM. 1977. Agonistic behaviour in domestic hens: the influence of housing method and group size. Animal Behavior 25:1056-62.
[217] Nicol CJ, Gregory NG, Knowles TG, Parkman ID, and Wilkins LJ. 1999. Differential effects of increased stocking density, mediated by increased flock size, on feather pecking and aggression in laying hens. Applied Animal Behaviour Science 65:137-152.
[218] Shinmura T, Eguchi Y, Uetake K, and Tanaka T. 2006. Behavioral changes in laying hens after introduction to battery cages, furnished cages and an aviary. Animal Science Journal 77(2):242-9.
[219] Lindberg AC and Nicol CJ. 1996. Space and density effects on group size preferences in laying hens. British Poultry Science 37:709-21.
[220] Lindberg AC and Nicol CJ. 1996. Space and density effects on group size preferences in laying hens. British Poultry Science 37:709-21.
[221] Häne M, Huber-Eicher B, and Fröhlich. 2000. Survey of laying hen husbandry in Switzerland. World's Poultry Science Journal 56:21-31.
[222] Appleby MC, Walker AW, Nicol CJ, et al. 2002. Development of furnished cages for laying hens. British Poultry Science 43:489-500.
[223] LayWel. 2006. Overall strengths and weaknesses of each defined housing system for laying hens, and detailing the overall welfare impact of each housing system. www.laywel.eu/web/pdf/deliverable%2071%20welfare%20assessment.pdf. Accessed May 28, 2024.
[224] Vits A, Weitzenbürger D, Hamann H, and Distl O. 2005. Influence of different small-group-systems on performance traits, egg quality and bone breaking strength of laying hens. 2nd Communication: Bone breaking strength. Züchtungskunde 77(5):355-66.
[225] European Commission. 2021. Communication from the Commission on the European Citizen's Initiative (ECI) 'End the Cage Age.' Official Journal of the European Union C 274:1-13. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=OJ:C:2021:274:FULL. Accessed May 28, 2024.
[226] Häne M, Huber-Eicher B and Fröhlich. 2000. Survey of laying hen husbandry in Switzerland. World's Poultry Science Journal 56:21-31.
[227] European Commission. Draft Decree on animal welfare. 2023/0603/BE (Belgium). technical-regulation-information-system.ec.europa.eu/en/notification/25004. Accessed May 28, 2024.
[228] European Commission. 2021. Communication from the Commission on the European Citizen's Initiative (ECI) 'End the Cage Age.' Official Journal of the European Union C 274:1-13. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=OJ:C:2021:274:FULL. Accessed May 28, 2024.
[229] European Commission. 2021. Communication from the Commission on the European Citizen's Initiative (ECI) 'End the Cage Age.' Official Journal of the European Union C 274:1-13. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=OJ:C:2021:274:FULL. Accessed May 28, 2024.
[230] Animal Welfare Livestock Regulation (Tierschutz-Nutztierhaltungsverordnung). 2015. https://www.bundesrat.de/SharedDocs/drucksachen/2015/0101-0200/112-15(B).pdf?__blob=publicationFile&v=1. Accessed May 28, 2024.
[231] European Commission. 2021. Communication from the Commission on the European Citizen's Initiative (ECI) 'End the Cage Age.' Official Journal of the European Union C 274:1-13. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=OJ:C:2021:274:FULL. Accessed May 28, 2024.
[232] Australian Government, Department of Agriculture, Fisheries and Forestry. 2022. Australian Animal Welfare Standards and Guidelines for Poultry.
[233] Australian Capital Territory. 2023. Animal Welfare Act 1992. www.legislation.act.gov.au/DownloadFile/a/1992-45/current/PDF/1992-45.PDF. Accessed May 28, 2024.
[234] National Farm Animal Care Council. 2017. Code of Practice for the Care and Handling of Pullets and Laying Hens. www.nfacc.ca/poultry-layers-code-of-practice#section2. Accessed May 28, 2024.
[235] New Zealand Government, Ministry of Agriculture. 2018. Code of Welfare: Layer Hens. www.mpi.govt.nz/dmsdocument/46036-Code-of-Welfare-Layer-hens. Accessed May 28, 2024.
[236] Surkes S. 2022. Cages for laying hens banned from new coops, to be phased out in existing ones. www.timesofisrael.com/cages-for-laying-hens-banned-from-new-coops-to-be-phased-out-in-existing-ones/. Accessed, 2024.

[237] The Poultry Site, 2012. Bhutan Bans Extreme Confinement Cages for Layers. www.thepoultrysite.com/news/2012/08/bhutan-bans-extreme-confinement-cages-for-layers. Accessed May 28, 2024.
[238] Ohio Admin. Code 901:12-9-03. https://casetext.com/regulation/ohio-administrative-code/title-90112-ohio-livestock-care-standards-board/chapter-90112-9-poultry-layers/section-90112-9-03-management. Accessed May 28, 2024.
[239] Act No. 117. State of Michigan. www.legislature.mi.gov/documents/2009-2010/publicact/pdf/2009-PA-0117.pdf. Accessed May 28, 2024.
[240] Act 132. State of Michigan. www.legislature.mi.gov/documents/2019-2020/publicact/htm/2019-PA-0132.htm. Accessed May 28, 2024.
[241] Oregon Department of Agriculture. 2011. Caged Laying-Hen Administrative Rule. www.oregon.gov/oda/shared/Documents/Publications/InternalServices/CagedLayingHenAdminRule.pdf. Accessed May 28, 2024.
[242] Oregon Department of Agriculture. About Senate Bill 805 & 1019. www.oregon.gov/oda/programs/AnimalHealthFeedsLivestockID/Hens/Pages/AboutHens.aspx. Accessed May 28, 2024.
[243] California Health and Safety Code Section 25990-25994. https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?sectionNum=25990.&nodeTreePath=24.42&lawCode=HSC. Accessed May 28, 2024.
[244] Keller & Heckman. 2024. Prop 12 takes full effect in California. The Daily Intake, January 2. www.dailyintakeblog.com/?s=prop+12. Accessed May 28, 2024.
[245] An Act to Prevent Cruelty to Farm Animals. Commonwealth of Massachusetts. https://malegislature.gov/Laws/SessionLaws/Acts/2016/Chapter333. Accessed May 28, 2024.
[246] Washington Wholesome Eggs and Egg Products Act. Revised Code of Washington, Sections 69.25.020, 69.25.065. https://app.leg.wa.gov/RCW/default.aspx?cite=69.25. Accessed May 28, 2024.
[247] Washington House Committee on Rural Development, Agriculture, & Natural Resources. 2019. House Bill Report SHB 2049. https://lawfilesext.leg.wa.gov/biennium/2019-20/Pdf/Bill%20Reports/House/2049-S%20HBR%20PL%2019.pdf. Accessed May 28, 2024.
[248] Arizona Secretary of State. 2022. Arizona Administrative Register, Notice of Final Rulemaking, 28(16): 802-808. https://apps.azsos.gov/public_services/register/2022/16/contents.pdf. Accessed May 28, 2024.
[249] Colorado General Assembly. Egg-laying Hen Confinement Standards. https://leg.colorado.gov/bills/HB20-1343. Accessed May 28, 2024.
[250] Nevada Revised Statute (NRS) Chapter 583, sections 583.211-583.251. www.leg.state.nv.us/NRS/NRS-583.html#NRS583Sec237. Accessed May 28, 2024.
[251] Nevada Department of Agriculture. Cage-free requirements to sell eggs & egg products in Nevada. https://agri.nv.gov/Plant/Producer_Certification/Cage-free_requirements/. Accessed May 28, 2024.
[252] Utah Agricultural Code Title 4, Chapter 4a Confinement of Egg Laying Hens. https://le.utah.gov/~2021/bills/static/SB0147.html. Accessed May 28, 2024.
[253] Rhode Island General Laws, Title 4 - Animals and Animal Husbandry. Chapter 4-1.1 - Unlawful Confinement of a Covered Animal. 4-1.1-1 and 4-1.1-3. webserver.rilegislature.gov//Statutes/TITLE4/4-1.1/INDEX.htm. Accessed May 28, 2024.
[254] State of Rhode Island. 2018. H 7456. http://webserver.rilin.state.ri.us/BillText/BillText18/HouseText18/H7456A.pdf. Accessed May 28, 2024.

# Our mission

Advancing the welfare of animals in more than 50 countries, Humane Society International works around the globe to promote the human-animal bond, rescue and protect dogs and cats, improve farm animal welfare, protect wildlife, promote animal-free testing and research, respond to disasters and confront cruelty to animals in all of its forms.

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