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Review Article

Behind Bars: Why Cage Housing in Laying Hens Should Be Banned

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ABSTRACT
The argument about the advantages and disadvantages of cage and cage-free housing in laying hens has long been a hot topic in social and scientific circles. The debate gained popularity again after wide public support and the positive response of the European Commission to the European Citizens' Initiative "End the Cage Age" in 2021. Welfare organizations have set their efforts to transform existing legislation into more ethical and sustainable farming systems based on documented behavior characteristics and enhanced human-to-animal relationships. Recently several reports have been published to offer insights into all questions concerning management, production, health issues, and profitability in the sector. The effect of short-term subsidies and educational programs have also been discussed as future measures if the ban on furnished cages is realized. This article aims to describe and analyze the current situation to search for alternatives that can ease the transition to cage-free husbandry.
Keywords: Welfare, Egg-Laying Hens, Furnished Cages, Alternative Systems

INTRODUCTION
The European Food Safety Authority (EFSA) has recently published (21st Feb 2023) a scientific opinion about the housing conditions in egg-laying hens concerning the

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factors that influence the welfare and behavior assessment in the sector. It states several problems that need to be addressed soon, namely: transition to cage-free systems, changes in the maximum level of stocking density, availability of natural light, access to open space, e.g. covered verandas, ability to perform species-specific reactions (EFSA, 2023a).

The number of laying hens in the European Union during 2019 was 365 million and 55% of these inhabited the territory of 4 member states (Germany, Poland, France, Spain). The use of furnished cages encompassed 49.5% or 180 million hens with a range variability between 1.9% in Austria to 99.4% in Malta. It was the preferred housing technology in Eastern, Central, and South Europe (Kollenda *et al*., 2020).

The information published on the official page of the European Commission states a similar number for 2022 - more than 350 million laying hens in the European Union which produce close to 6.7 million tons of eggs each year (EC, 2023a). The percentage by way of keeping is distributed into 43.2% furnished cages, 36.2% barn housing, 14% free range, and 6.5% organic. Furnished cages are widely distributed among member states with up to 99,4% for Malta, 87.7% for Estonia, 79.6% for Lithuania, 76.5% for Greece, 76.2% for Poland, between 75 and 70.1% for Portugal, Spain, Hungary, and Bulgaria. The percentage is lowest in Sweden, Germany, the Netherlands, Denmark, and 0% in Austria and Luxembourg (EC, 2023b). The preference for caged housing remained unchanged for Eastern and South Europe as well as for some other typical egg producers; however, some countries have diminished or set to zero such systems and managed to transition the sector to cage-free alternatives.

EFSA`s report for the same period outlines the negative effects of furnished cages: isolation and group stress; resting problems; inability to perform exploratory or foraging behavior (scratching, pecking); restriction of movement; bone lesions (including fractures and dislocations); soft tissue lesions; damage to feathers, claws, and beak; etc. (EFSA, 2023b).

Housing methods in laying hens were described in Directive 1999/74 of the European Commission and conventional battery cages were banned since 2012 (European Commission, 1999). Nevertheless, hens can still be raised in the so-called furnished or enriched cages. These structures possess different dimensions and can accommodate from 4-20 to 40-80 birds with a 750 cm^2 allowance per individual. According to standards equipment should include containers for feeding and drinking, an area for egg collection, transport belt for manure removal, doors for insertion and removal of hens as well as perches, nests, zones for dust bathing, pecking, and claw shortening as an attempt to answer certain behavior needs (EFSA *et al*., 2023).

However, are these minimal requirements able to provide normal conditions of existence in farms for egg-laying hens?

MATERIALS AND METHODS

Structured database research was carried out in PubMed and Google Scholar to identify relevant articles that correspond to the set keywords (egg-laying hen, cage housing, enriched cages, alternative housing, animal welfare, space allowance, nesting, foraging, perching, keel bone fracture, transitioning to cage-free systems). Only evidence-based and well-structured studies were selected. Official documents of European and world public organizations were also included.

RESULTS AND DISCUSSION

The Five Freedoms and the Definition of Welfare

In 1965 the Brambell Committee published a report of 85 pages that set the standards of welfare for animals in the industry. The most famous part of this scientific work became "The Five Freedoms": freedom from hunger and thirst; freedom from discomfort; freedom from pain, injury, and disease; freedom to express normal species-specific behavior; freedom from fear and distress (Brambell *et al*., 1965).

The definition of "freedoms" can describe the term "welfare" to a great extent as these are strongly connected. According to the World Organization for Animal Health (WOAH), existence in welfare should include "the physical and mental state of an animal about the conditions in which it lives and dies". Undoubtedly, nature or genetic characteristics (as manifested in the breed and temperament) should also be satisfied (Hewson, 2003).

Furnished cages possess many advantages compared to the out-of-use conventional cages, but still, these are characterized by limited size and increased stocking density. Individual space allowance of 550 cm^2 is not much different from 750 cm^2 of which only 600 cm^2 are usable; stocking density should not exceed 9 laying hens per m^2 in alternative systems, but it has not been specified for furnished cages (European Commission, 1999). The improvements introduced do not cover the hen behavior needs and the incidence of diseases caused by the productive system remains high. Influenced by social opinion the European parliament raised the question of change in legislation and opened the discussion for measures that will allow the transition to cage-free housing on the territory of member states (Rodenburg *et al*., 2020).

Limited Space Allowance

One of the main disadvantages of furnished cages is the lack of space for normal locomotion of birds (Weitzenbürger *et al*., 2006). Dimensions vary depending on the model. For example, small-sized furnished cages for up to 6 hens usually measure 1200 mm in width, 500 mm in depth, and 450 mm in height; measurements of 1920×625×450 mm or 1600×750×700 mm are seen in medium-sized furnished cages respectively (Li *et al*., 2017).

According to European legislation, each individual should be provided with 750 cm^2 including the area for dust bathing and nesting, or in reality only about 600 cm^2 (Kollenda *et al*., 2020; EC, 1999). This is insufficient for normal movement, especially in high stocking density. Furthermore, the standard height of 45 cm does not favor the natural wing flapping behavior in the species (Mench and Blatchford, 2014). It was estimated that the space needed for physiological wing stretching in brown breeds is 2800 cm^2 (Riddle *et al*., 2014), while the height should be at least 49.5 cm (Mench and Blatchford, 2014). Consequently, the artificial environment is a limiting factor for both locomotory and behavior reactions in hens (Mench and Blatchford, 2014). When alternative housing systems are being discussed it is noted that the species-specific behavior can be manifested in a surface allowance of a minimum of 5000 m^2 per individual (compared to the current minimum of 1111 m^2) (Savory *et al*., 2005), while the stocking density should not exceed 9 hens/m^2 (Rodenburg *et al*., 2020).

A directive of the European Commission states that when "an animal is continuously or regularly tethered or confined, it must be given the space appropriate to its physiological and ethological needs by established experience and scientific knowledge" (EC, 1998). Increased stocking density under cage housing conditions results in an inappropriate locomotor activity combined with almost complete mechanization of the production process, which is the cause of constant stress, altered behavior, and physiological deviation with a direct effect on hens` health and performance as well as the eggs` quality (Sosnówka-Czajka *et al*., 2021).

Inability to Exercise and Bone Health

Restriction to locomotor activity together with high egg-laying capacity predispose hens to osteoporosis and increased risk of fracture (The Humane Society of the United States, 2010). The frequency of this problem can reach 30% during the period of intensive egg laying (Whitehead and Fleming, 2000) with loss of bone mass and density (Regmi *et al*., 2016) being the main reasons for the so-called "cage layer fatigue" (Webster, 2004). The syndrome was first noticed after laying hens were accommodated in cages in the middle of the 20th century (Zhao *et al*., 2020). Bone weakness is associated with an increased incidence of fracture at various sites by the end of the laying period (Zhao *et al*., 2020; Olgun *et al*., 2016). Symptoms include inability to stand on the feet, decreased egg production, and thin egg shells (Grumbles, 1959).

A constantly investigated parameter in different housing designs relies on the occurrence of keel bone deformation and/or fracture (Thøfner *et al*., 2021). Data varies according to the research, however, lesions seem to be a common pathological finding with the incidence of 39-87% (Norman *et al*., 2021), 31.7% (Sherwin *et al*., 2010), 60% (Casey-Trott *et al*., 2017) or 62% (Rodenburg *et al*., 2008).

Predisposing factors include impaired metabolism of mineral substances due to intensive egg production, early egg laying (Thøfner *et al*., 2021; Toscano *et al*., 2020; Gebhardt-Henrich and Fröhlich, 2015), late ossification of the keel bone, low level of locomotor activity (Toscano *et al*., 2020). Damage to the keel bone is associated with pain and decreased mobility (Casey-Trott and Widowski, 2016) resulting in altered behavior and poor welfare in hens as well as a negative influence on performance, food consumption, and eggshell quality (Campbell, 2020; Wei *et al*., 2020).

Opposite to the common belief life in the narrow space of furnished cages is still representative of unacceptably high levels of keel bone damage without the opportunity to express several motivated behavior reactions (Compassion in World Farming EU, 2021).

The problem is exacerbated during the depopulation phase when more than 8.1% of individuals show new severe injuries (fractures and muscle traumas) or signs of significant stress reactions (Gerpe *et al*., 2021). The increased risk of fracture in cage depopulation (Sherwin *et al.*, 2010) is correlated to the weakness of bone structure due to the inability to exercise in confinement (Rodenburg *et al*., 2008).

It has been proven that locomotion affects positively bone quality (Webster, 2004; Whitehead and Fleming, 2000) by reducing the loss of bone tissue and increasing the resistance to bone fracture (Sharma *et al*., 2021). The availability of active load-bearing exercises improves the strength and mineral composition of bones and seems to be extremely important during the critical period of pullet growth (Campbell, 2020; Casey-Trott *et al*., 2017). Increased mobility and wing flapping can decrease the incidence of keel bone damage (Toscano M.J. *et al*., 2020; Casey-Trott T.M. *et al*., 2017), especially when pullets are reared in aviaries (Casey-Trott T.M. *et al*., 2017).

Dust Bathing, Foraging, Nesting, and other Natural Behaviors in Hens

Egg-laying hens housed in industrial systems express many other genetically determined behaviors like dust bathing, foraging, pecking, nesting, and perching.

Dust Bathing, Foraging, and Pecking Behavior

To satisfy the need for dust bathing furnished cages should provide areas covered with suitable substrate. However, the space allowance in these areas does not correspond to the actual number of birds and the litter is easily scattered (The Humane Society of the United States, 2010). The size of a litter box is usually 240 x 500 x 50 mm situated above or under the nest (Li *et al*., 2017). It was estimated that the minimal area for normal dust bathing behavior should be at least 1190 cm^2 (Riddle *et al*., 2008) or the size of boxes corresponds to the recommendations, but it is difficult for all individuals to reach and use the litter in high stocking density (The Humane Society of the United States, 2010). It was noted that dust bathing was manifested with varying frequency among hens in a group, which may reflect the fact that the substrate is not appreciated

by birds because it was not the right composition or concurrence between individuals was high enough to limit the ability of less dominant ones to take advantage of the litter box (Wall *et al*., 2008).

Dust bathing is known to be a social activity and the sight of hens manifesting this behavior acts as a trigger for other individuals (Duncan *et al*., 1998). It may occupy more than half of the daily routine in hen colonies (Rodenburg *et al*., 2022) but remains severely restricted in furnished cages due to the limited area (Platz *et al*., 2009).

The availability of a suitable substrate is also related to the normal foraging behavior that can cover another 50% of the time spent in a natural environment (Dawkins, 1989; Savory *et al*., 1978) and continues to be observed even when the same type of forage is present in the feeders (Dawkins, 1989; Duncan and Hughes, 1972). It is not only the quality but also the quantity of substrate that matters and having in mind the area provided it is still not possible for all individuals to participate equally (Rodenburg *et al*., 2020).

A significant factor that was already mentioned is the high stocking density that can predispose to the development of a negative behavior like feather pecking directed to some individuals in the group (EFSA *et al*., 2023; Fijn *et al*., 2020; Appleby *et al*., 2004). This indicator is equal to 10 hens per square meter in small and medium-sized furnished cages (Li *et al*., 2017). The problem can cause a serious economic effect as it is connected to a decrease in egg-laying performance, loss of body heat, worsening of feed conversion indices, and increase in mortality rate (Nicol *et al*., 2013). Therefore it can lead to decreased production and increased expenses. The pathology is characteristic of all types of housing in laying hens and probably develops due to stress, boredom, and hunger, which can be manifested as an altered foraging behavior transformed into feather pecking (Compassion in World Farming EU, 2021). Observations indicate that the risk is potentiated by space restriction (Louton *et al*., 2016) and inappropriate choice of substrate (Rodenburg *et al*., 2013).

The establishment of such a stereotypical biologically unfavorable behavior is an indicator of the inability to adapt to conditions characteristic of intensive production systems (Rodenburg *et al*., 2020). Evaluation of small group housing systems in comparison to furnished cages showed that feather pecking was more pronounced in the cage environment; the occurrence of the negative behavior in some of the individuals was attributed to the inappropriate substrate for dust bathing and foraging (Weitzenbürger *et al*., 2006).

The introduction of strategies to improve welfare was found to significantly reduce feather pecking as well as mortality (Lambton *et al*., 2013). Alterations in the environment should be dedicated to encouraging normal foraging and pecking behavior and the availability of an optimized diet (Compassion in World Farming EU, 2021), for example, the inclusion of rough forages and sand with pebbles for pecking

(Rodenburg *et al*., 2022). Gathering hens in smaller groups has a positive effect on limiting injurious reactions (Rönchen *et al*., 2007). The institution of dark brooders during pullet rearing shows promise to cope with unfavorable behavior (Rodenburg et al., 2022). Plumage conditions can also be controlled by the choice of a breed in combination with innovations and caretaker education to reduce the factors that cause stress in hens (de Haas *et al*., 2021, 2014).

Nesting Behavior

Searching for a suitable site and building a nest remains a strongly motivated behavior even in caged hens (Elson and Croxall, 2006), but can be influenced by many factors such as the structure of the nesting box, the substrate, the size of the enclosure, the stocking density and the breed (Hunniford and Widowski, 2016, 2017; Hunniford *et al*., 2014; Guinebretière *et al*., 2012; Guesdon and Faure, 2004). Nests in the artificial environment are usually made up of a metal sheet finally measuring 240 mm in width, 500 mm in depth, and 270 mm in height which should be covered with tuff (Li *et al*., 2017). The area is darkened to ensure normal egg-laying behavior but the substrate is often missing or not suitable to stimulate nest building (Compassion in World Farming EU, 2021).

Under natural conditions, hens are observed to search and choose the place for egg-laying from several possibilities giving preference to the availability of a substrate that can be easily molded (Duncan and Kite, 1989). Therefore the premises no matter the housing system should possess several types of nests; (Hunniford and Widowski, 2016, 2017); near the moment of egg-laying birds may check 25 or more places and sit in several of these before choosing the “right” one (Rodenburg *et al*., 2022).

Often nests are not utilized according to their purpose but rather as a hiding place where birds can remain during the whole light part of the day (Weitzenbürger *et al*., 2006). High stocking density is once again a factor in crowding when several individuals desire to use the area at the same time (The Humane Society of the United States, 2010), which can lead to developing concurrent behavior, frustration, and aggression (Sosnówka-Czajka, 2021). It was noticed that hens can put increased body weight pressure for access to the nest box compared to a lower urge to reach the feeders (Rodenburg *et al*., 2022).

Perching

Perches were among the main innovations to improve welfare conditions in furnished cages; however, their use depends on several factors like the choice of height and positioning, the size and height of the cage, age of the birds, and their genetic characteristics (Sosnówka-Czajka, 2021). The necessity to perch at a definite height over the ground originates from wild ancestors of the hen as an evolutionary defensive strategy against predation (Baishya *et al*., 2021).

The limited dimensions of furnished cages do not allow the positioning of perches at a higher level (Rodenburg *et al*., 2022). It was estimated that the distance from the ground should be 40 cm to diminish the natural fear of attack and also reduce the risk of feather pecking; another 20 cm above the perch is needed to maintain the birds in a comfortable sitting position (Compassion in World Farming EU, 2021). The height in small and middle-sized cages is 450 mm, and perches are situated at 150 mm from the wire floor (Li *et al*., 2017). Even in middle-sized models with the height of 700 mm (Li *et al*., 2017) there is no space to situate the perches at different levels (Mench and Blatchford, 2014) which is contradictory to the natural behavior where more dominant individuals occupy higher perches during the night (Baishya A. *et al*., 2021).

According to European Directive 1999/74/EC each hen should be granted a 15 cm perch surface (European Commission, 1999). However, the total length of these structures is not enough to allow birds to align all together (Riddle *et al*., 2018). Such minimal requirements cannot answer the high motivation to follow the instinct; as a result, perching is manifested by less than 75% of individuals (Platz *et al*., 2009).

Positioning perches at different levels allows for segregation based on the hierarchy structure within the group which can prevent negative events such as feather pecking and cannibalism (Baishya A. *et al*., 2021). More even distribution within housing dimensions can lower the stocking density on the floor (Struelens *et al*., 2008). Weitzenbürger *et al*. (2006) observed that perching was more pronounced in smaller groups raised in aviaries compared to furnished cages.

On the other hand, the introduction of perches was correlated to the higher incidence of trauma (Casey-Trott and Widowski T.M., 2016) possibly serving as a contributing factor for falls and high-energy collisions (Toscano *et al*., 2020). The outcome can be keel bone fractures seen in all housing systems; the comparison between these can be however challenging and is complicated by differences in the method for estimating the level of tissue damage, the genetic line, and the age of the birds (Hardin *et al*., 2019). The mean incidence of keel bone fracture is lowest in conventional cages, middle in aviaries, and highest in furnished cages, floor housing, and single-tier systems (Rufener and Makagon, 2020). These results may vary depending on the study. For example, 50% for free range, 24% in furnished cages, and 7% in floor systems (Dedousi *et al*., 2020). However, another research concluded of less significant difference between cage systems and free range - 50-98% and 53-100% respectively (Thøfner *et al*., 2021). Rufener and Makagon (2020) express the opinion that having in mind all factors the commonly established relationship between keel bone damage and housing technology may not be so straightforward. Keel bone fracture in caged hens may have been underestimated in previous studies due to scarce callus development in this category and diagnosis based on palpation (Kittelsen *et al*., 2020). Therefore, other causes should be well analyzed such as the metabolic changes observed during the egg-laying period (Thøfner *et al*., 2021; Toscano *et al*., 2020),

genetic background (Hardin *et al*., 2019), diet (Hardin *et al*., 2019), limited locomotion (Toscano *et al*., 2020), etc. An interesting fact that supports the relationship between egg laying and higher keel bone fracture incidence is that the problem is not found in male roosters (Kittelsen *et al*., 2020).

A possible solution can be found in the installation of ramps in open-type systems to allow movement between levels and lower the risk of trauma (Pettersson *et al*., 2017). In addition to lowering the percentage of keel bone fracture, these innovations can serve as prophylaxis to common inflammatory conditions affecting hens` feet (Mackie, 2019; Heerkens *et al*., 2016). Research by Stratmann *et al*. (2015a) showed a 59% decrease in collisions, 43% in falls, and 23% in fractures. Supplying omega-3 fatty acids in the diet resulted in 42-62% fewer diagnosed fractures due to visibly improved bone strength (Tarlton, 2013).

Another significant factor is the material that makes up the floor and perches. The replacement of the metal wire flooring with a softer plastic surface can reduce fractures by up to 76-85% (Heerkens *et al.*, 2016). Perches of compressible material are likely to absorb kinetic energy during collisions and increase the spread of pressure on the keel bone during perching (Stratmann *et al*., 2015) which can prevent the occurrence of keel bone fracture and deformation (Campbell, 2020; Riber *et al*., 2018; Stratmann, 2015b). Furthermore, the research on the traumatic effect of perches was carried out under experimental conditions in a controlled environment while the comparison of different housing systems should also estimate the physical characteristics of the perches` material and form (Rufener and Makagon, 2020).

The choice of housing technology was found to directly influence bone strength and frequency of fractures. Rearing in aviaries resulted in the decrease in fracture occurrence between 41.5 and 60.3% after transferring adult birds to furnished cages (Casey-Trott *et al*., 2017). The institution of ramps for pullets was correlated to better utilization of elevated structures that were retained in adult birds; keel bone damage was diagnosed in 52% of cases compared to 64.8% in controls at 40 days of age (Norman *et al*., 2021).

Variables such as breed (Kittelsen *et al*., 2020; Uzunova and Lazarov, 2020; Hardin *et al*., 2019) or strain (Fawcett *et al*., 2020) can serve as predisposing factors for keel bone fracture. Incidence can be diminished by breeding for increased bone strength (Campbell, 2020; Bishop *et al*., 2000). The effort to select hybrids that are better adapted to the specificities of the housing technology may be the way to effectively improve the welfare of egg-laying hens (Heerkens *et al*., 2019).

Fearfulness

Behavior testing of hens from different housing systems demonstrated that fear reactions were more pronounced in individuals from furnished cages compared to cage-free environments (Rodenburg *et al*., 2008). Response to anxiety was more

serious in pullets from cages than those from aviaries (Brantsæter *et al*., 2016a). Signs of fear manifested as tonic immobility, withdrawal, fight or flight reaction (Brown *et al*., 2022). Consequences can be described not only as an alarming welfare issue but also as a serious constraint to performance as it may lead to a decrease in egg productivity, reduced weight gain, and immune system suppression; fearful birds are more difficult to manipulate and show a higher risk of trauma (Erasmus *et al*., 2016). Individuals from cage-free systems are often better adapted to human interaction and less influenced by stressors from the environment (Rodenburg *et al*., 2005a).

Fear reactions were strongly correlated to feather pecking (Tahamtani *et al*., 2023; de Haas *et al*., 2013); increased anxiety of pullets to staff developed as a high level of feather damage in adults (de Haas *et al*., 2021, 2014). A similar correlation was observed in the frequency of keel bone fracture (Harlander-Matauschek *et al*., 2015). Therefore it is not only a matter of welfare, but it is also worth investing in a better human-to-animal bond which can result in a mutually positive effect (Eurogroup for Animals, 2023).

Outside cages hens can avoid people or other possible treads like individuals showing dominant and/or aggressive behavior, while on the contrary – it is hard for caged birds to isolate or hide from others that may start feather pecking for example (Rodenburg *et al*., 2008; Rodenburg *et al*., 2005b). The ability to manifest a "flight" behavior is completely natural and evolutionary stable in hens that feel endangered (Compassion in World Farming EU, 2021), it is just the way their wild ancestors will choose to do.

It was recommended for pullets and later adults to be reared in an enriched environment, which does not include furnished cages, but preferentially aviaries, in an attempt to decrease stress reactions (Brantsæter *et al*., 2016a, 2016b). The effect is better expressed up to the 5th week after hatching (Brantsæter *et al*., 2016b). Further enriching the living area in adults results in a positive outcome (Dumontier *et al*., 2022). Structural methods should be applied to optimize the normal development of the musculoskeletal, visual, and auditory systems, which will consequently promote adaptation and assist in producing adequate immune responses (Campbell *et al*., 2019). Birds from cage-free systems are generally more active, they use perches and nail trimming areas more frequently; their bones are stronger; and fear reactions are less pronounced (Rodenburg *et al*., 2008). Fearfulness in hens is characterized by low to intermediate heritability and can therefore be selected against in addition to applying better housing practices (Brown *et al*., 2022).

Risk of Infectious Diseases

The large number of birds under intensive production conditions presents an important prerequisite for the rapid spread of infectious diseases which often lead to serious economic disturbances. High stocking density induces a state of constant group stress (EFSA, 2023b; Sugiharto, 2022; Nasr *et al*., 2021; Villagrá *et al*., 2009) and may be

the cause of immune suppression (Zhang *et al*., 2022; Hofmann *et al*., 2020). Pullets kept under high stocking density had lower numbers of T lymphocytes which persisted during the laying period (Hofmann *et al*., 2021). High population density together with other factors can increase the risk of mutation and reassortment in pathogens to favor virulence (Moreno-Madriñan and Kontowicz, 2023) as well as the ease of spread (van Hoorebeke *et al*., 2010).

The unprecedented epidemic of Highly Pathogenic Avian Influenza from 2021/2022 in Europe imposed a preventative "lockdown" to all domestic birds, even those from free range that lasted for months. It is a critical situation that necessitates drastic measures; however, alternatives should be available like covered verandas and areas for foraging/pecking/dustbathing that allow access to natural light (Rodenburg *et al*., 2022).

Environment Contamination

High concentrations of nitrogen, phosphorus, and potassium in chicken manure present a major source of air, soil, and water pollution, particularly in the case of intensive systems with large volumes of waste products. European legislation has developed specific measures to prevent the negative influence on the environment and critically on human health (Kollenda *et al*., 2020).

Mortality

A meta-analysis of data from commercial farms comparing mortality in alternative and cage housing systems revealed that differences are not practically significant with average figures ranging from 3 to 5% at 60 weeks of age (Schuck-Paim *et al*., 2021). The parameter varies with age, genetic strain, population density, housing type, and seasonal alterations (Fulton, 2017). However, each year of experience with cage-free aviaries is associated with a 0.35 to 0.65% decrease mainly due to evolution in management knowledge and genetic research (Schuck-Paim *et al*., 2021). Incidence can be reduced when producers and staff get well acquainted with the specific rearing method, for example, by providing a sufficient number of perches corresponding to population density which can act as a measure against feather pecking, or by timely applying vaccines/deworming to prevent the rise of infectious diseases (Eurogroup for Animals, 2023). A practical, low-cost solution to avoid smothering and piling of hens can be the introduction of an A-shaped frame at the entrance and corners of the aviaries (Rodenburg *et al*., 2022). Breeding for better-adapted genetic lines and utilization of scientific innovations are expected to influence and reduce mortality (Schuck-Paim *et al*., 2021).

The Transition from Cage to Cage-Free Housing

The 2021 Report of Compassion in World Farming EU announces the already existing ban on furnished cages in Luxembourg, Austria and Switzerland, while Germany, the Czech Republic, Slovakia, Denmark, and France plan to follow soon.

Some of the biggest egg producers in Europe have already stated their intention and taken specific actions for the transition to cage-free housing. Projects to facilitate the development of new production methods in the egg laying industry are going like the Best Practice Hens Project and the EVOLUTION project (Eurogroup for Animals, 2023).

Sustainability analyses conclude that cage-free methods can be equally economically, ecologically, and socially concurrent to housing in furnished cages (Rodenburg *et al*., 2020). Free range proved to be the most cost-effective system in some research papers immediately followed by organic production (Dekker *et al*., 2011). It is expected that the widely discussed question about the replacement of furnished cages with cage-free housing may not affect profitability and even be more profitable in the case of free-range and organic eggs (Rodenburg *et al*., 2020). Furthermore, the quality assessment of eggs from alternative systems seems to be better based on yolk color (Castellini *et al*., 2002) and nutritional value (Rakonjac *et al*., 2014) compared to eggs originating from caged layers.

The market is changing and consumer's attention is now focused on cage-free production. Eggs from the retail sector are predominantly of this type in Germany and the Netherlands and the tendency is spreading to other European countries as well (Rodenburg *et al*., 2020). The Wageningen Economic Research (2022) predicts increased demand for eggs with codes other than “3” (cage housing) from 2026 on (van Horne and Bondt, 2023).

The transition to cage-free production is predicted to be a continuous process; however, the first measure that should be undertaken is a ban on furnished cages similar to the one introduced in 2012 for conventional cages. Adaptive alterations in the sector can be alleviated and in a way stimulated by short-term subsidies granted by the European Union (Rodenburg *et al*., 2020). Some of the important egg producers have already started reorganizing their business through private funding or by taking advantage of different programs (Eurogroup for Animals, 2023). The egg laying industry depends on large-scale investment approximately every 15 years. The last such investment was imposed by the ban on conventional cages in 2011/2012; therefore the next key period will be around 2026 and may coincide with the expected ban on furnished cages (van Horne and Bondt, 2023). Among other factors that can favor the transition, educating the staff to manage challenges in the new working environment as well as potentiating the exchange of information for good practices and cooperation on the producer-retailer level will contribute to an overall positive effect (Eurogroup for Animals, 2023).

Interviews summarized in the Eurogroup for Animals report suggest that farmers appreciate the possibility of housing conditions similar to the natural environment of hens that will allow them to manifest freely a species-specific behavior (Eurogroup for Animals, 2023). The "Best Practice Hens" project offers certain economic advantages as a result of welfare improvements which can be correlated to increased productive efficiency together with job satisfaction (Best Practice Hens, 2022a, 2022b).

End the Cage Age: Looking for Alternatives

The latter is the title chosen by the European Parliament's Committee on Petitions (PETI) that deals with the argument for or against furnished cages. Conclusions suggest that hens from cage-free systems possess the greater possibility to manifest highly motivated behavior like foraging, pecking, and dust bathing. Space allowance for active locomotion can reduce the severity of the consequences of osteoporosis. In the case of free-range housing, the risk of feather pecking, cannibalism, and fracture incidence during depopulation can also be decreased. Educating the staff and continuing scientific research can give the solutions to overcoming disadvantages in alternative housing systems (Rodenburg *et al*., 2020).

The last EFSA report on laying hens recommends the choice of cage-free housing systems. Welfare assessment systems are offered to estimate the risk of keel bone fractures and feather damage. Investment in perches and raised platforms as well as a suitable substrate (sand) to potentiate the species-specific behavior of foraging, pecking and dust bathing is obligatory. To reduce high stocking density during the daytime access to covered verandas should be granted or the common space for the group should be increased (EFSA, 2023b). Rana *et al*. (2021) concluded that hens prefer UV light for foraging and dust bathing behavior; therefore, they should be allowed to roam freely outside the premises or at least have the opportunity to occupy areas with natural light.

With the enforcement of the Lisbon Treaty in 2009 animals were finally recognized as sentient beings whose welfare requirements should be addressed (European Commission. Food safety. Animal welfare). Species-specific characteristics can be estimated by a system called Welfare Quality based on the Five freedoms and four basic principles, namely: good feeding, good housing (freedom of movement), good health (osteoporosis, keel bone fracture), and appropriate behavior (Rodenburg *et al*., 2020). Etiology research has already proved that hens can no longer be raised in cages (Rodenburg *et al*., 2022).

CONCLUSIONS

In 2021 the European Citizens` Initiative "End the Cage Age" was able to collect 1.4 million votes from 28 member states and was submitted for consideration by the European Commission (Questions and Answers: Commission's response to the

European Citizens' Initiative on “End the Cage Age”). The wide public support presents a significant indicator of the altered attitude to the egg industry and the need for alternatives in hen layers housing. An increasing number of consumers seem to prefer eggs or egg-containing products from cage-free systems independent of the higher-end price (van Horne and Bondt, 2023). This on the other hand is a good stimulus for producers and may be able to compensate for the transition to alternative housing (Eurogroup for Animals, 2023). The European Commission must comply with popular opinion and take steps toward the ban a practice that does not coincide with the high moral values set in European legislation. “Cage should not be used!” (EFSA *et al*., 2023) It is a simple sentence that says it all. And it is encouraging that not only the people and non-profit organizations but also scientists and the authorities start to believe in this undeniable truth.

CONFLICT OF INTERESTS

The authors declare no potential conflict of interest is reported regarding the subject matter of this manuscript either for financial, commercial, or intellectual purposes.

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