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THE WELFARE OF LAYER HENS IN CAGE AND CAGE-FREE HOUSING SYSTEMS

The RSPCA is Australia's leading animal welfare organisation and one of Australia's most trusted charities.

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AUGUST 2016

The current review of the *Model Code of Practice for the Welfare of Animals – Domestic Poultry* offers the first opportunity in 15 years to improve the minimum welfare standards for layer hens in Australia. It provides the chance to update Australian standards to reflect current animal welfare science and equivalent international developments.

For many years, RSPCA Australia has emphasised the importance of ensuring the standards review process is informed by a thorough review of relevant domestic and international scientific literature, conducted by an independent scientific advisory committee. Internationally, this is recognised as an essential step in the development and review of evidence-based animal welfare standards. Unfortunately, no such process yet exists in the standards development process in Australia.

In the absence of a government-initiated independent scientific review, RSPCA Australia provides this review on the current science relating to the welfare of layer hens in cage and cage-free housing systems in Australia.

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EXECUTIVE SUMMARY

There are two main types of housing systems for layer hens in Australia. The first is conventional or 'battery' cages, which are barren wire cages, set in rows and tiers. A small number of hens are kept in each cage. The second is cage-free systems, which comprise free range and barn. Hens in cage-free systems are typically able to move throughout a shed (barn), which may have more than one level (multi-tiered, or aviary systems). Birds may have access to litter, a covered outdoor area (veranda), and/or a range (free range). Hens in cage-free systems are provided with nests, and sometimes perches.

Furnished cages were developed to overcome some of the welfare issues in battery cages. They are larger than battery cages, contain more hens, and usually include perches, enclosed nests, some substrate, and scratching areas. Furnished cages have been adopted in the European Union, Canada and New Zealand, however some countries have prohibited them (Switzerland) or committed to a phase-out of their use (Austria, Belgium). They are currently not used widely in Australia.

In recent years in Australia there has been an increase in the use of cage-free systems due to public concern for animal welfare. The major supermarkets and food service companies are contributing to the trend. Free-range egg production has increased by 50% in the past five years, while the portion of eggs from hens in cages sold at retail has shrunk. However, due to increasing overall demand for eggs, the absolute number of hens kept in battery cages has not fallen: it is estimated that between 11 and 12 million layer hens are currently housed in cages in Australia.

This shift in production from cage to cage-free systems has the potential to reduce the number of hens housed in battery cages. However, it is unlikely to result in a complete phase-out of this housing system while it continues to be permitted in regulations and standards for layer hens.

Current minimum welfare standards are set out in the Australian *Model Code of Practice for the Welfare of Animals – Domestic Poultry – 4th Edition.* In 2013, State and Territory governments agreed to commence a full review of the Model Code 'in recognition of significant advances in husbandry practices, technology, and in available science'. This review commenced in June 2015, managed by Animal Health Australia and led by the NSW Department of Primary Industries. The review of the Model Code offers the first opportunity in 15 years to improve the minimum standards for layer hens in Australia.

For many years, RSPCA Australia has emphasised the importance of ensuring the standards review process is informed by a thorough review of relevant domestic and international scientific literature, conducted by an independent scientific advisory committee. In the absence of such a process, RSPCA Australia provides this review of the current science relating to the welfare of layer hens in cage and cage-free housing systems in Australia.

Assessment of layer hen welfare

Historically, animal welfare has been defined by the absence of negative states such as disease, hunger and thirst. However, a shift in animal welfare science has led to the understanding that good animal welfare cannot be achieved without the experience of positive states. Thus good welfare involves a combination of good nutrition, a good environment, good health, appropriate behaviour and positive mental experiences.

Positive affective states in layer hens require not only the absence of disease, hunger, and thirst, but also the opportunity for hens to perform behaviours which they are motivated to perform. These behaviours include nesting, foraging, ground-scratching, perching, and dustbathing. The expression of these behaviours leads to better health and welfare while preventing their expression leads to frustration and can create welfare problems. There is a growing trend for animal welfare standards to require hens be allowed to perform normal behaviours, which has led to the phasing-out of battery cage housing systems as they do not meet this requirement.

Layer hen welfare is multifactorial and can be affected by disease, nutrition, pests and parasites, the external environment, behaviour, stress, emotional states, and genetics. This report focuses on factors relating to layer hen housing systems. Key factors affecting hen welfare due to housing system include bone health, disease, behavioural expression (movement, perching, nesting, dustbathing, foraging and exploration), severe feather pecking, early life experiences, group size, and husbandry and handling (Box 1).

Welfare by housing system

The main disadvantage of battery cages is extreme behavioural restriction and the inability for hens to perform normal behaviours including foraging, exploring, nesting, perching, and dustbathing. Hens are also not able to escape other aggressive hens. The inability of birds to move properly or walk leads to non-transmissible diseases including very poor musculoskeletal health, disuse osteoporosis, and a non-infectious disease called fatty liver. The bone weakness incurred by hens in battery cages contributes to a very high rate of fractures when the hens are removed from the cages at the end of their lives. Although some of these problems can be addressed through husbandry and genetic selection, the major issues are unable to be resolved when birds are confined to battery cages.

The main welfare risks in cage-free systems are the transmission of infectious diseases and severe feather pecking, both of which can lead to mortality. Hens can also experience fractures due to collision with objects such as perches and nest boxes. These issues, and the extent to which they occur, are largely affected by the management and stockpersonship on each farm. Addressing severe feather pecking requires an integrated approach comprising genetic selection, the provision of appropriate housing conditions, and good management. The transmission of infectious diseases is strongly affected by biosecurity and health management practices. The incidence of fractures in these situations may be addressed by the design, maintenance, and placement of structures within the shed, complemented by genetic selection for improved bone strength. Overall, management is a very large determinant of welfare in cage-free systems.

Furnished cages possess some of the qualities of battery cages in terms of lower disease transmission, as well as some qualities of cage-free systems in terms of greater behavioural expression and improved bone strength. However, they do not cater fully for the behavioural needs of the birds since foraging and dustbathing may only be partially accommodated as substrate may be insufficient, or quickly depleted.

There are advantages and disadvantages to hen welfare in each type of housing system (Box 2). The main risks to hen welfare in cage-free systems are, at present, highly variable. Many of the disadvantages in cage-free systems may be addressed and improved by good infrastructure design, good management practices, genetic selection, and further research. Conversely, the welfare issues in battery cages are inherent to the system, are therefore largely not affected by management and thus cannot be avoided.

Layer hen welfare standards

Examination of the relevant animal welfare science indicates two key areas for improvement to layer hen welfare standards in Australia. The first is to remove the extreme behavioural restriction inherent to battery cages by phasing out their use. The second is to improve management practices, genetic selection and minimum standards for cage-free systems.

The discipline of animal welfare science treats animal welfare as the primary concern, with productivity and efficiency as correlated benefits. However, the economic value of farm animals is largely determined by their productivity. In contrast to improvements in productivity, improvements in welfare do not necessarily guarantee an increase in profit. Therefore, there is an obvious role for government policy in establishing and enforcing standards, and a clear need for government to intervene when market processes fail to adequately protect animals from poor welfare practices.

In Australia, public concern over the use of battery cages is consistently high and has increased further in recent years. This concern is reflected in supermarket purchasing choices, with almost half of consumers purchasing eggs from hens in cage-free systems and all major supermarkets making cage-free commitments. Cage-free eggs now represent the highest value to the egg industry in Australia in terms of grocery sales market share. Despite this shift, cage layer farming still constitutes 68% of total egg production.

The Australian egg industry is largely self-regulated, with independent welfare accreditation schemes emerging in response to the increasing consumer concern for farm animal welfare and the lack of adequate poultry welfare regulation.

The manner in which animal welfare standards are developed has large impacts on their acceptability and the extent to which they are supported by stakeholders and the wider community. The development of Australian animal welfare standards has been criticised for its lack of independence and the lack of focus on animal welfare science. In order for the welfare of layer hens in Australia to improve, standards need to be based on internationally recognised science, and be independent of industry productivity goals. This separation has been achieved in other countries by establishing independent scientific welfare committees and animal welfare frameworks and has led to the phasing-out of battery cage production in a growing number of countries.

Battery cages have been prohibited in the European Union since 2012 due to a 1999 Directive which legislated their phase-out. Switzerland prohibited battery cages in 1992, and Sweden prohibited them in 2002. Austria prohibited battery cages in 2009. New Zealand has implemented a legislative phase-out of battery cages from 2012. Canada has recently announced an industry-led phase-out of battery cages with a draft code proposing a mandated end date of 2036. In the United States, three states have passed legislation to end their use and nearly 100 major companies have stopped sourcing eggs from battery cages.

In 1999, the Australian Senate recommended the prohibiting of battery cages once viable alternatives were developed, based in part on the large amount of scientific literature on the welfare of laying hens dating back to the mid-1960s. When the *Model Code of Practice for the Welfare of Animals – Domestic Poultry* was last reviewed in 2000, the Working Group concluded that there was an urgent requirement to identify the successful principles of managing cage-free systems and facilitate the successful adoption of these alternative systems. Several Working Group members agreed that the scientific literature identified major problems with battery cages and that an end-date for the use of battery cages in Australia should be set.

Australia is now behind much of the developed world in layer welfare standards and regulation. To date, the only jurisdiction in Australia which has prohibited the use of battery cages to house layer hens is the ACT, in 2014. The current review of the *Model Code of Practice for the Welfare of Animals – Domestic Poultry* offers legislators the first opportunity in more than 15 years to implement a national phase-out of battery cages and introduce uniform minimum standards for cage-free systems that reflect current animal welfare science. However, despite the overwhelming scientific evidence, battery cages were still permitted in the first draft of these standards, a reflection of the lack of independence and focus on science in the animal welfare standards setting process.

To ensure layer hens in Australia have a good quality of life, the poultry standard must set an end date for the use of battery cages. Animal welfare standards for poultry must be underpinned by current welfare science that clearly shows that battery cages cannot meet the needs of layer hens.

Box 1. Key factors affecting layer hen welfare

Bone health	Commercial layer hens are highly susceptible to osteoporosis and poor bone strength due to very high rates of egg laying. The severe behavioural restriction in battery cages causes disuse osteoporosis, the poorest musculoskeletal health, and the highest number of fractures at depopulation of all housing systems. Hens in furnished cages have improved bone strength compared to battery cages due to the increased behavioural repertoire in these systems. Hens in cage-free systems have the best musculoskeletal health of all systems, but a higher rate of fractures during the production period due to misadventure.
Disease	Non-infectious diseases including disuse osteoporosis and fatty liver are largely attributed to the restriction of movement in battery cages. The transmission of infectious diseases is a higher risk in cage-free systems. Appropriate disease control standards, standard enforcement, and good management practices can allow the prevention and control of infectious diseases and parasites.
Movement	Hens in battery cages experience extreme behavioural restriction. They cannot flap their wings, walk or run, and do not adjust to this behavioural restriction. Furnished cages allow greater movement and expression of more normal behaviours, but behaviour is still restricted. There are greater opportunities for movement in cage-free systems, although this can be compromised if stocking densities are too high.
Perching	Hens have a strong motivation to use perches, and most birds will perch at night if given the option. The provision of perches: • improves bone strength • reduces fearfulness and aggression • gives places for refuge • reduces injurious pecking • enhances the use of space and reduces stocking density on the floor. The inability to perch decreases musculoskeletal health. Rearing without early access to perches causes low muscle strength, a lack of motor skills, the inability to keep balance, and impaired cognitive spatial skills, with long-lasting effects on welfare. Hens show signs of unrest when they are deprived of the opportunity to perch at night, and experience frustration and reduced welfare if perching is not possible. The inclusion of perches in all housing systems is relatively straightforward, and has the potential to yield large improvements in welfare if placed and managed correctly.
Nesting	Nesting is a high priority for hens. The need for hens to use a nest has been consistently demonstrated by motivation tests. Hens have been found to work harder to access a discrete nest site prior to egg laying than they do gaining access to food following 4 hours of food deprivation. An enclosed nest area can reduce cannibalism. If denied a nest, hens can become frustrated, pace, and retain their eggs beyond the expected time of lay.

Dustbathing	Hens typically perform dustbathing every other day to clean their feathers. Hens have an instinctive motivation to dustbathe. Hens are unable to dustbathe in battery cages, and can perform sham-dustbathing in lieu of this normal behaviour. Sham-dustbathing lacks positive feedback, does not satisfy birds, and can indicate a reduced state of welfare. When hens are unable to dustbathe, their plumage is in a poorer condition as it is dirtier and less insulative.
Foraging and exploration	Foraging is a significant part of the normal behaviour of hens. Studies have found that when litter is available, hens spend the majority of their time pecking and scratching the ground. Hens perform foraging behaviours even when feed is freely available in feed troughs, demonstrating an instinctive behavioural motivation to forage for food. Hens will work to have litter and even enter smaller cages in order to have access to litter, indicating that it is a high priority.
Severe feather-pecking and cannibalism	Severe feather pecking is an injurious behaviour where hens vigorously peck at and pull out the feathers of other birds. It is a widespread and serious welfare concern in the egg industry. Severe feather pecking is multifactorial, and is affected by genetics, the environment, and nutrition. Large group sizes are thought to be a risk factor in the spread and subsequent prevalence of severe feather-pecking. Research, genetic selection, and good management strategies are required to address the expression of severe feather pecking.
Beak trimming	Beak trimming is the partial removal of the tip of the beak, and one of the most common methods utilised by the poultry industry to control the impacts of severe feather pecking. Beak trimming can cause both acute and chronic pain, and can lead to difficulty feeding. While relatively effective in controlling severe feather pecking, beak trimming is an invasive procedure which affects birds' sensory capabilities and normal behaviour, and is prohibited in several countries. There is a need to move away from beak trimming and instead focus on good management strategies, environmental complexity and enrichment, the selection of appropriate genetics, small group sizes, and more research to elucidate the causes of severe feather pecking.
Rearing – early life experiences	Early life experiences have large impacts on hens later in life. Matching the rearing and laying environments as closely as possible allows birds to effectively utilise the resources provided during the laying period and reduce the risk of severe feather pecking. Hens that do not have access to perches during their early lives can have difficulty adapting later in life, which can result in reduced bone strength, increased severe feather pecking and reduced access to feed, water, perches, and nests. Exercise during rearing is linked with skeletal health later in life. The opportunity to forage in early life can prevent the development of severe feather pecking in adulthood.

Foot health	Foot pad dermatitis, the ulceration of the bottom of the foot, is largely attributable to contact with damp or wet litter. Bumblefoot, abscesses on the foot and swelling, is affected by moisture on perches or litter. Hyperkeratosis, the hypertrophy of the feet and toes, occurs most frequently in hens in battery cages. Battery cages can cause excessive claw length due to the lack of solid flooring and the inability for birds to scratch the ground. This can lead to trapping of the claw and damage to the foot. Dry litter can prevent foot pad dermatitis and bumblefoot, as well as excessive claw length.
Group size and space allowance	Group size and social preferences have big impacts on hen welfare. In battery cages, where group sizes are small, there is very limited opportunity for subordinate hens to escape aggressive hens. This can lead to chronic fear, injuries, and sometimes death due to cannibalism. Hens in larger groups in more complex environments may have a greater ability to escape aggressive birds and seek refuge. However, severe feather pecking can spread rapidly throughout large groups. Hens should be housed in complex environments at low densities and in optimum group sizes, to enable them to make choices about their environmental and social preferences and adequately perform normal behaviours. As space allowance increases, hens engage in a greater range of behaviours. Sufficient space allows hens to perform basic movements and comfort behaviours such as stretching and preening, as well as unrestricted opportunities for nesting, dustbathing and foraging. While research is not definitive, group sizes between 10 and 60 appear to be optimal for hen welfare.
Husbandry and handling	Good animal husbandry and management are crucial to animal welfare in any type of system. Those responsible for hen welfare should be appropriately trained, handle hens gently to minimise distress, be able to identify sick or injured animals and administer appropriate treatment, and proactively monitor hens for health and behaviour. Husbandry and stockpersonship are particularly important in cage-free systems, where there is a heightened need to monitor for severe feather pecking and infectious diseases.
Access to feed and water	Adequate access to feed and water is affected by stocking densities, positioning of the feeders and drinkers, and the positioning of other objects within the housing environment.
Diet	Diet formulation, composition, and changes in diet have big impacts on the expression of severe feather pecking. Feed ingredients and structural composition of the feed (e.g. pellets versus mash) affects behaviours including severe feather pecking.

Diet *(cont.)*	The health and behaviour of hens should be monitored, and the diet adjusted where appropriate to meet the needs of the birds.
Air quality	In indoor, intensive housing systems, there can be high concentrations of ammonia in the air. Atmospheric ammonia is aversive to the hen and can result in damage to the respiratory system and a higher risk of infectious disease.
Light	Poultry reared in dim light can have impaired vision Birds show less preening and foraging behaviours under low lighting. Low light intensities can be inadequate for workers to effectively inspect birds. Adequate light intensities should be provided to allow healthy eye development and normal behaviours as well as aid inspection of birds.

Box 2. Summary of welfare issues by housing system

Battery cages	Hens in cages experience a lower risk of infectious diseases, and the small group sizes means there is a lower transmission of severe feather pecking. Hens in battery cages experience the highest rate of some non-infectious diseases including fatty liver and disuse osteoporosis due partly to the lack of movement. The extreme behavioural restriction in battery cages which includes the inability for hens to walk, nest, dustbathe, forage, flap their wings or perch, causes the poorest bone strength of all housing systems, and the highest number of fractures at depopulation. The welfare disadvantages of battery cages are inherent in the infrastructure design and cannot be overcome by management. Battery cages prevent hens from carrying out innate behaviours such as laying their eggs in a nest, dust bathing and foraging.
Furnished cages	Furnished cages offer the benefits of battery cages in terms of hygiene and disease control, whilst offering some benefits of cage-free systems in terms of increased behavioural expression and improved musculoskeletal health. Hens in furnished cages have increased opportunities for behavioural expression with the inclusion of perches, substrate, claw-shortening devices, and nest boxes, but the full range of behaviours is not able to be expressed satisfactorily.
Cage-free systems	Cage-free systems can allow hens to perform all of their behaviours including nesting, perching, and dustbathing, if litter is provided and well maintained. This contributes to hens in these systems experiencing the best musculoskeletal health, and a lower incidence of osteoporosis and fractures during depopulation. Cage-free systems pose a higher risk of transmissible diseases and severe feather pecking, and hens experience a higher rate of fractures during the laying period. There is more variability between cage-free farms, and these systems are highly susceptible to management practices to improve welfare.

1. INTRODUCTION

There are two main types of housing systems for layer hens in Australia. The first is conventional or 'battery' cages, which are barren wire cages, set in rows and tiers. A small number of hens are kept in each cage. The second is cage-free systems, which comprise free range and barn. Hens in cage-free systems are typically able to move throughout a shed (barn), which may have more than one level (multi-tiered, or aviary systems). The flooring may be litter or other material such as slats or wire mesh, or a combination of litter and slats. Birds may have access to an outdoor area (free range), which may include a covered outdoor area, or veranda. Hens in cage-free systems are provided with nests, and sometimes perches (Primary Industries Standing Committee 2002).

Furnished or 'enriched' cages were developed to overcome some of the welfare issues in battery cages. They usually include perches, enclosed nests, some substrate, and scratching areas or claw abrasives (Appleby et al. 2002). Furnished cages provide extra cage height, are larger than battery cages, and contain more hens (typically between 10 to 30 hens in small and medium furnished cages, and ranging from 40 to greater than 100 hens in larger furnished colony cages) (Widowski et al. 2013). While furnished cages have been adopted in many other countries, they are not currently widely used in Australia.

There has been an increase in cage-free systems in Australia in recent years due to public concern for the welfare of hens in battery cages. Free-range egg production has increased by 50% over the past five years, while the portion of eggs from hens in cages sold at retail has shrunk (64% were cage in December 2010 to 51% in December 2015; AECL 2010; 2015).

The major supermarkets Woolworths, Coles, and Aldi, as well as major food service companies such as McDonald's, Hungry Jacks, Subway, and Simplot Australia (Lean Cuisine, Leggo's) are contributing to the trend. Coles no longer sells cage eggs under its own brand, Woolworths is phasing out the sale of eggs from hens in cages altogether by 2018, and Aldi is phasing out cage eggs by 2025. Subway and Simplot Australia are currently cage free, with McDonald's and Hungry Jacks committing to being cage free by 2018.

The increase in hens in cage-free systems is set to continue as these commitments come into play (IBISWorld 2015).

This shift in production from cage to cage-free systems has the potential to reduce the number of hens housed in battery cages. However, it is unlikely to result in a complete phase out of battery cages while the minimum standards for layer hens continues to permit their use.

Current minimum standards for the housing of layer hens are set out in the Australian *Model Code of Practice for the Welfare of Animals – Domestic Poultry – 4th Edition* (Primary Industries Standing Committee 2002). While the Model Code itself is not enforceable, specific aspects are regulated under state animal welfare legislation, in particular, minimum height and floor area allowances for layer hens in cage systems.

In 2013, the Animal Welfare Committee (a standing committee of State and Territory government officers working under the Council of Australian Governments framework), agreed to commence a full review of the Model Code for poultry 'in recognition of significant advances in husbandry practices, technology, and in available science, since the current code was endorsed in 2002' (Australian Animal Welfare Standards and Guidelines 2016). In May 2015, the Animal Welfare Task Group (AWTG), which replaced the AWC, reconfirmed this decision and appointed Animal Health Australia and the NSW Department of Primary Industries to manage and lead the process. The review commenced in June 2015 and the first meeting of the Stakeholder Advisory Group was held in May 2016.

The current review of the Model Code offers the first opportunity in 15 years to improve the minimum standards for layer hens in Australia. In particular, it offers the prospect of updating Australian standards to reflect current animal welfare science and equivalent international developments.

For many years, RSPCA Australia has emphasised the importance of ensuring the standards review process is informed at its commencement by a thorough review of relevant domestic and international scientific literature, conducted by an independent scientific advisory committee (RSPCA Australia 2014). Internationally, this is recognised as an essential step in the development and review of evidence-based animal welfare standards. Examples of such reviews include the R*eview of Scientific Research on Priority Issues for the Code of Practice for the Care and Handling of Pullets, Layers, and Spent Fowl: Poultry (layers) in Canada* (Widowski et al. 2013), the R*eport on the Welfare of Laying Hens by the Scientific Veterinary Committee for Animal Welfare in the European Union* (European Commission 1996), and the *Animal Welfare (Layer Hens) Code of Welfare Report* by the National Animal Welfare Advisory Committee of New Zealand (NAWAC 2012). Unfortunately, no such process yet exists in the standards development process in Australia.

In the absence of a government-initiated independent scientific review, RSPCA Australia provides this review on the current science relating to the welfare of layer hens in cage and cage-free housing systems in Australia.

This report does not offer an exhaustive summary of all welfare issues in layer hens but is focused on those related to housing systems. There are many other serious welfare issues in the poultry industry which warrant their own scientific review but are not included here.

The report begins with an explanation of what animal welfare is, how it may be assessed, and examines the key factors that affect layer hen welfare. These factors are then summarised by housing system. The report ends by identifying the main areas for improvement, the background to the animal welfare standards-setting process, reforms to layer hen housing regulation in other countries, and suggests a way forward to ensure that the way in which layer hens are housed in Australia reflects current science and meets community expectations.

2. ASSESSMENT OF LAYER HEN WELFARE

2.1 What is animal welfare and how is it assessed?

There are three main science-based conceptual frameworks which have been used to understand animal welfare (Hemsworth et al. 2015).

1. *Biological functioning*
   The biological functioning approach reflects an individual's ability to cope with its environment and whether its needs are met (Broom 1986). It considers basic health and normal body function, stress responses, and normal behaviour (EFSA 2005; Widowski et al. 2013). Essentially, the ability for an animal to cope with environmental challenges is reflected in its function. Biological function may be measured by behavioural and physiological changes, including the synthesis of catecholamines and glucocorticoids (Hemsworth et al. 2015).
2. *Affective state*
   An animal's affective state encompasses its experience of negative states such as pain, fear and frustration, and positive states such as comfort and contentment (EFSA 2005; Widowski et al. 2013). An animal's affective experiences are a combination of its internal functional state as well as its perception of its external environment. Methods that have been used to assess affective states include measures of behavioural preferences, cognitive bias, and physiology. However, additional methods are still being sought (Hemsworth et al. 2015).
3. *Natural living*
   Natural living is essentially the ability for an animal to live according to its nature, and express normal behaviours (EFSA 2005; Widowski et al. 2013). This approach emphasises the potential welfare benefits of engaging in natural behaviours. In order to improve animal welfare, there is a need to identify which behaviours animals are motivated to perform, and which are beneficial for their welfare (Hemsworth et al. 2015).

Although initially seen as competing, the biological functioning and affective state frameworks are effectively unified. Biological functioning includes affective experiences, and affective experiences are products of biological functioning. Understanding the interactions between the two is fundamental to improving animal welfare (Hemsworth et al. 2015).

Feelings play a major role in animal welfare (Duncan and Dawkins 1983). Appleby and Hughes (1997) gave the example of nutrient deficiency. If an animal is unable to eat enough to meet its biological requirements, nutrient deficiency may affect biological functioning. However, it is the experience of the state of hunger that reduces the animal's welfare. Similarly, if an animal is sick, it is the feeling of sickness which compromises its welfare (Appleby and Hughes 1997).

Animal welfare should therefore be evaluated using scientific evidence on animals' structure and function and also on their behaviour (Hemsworth et al. 2015), considering the three scientific frameworks for assessing animal welfare: biological functioning, affective states, and natural living.

2.1.1 The Five Freedoms

Although there are many approaches to assessing animal welfare, there needs to be a common framework with which to assess whether welfare is in a positive or negative state. The Five Freedoms were developed by the United Kingdom Farm Animal Welfare Council and released in 1979. The principles form a basic qualitative framework on which welfare schemes and welfare assessment tools have been based. The Five Freedoms are:

1. *Freedom from hunger and thirst* – by ready access to fresh water and a diet to maintain full health and vigour.
2. *Freedom from discomfort* – by providing an appropriate environment including shelter and a comfortable resting area.
3. *Freedom from pain, injury or disease* – by prevention or rapid diagnosis and treatment.
4. *Freedom from fear and distress* – by ensuring conditions and treatment which avoid mental suffering.
5. *Freedom to express normal behaviour* – by providing sufficient space, proper facilities and company of the animal's own kind.

The Five Freedoms have been highly influential in the development and scope of animal welfare standards internationally, particularly for farm animals. While they do not prescribe specific conditions which are to be met to ensure welfare, they were the first to include subjective experiences, health status and behaviour in one framework (Mellor 2016). Over time, they have resulted in a shift in animal welfare assessment away from a focus on biological functioning towards a focus on the animal's experiences.

2.1.2 The Five Domains

The Five Domains of Potential Welfare Compromise (the Five Domains) model was originally developed as a framework to assess the welfare of animals used in research in 1994 (Mellor and Reid 1994). This model was subsequently adopted in 1997 as part of regulatory requirements for assessing the welfare of animals used for scientific purposes in New Zealand.

The Five Domains model integrates biological functioning and affective states by considering internally regulated, as well as externally generated inputs. The physical considerations of the model comprise nutrition, environment, health, and behaviour, while the fifth domain considers mental state, or affective experiences.

Table 1: Description of the Five Domains (Mellor and Beausoleil 2015).

Domain	Compromise	Physical effect	Subjective or emotional experience
Nutrition	Food or water deprivation	Dehydration, low energy content	Thirst, hunger
Environment	Excess heat or cold	Hypothermia or Hyperthermia	Chilling related debility or heat load debility, malaise
Health	Disease or physical injury	Organ/tissue damage or inflammation; fever; impaired mobility	Pain, nausea, sickness, distress, breathlessness, fear and/or anxiety
Behaviour	Restricted space, isolation, invariant features in enclosures, barren environment, nutrient-dense feed	Impoverishment, muscle atrophy and leg problems; stereotypies; withdrawal, inactivity	Weakness and pain, boredom, frustration
Mental state	Cognitive awareness of external challenges	Fight/flight/fright response	Anger, frustration, anxiety, loneliness, fear, boredom, helplessness, depression, nervousness

Historically, animal welfare has been defined by the absence of negative experiences such as disease, hunger, thirst, stress, frustration, abnormal behaviours, aggression, or reduced fitness (Bracke and Hopster 2006). Indeed, the majority of animal welfare research in the last 40 years has focused on the avoidance of negative states. However, there is increasing interest and research in the experience of positive welfare states in animals (Hemsworth et al. 2015). This shift in welfare science has led to the understanding that good animal welfare cannot be achieved without the experience of positive affective states (Mellor and Beausoleil 2015).

The Five Domains model has recently been adapted to allow the assessment of positive as well as negative experiences to encourage more opportunities for animals to experience positive states whilst minimising negative states (Mellor 2013; Mellor and Beausoleil 2015). A compromise in any of the physical domains also influences the emotional experience directly, such as pain and hunger, which in turn will lead to further negative mental states, such as fear and anxiety (Table 1). Thus good welfare involves a combination of good nutrition, a good environment, good health, appropriate behaviour and positive mental experiences.

The ability for animals to perform key behaviours is essential for positive affective states (Mellor and Webster 2014). Innate or 'normal' behaviours are those which are inherent to animals, and typically, which animals are motivated to carry out. The performance of these behaviours is thought to be a component of biological functioning, is pleasurable, and necessary to avoid stress (Bracke and Hopster 2006). Assessment of animal welfare and the management of animals in the future will require an emphasis on the experience of positive affective states (Hemsworth et al. 2015).

2.1.3 Application to layer hen welfare

In layer hens, normal behaviours include dustbathing, perching, foraging, exercising, interacting with conspecifics (other members of the same species), and nesting. Housing can create welfare problems when it causes frustration in the animals. Frustration is an aversive state which arises when animals are prevented from performing behaviour that they are strongly motivated to perform (Fraser et al. 2013).

The need to express normal behaviours, the level of satisfaction these behaviours provide, and the amount of frustration caused by their inhibition, can be scientifically assessed by measuring the intensity, duration, and incidence of the performance of particular behaviours (Bracke and Hopster 2006). Normal behaviours which benefit animal welfare may be defined as those which are intrinsically motivated. These behaviours, such as dustbathing, are often internally and physiologically regulated, and driven by internal factors (Hughes and Duncan 1988). The frequent occurrence of stereotyped behaviours in animals kept under artificial conditions is evidence that behavioural needs are not satisfied.

While some behaviours are beneficial for hen welfare, others, including aggression, severe feather pecking, cannibalism, and predator avoidance can indicate a reduced welfare state. Housing systems for layer hens should be designed and managed to enhance the ability for hens to perform normal behaviours which improve welfare, while minimising the expression of detrimental behaviours. This will help to ensure that physiological needs are met, negative mental states are minimised, and the opportunity for positive welfare states is increased. The opportunity for hens to perform behaviours which they are motivated to perform is central to achieving positive welfare states (Mellor and Webster 2014).

2.2 Factors affecting the welfare of layer hens

Layer hen welfare is multifactorial and can be affected by disease, nutrition, pests and parasites, the external environment, behaviour, stress, emotional states, and genetics (Lay et al. 2011). Some key welfare issues are outlined in this section.

2.2.1 Bone health

Commercial layer hens have been genetically selected for production characteristics. This includes a higher growth rate and adult body weight, earlier sexual maturity, a much higher rate of egg laying and larger egg sizes than their ancestors (PoultryHub 2016). Their ancestors, the red jungle fowl, lay approximately 10 to 15 eggs per year (Romanov and Weigend 2001), whereas modern day layer hens can produce over 350 eggs each year (PoultryHub 2016).

The formation of egg shells requires the deposition of calcium, since eggs are laid at a very high rate, this leads to a loss of bone calcium. Osteoporosis is an end result of this process and is a widespread problem in commercial hens (Webster 2004). Osteoporosis is related to nutritional imbalance, level of egg production, and the birds' inability to move and keep their muscles and bones healthy. It can result in an increased susceptibility to bone fractures. Poor bone health and bone fractures cause pain (Webster 2004; Nasr et al. 2012). Additionally, fractures cause stress, and affect biological functioning, activity levels, egg production, and egg quality (Nasr et al. 2012).

Osteoporosis and susceptibility to fractures are problems for layer hens in all types of housing systems (Widowski et al. 2013). However, lack of movement is the main cause of bone fragility in hens (EFSA 2005). In battery cages, hens are not able to exercise or perch and their movement is severely restricted. This severe behavioural restriction contributes to bone weakness and disuse osteoporosis (LayWel 2006a). When birds from battery cages are handled, it results in a very high rate of bone fractures. Hens in battery cages therefore suffer the poorest bone strength, and the highest number of fractures at depopulation (Widowski et al. 2013).

Hens in cage-free systems experience the best musculoskeletal health. Exercise is the main reason for increased bone strength (Widowski et al. 2013). An increased behavioural repertoire and the ability to exercise, including walking, running, flying and wing-flapping increases musculoskeletal strength, and decreases the incidence of osteoporosis and fractures which occur during depopulation. However, bone fractures are a risk when hens fall, or sustain injuries during flight on objects such as perches, feeders, drinkers, or nest boxes within the shed (Lay et al. 2011; Fraser et al. 2013). Therefore, hens in cage-free systems experience fewer fractures at depopulation than hens in cages, but more fractures during the laying period (Lay et al. 2011; Widowski et al. 2013).

Typically, furnished cages allow hens to perch, which contributes to improved bone strength (Lay et al. 2011). Hens housed in furnished cages exhibit the lowest number of total fractures compared with both cage-free and battery cage systems. This is probably due to the absence of poorly constructed and maintained perches and environmental complexity which can be present in cage-free systems, and the improved musculoskeletal health due to the use of perches, when compared to battery systems (Widowski et al. 2013).

Bone strength has been found to be heritable, and genetic selection is extremely effective in improving bone strength and resistance to osteoporosis (Fleming et al. 2006), with bone strength improving over just one or two generations (LayWel 2006a). A study by Fleming et al. (2005) found that hens selected for improved bone strength also had significantly higher egg production. The number of fractures sustained by birds in cage-free systems should therefore be addressed through a combination of selective breeding, optimised diets, plus improvements in the design, placement, and maintenance of structures in the shed, including perches (LayWel 2006a; Widowski et al. 2013).

Summary

- » Commercial layer hens are highly susceptible to osteoporosis and poor bone strength due to very high rates of egg laying.
- » The severe behavioural restriction in battery cages causes disuse osteoporosis, the poorest musculoskeletal health, and the highest number of fractures at depopulation of all housing systems.
- » Hens in furnished cages have improved bone strength compared to battery cages due to the increased behavioural repertoire in these systems.
- » Hens in cage-free systems have the best musculoskeletal health of all systems, but a higher rate of fractures during the production period due to misadventure.

2.2.2 Disease

The prevention and control of diseases and parasites are widely regarded as fundamental to animal welfare (Fraser et al. 2013). Infectious diseases include viral and bacterial infections, intestinal parasites such as coccidia and worms, and ectoparasites such as mites (Widowski et al. 2013). Infectious diseases can occur in any housing system, although some types of housing systems, namely those in which birds are housed at high stocking densities, in large group sizes, and on litter, can increase the risk of disease transmission (EFSA 2005; Lay et al. 2011; Widowski et al. 2013).

Generally, bacterial infections, viral diseases, coccidiosis, and red mites are reported to be higher in litter-based and free-range systems than in cage systems (Rodenburg et al. 2008a; Fossum et al. 2009; Widowski et al. 2013). Contact with soil, litter, faeces, and other vectors including rodents and insects increases the risk of infectious diseases. Birds with access to the outdoors may have a higher risk of contracting diseases such as avian influenza, Newcastle disease, and ectoparasites from wild birds (Lay et al. 2011; Widowski et al. 2013), while red mites often reside in the environment (Chauve 1998; Lay et al. 2011; Fraser et al. 2013).

Biosecurity plays a critical role in lowering the risk for infectious diseases to develop and spread. The main risks for an outbreak of infectious disease lie in management practices and the number of birds kept in close contact. Good biosecurity practices can prevent the entry of diseases onto farms. Since wild birds can be a source of infection for poultry, isolation of poultry from wild birds or rodents greatly reduces the risk of avian influenza and infection with *Salmonella* spp. (Martin 2011; Fraser et al. 2013). It has been suggested that keeping layer hens indoors during wild birds' migratory seasons could act to decrease this risk (EFSA 2005). If isolation is not possible, the outdoor environment may be made unattractive to wild birds. For example, by not placing feed sources on the range, and locating farms away from water sources such as lakes and ponds.

Knierim (2006) suggested that to reduce the risk of infection in free-range systems, an integrated approach should be taken which includes restricting group size, rotating access to various parts of the range, encouraging the hens to use the entire range area by using well-dispersed covers or using mobile housing systems that may be moved frequently. In litter-based systems, there can be poorer air quality which may increase the risk of infective agents and depresses the immune system. Good ventilation and reduced stocking densities can counteract this (LayWel 2006c).

Although the risk of disease transmission can be higher in systems in which large groups are housed together on floor-based (and particularly litter-based) systems, the risk can be significantly lowered by proactive approaches with the use of good management and vaccination programs. This has led to a consistent decline in the proportion of birds with viral, parasitic, and non-infectious diseases in cage-free systems in Switzerland (Kaufman-Bart 2009; Widowski et al. 2013). Furnished cages generally maintain the health and hygiene benefits associated with battery cages, while allowing the expression of some normal behaviours (Widowski et al. 2013).

Appropriate disease control standards, standard enforcement, and good management practices can allow the prevention and control of infectious diseases and parasites. Four approaches to infectious disease control have been suggested (Fraser et al. 2013). These are:

1. *Protecting individual animals* – hygiene, vaccination, and anti-parasite treatments. These include comprehensive vaccination programs, which, especially if utilised in conjunction with biosecurity and quarantine programs, have high efficacy in protecting layer hens from disease.
2. *Preventing spread of disease within a farm* – management routines, including 'all-in, all-out' methods which include cleaning and disinfecting sheds between flocks.
3. *Preventing the entry of diseases onto a farm* – biosecurity barriers to prevent the entry of diseases onto farms. For example, monitoring the movements of staff, visitors and contractors on and off the farm and ensuring hygienic practices are followed, and the isolation of poultry from wild birds or rodents reduces the transmission of avian influenza and *Salmonella* species.
4. *Regional programs to eliminate diseases over large areas* – regional or national programs, combined with strict biosecurity and regular testing and elimination of positive flocks can greatly reduce, if not eradicate, certain diseases such as fowl typhoid and pullorum.

Some non-infectious diseases including fatty litter and osteoporosis are more prevalent in battery cages compared with systems that allow a greater opportunity for behavioural expression and movement (Weitzenbürger et al. 2005; Kaufman-Bart 2009; Lay et al. 2011; Widowski et al. 2013). Fatty liver is a common metabolic disease typically seen in layer hens housed in battery cages (EFSA 2005; Jiang et al. 2014). It causes rupture of the liver and sudden death. The main factors which are thought to contribute to the development of fatty liver include a lack of exercise and restricted locomotion, high environmental temperatures, and a high level of stress (EFSA 2005). Non-infectious diseases which may be attributed to a lack of movement such as disuse osteoporosis and fatty liver are difficult to manage in battery cages due to the inherent nature of the system, and the behavioural restriction that occurs in battery cages.

Summary

» Some non-infectious diseases including disuse osteoporosis and fatty liver are largely attributed to the restriction of movement in battery cages.

» The transmission of infectious diseases is a higher risk in cage-free systems.

» Appropriate disease control standards, standard enforcement, and good management practices can allow the prevention and control of infectious diseases and parasites.

2.2.3 Movement

The behaviour of modern layer hens is derived from their ancestors, the red jungle fowl. A number of factors influence behavioural expression, including genetics, management, early-life experiences during rearing, and the current housing environment (Lay et al. 2011; Janczak and Riber 2015).

Studies have demonstrated that hens are highly motivated to perform a number of behaviours (Dawkins 2004; Dawkins 2008; Fraser and Nicol 2011; Fraser et al. 2013). When housing constraints prevent hens from performing these behaviours, they can experience frustration and emotional distress. There may also be physical consequences including compromised biological function or harmful variants of the behaviour such as feather pecking or hysteria (Lay et al. 2011).

Locomotion is severely restricted in cages. The inability for birds to exercise contributes to disuse osteoporosis (LayWel 2006a). In addition, maintenance and thermoregulatory behaviours are significantly compromised (Dawkins 1989; Lay et al. 2011). Hens have been found to perform higher levels, or 'rebound' levels of wing-flapping, tail wagging, and stretching when they are moved to a larger space after weeks of confinement in a small area, with some behaviours correlated to the duration of confinement. This indicates that hens do not adjust to prolonged spatial restriction (Nicol 1987; Lay et al. 2011).

Furnished cages generally allow more movement than battery cages. This is due in part to larger cage sizes which provide varying opportunities for locomotion and comfort behaviours. They typically provide more space for movement than battery cages, and also include perches, enclosed nest boxes, some substrate, and an area to scratch. Behaviour is generally more unrestricted and varied than in battery cages, hens are able to perform some of the most highly motivated behaviours which are prevented in battery cages, and physical condition is better (Appleby et al. 2002). However, the extent to which behaviours are able to be expressed in furnished cages has come under question (Cronin et al. 2012), and locomotion, wing-flapping and flying are still limited in these systems (Appleby et al. 2002; Lay et al. 2011).

Although cage-free systems increase behavioural opportunities, they also introduce difficulties in terms of bone fractures and disease. In addition, environmental complexity can create opportunities for hens to express behaviours that may be detrimental to their welfare (Lay et al. 2011). The large spaces provided to birds in cage-free systems allow greater opportunities for locomotion than in cage systems. Locomotion is increased because resources are spread out horizontally and sometimes vertically. However, stocking densities must be low enough to facilitate movement around the shed, as movement may be compromised if stocking densities are too high (Leone and Estevez 2008; Lay et al. 2011).

In free-range systems, birds' use of the outdoor area is dependent on a number of variables. These include weather, condition of the range area, pop-hole size (Hegelund et al. 2005; Gilani et al. 2014), flock size (Bestman and Wagenaar 2003; Gebhardt-Henrich et al. 2014), the presence of vertical structures (Rault et al. 2013), shade structures and vegetation on the range (Bestman and Wagenaar 2003; Nicol 2003; Zeltner and Hirt 2003), and fearfulness (Grigor 1995; Hartcher et al. 2016a). Natural and artificial shade structures can encourage use of the range. Nagle and Glatz (2012) found that hay bales, forages, and shelter belts encouraged a large number of birds onto the range compared to an outdoor area with no enrichment. The management of shade structures and forages on the range over time maintained the attractiveness of outdoor areas (Nagle and Glatz, 2012). Range use may also be affected by the age of the birds, time of day, mean temperature and climate (including wind speed, rainfall and total number of hours of sunlight) (Richards et al. 2011). The number of birds accessing the outdoor area varies, and the understanding of why birds do or do not use an outdoor area is limited.

Summary

- Hens in battery cages experience extreme behavioural restriction. They cannot flap their wings, walk or run, and do not adjust to this behavioural restriction.
- Furnished cages allow greater movement and expression of more normal behaviours, but behaviour is still restricted.
- There are greater opportunities for movement in cage-free systems, although this can be compromised if stocking densities are too high.

2.2.4 Perching

Hens have demonstrated a strong motivation to access perches in behavioural tests, for example by pushing through weighted doors (Olsson and Keeling 2002). The provision of perches allows hens to perform their normal perching behaviour, therefore satisfying a behavioural demand (Lay et al. 2011). Almost all layer hens use perches at night if adequate perch space is provided (Blokhuis 1983; Blokhuis 1984; Appleby et al. 2002; Lay et al. 2011; Fraser et al. 2013). Hens show signs of unrest when they are deprived of the opportunity to perch at night, and experience frustration and reduced welfare if perching is not possible (Olsson and Keeling 2002; Fraser et al. 2013).

The use of perches improves bone strength (Lay et al. 2011) and musculoskeletal health due to exercise (Yan et al. 2014). Enneking et al. (2012) provided pullets with perches from one day to 17 weeks of age. Birds with perch access had greater bone mineral content of the tibia, sternum and humerus, as well as greater muscle deposition at 12 and 71 weeks of age compared with birds without access to perches (Enneking et al. 2012; Yan et al. 2014). Provision of perches within the first four weeks of hatching has been shown to reduce the risk of injurious feather pecking (Widowski et al. 2013).

Other benefits associated with the use of perches include a reduction in fearfulness and aggression (Donaldson and O'Connell 2012), improvements in motor activity, and resting locations and places of refuge from aggressors (Lay et al. 2011). Gunnarsson et al. (1999) found that cloacal cannibalism in adulthood was reduced when perches were provided by four weeks of age. Perches have also shown to reduce the frequency of aggressive interactions, reduce bird density on the floor (Cordiner and Savory 2001), and potentially lower the risks of piling and smothering (Lay et al. 2011). Perches may also be used extensively by subordinate hens to escape dominant members of the flock during the day time (Cordiner and Savory 2001; Yan et al. 2014).

Management practices can affect perch use. In particular, the rearing environment and whether pullets are provided with perches during rearing, the stocking density during the laying period, and the lighting programs all affect how hens utilise perches (EFSA 2015). Hens that do not have access to perches during the rearing period can experience difficulty using perches later in life. Rearing without early access to perches appears to cause low muscle strength, a lack of motor skills, the inability to keep balance, and impaired cognitive spatial skills, with long-lasting effects on welfare (EFSA 2015). Therefore, providing perches during the rearing period enhances their ability to utilise them in the laying period, and also reduces the incidence of floor eggs (Gunnarsson et al. 1999; Lay et al. 2011). A recent review by Janczak and Riber (2015) recommends that the rearing system should provide constant access to perches.

The use of perches in layer hens can cause keel bone deformities, and there is risk of fractures if birds do not land successfully when jumping or flying between perches in cage-free systems. The use of the perches in furnished cages has been associated with some keel bone damage, although it has not been established whether keel bone deformations negatively affect welfare. Poorly designed and maintained perches have been associated with bumblefoot due to an accumulation of droppings and litter (Lay et al. 2011), and perches in furnished cages have been associated with an increased risk of cloacal cannibalism. Monitoring the incidence of keel bone deformities in multi-tier aviary systems is essential, as housing design and perches affect the incidence of keel bone deformities (Käppeli et al. 2011). The issues associated with perches may be addressed by good management, placement and design. For example, the risk of unsuccessful landings, and therefore bone deformities and fractures, may be reduced by perch type and placement (Scott et al. 1997; Lay et al. 2011).

To improve welfare, it is essential that standards acknowledge the value of perching for hens, considering both the priority that hens give to the behaviour, as well as the improvement in musculoskeletal strength. There is a growing trend for animal welfare standards to require hens be allowed to perch (Fraser et al. 2013), and studies have recommended that hens be provided with constant access to perches (Olsson and Keeling 2002; Fraser et al. 2013). The inclusion of perches in all housing systems for poultry is relatively straightforward, and has the potential to yield large improvements in welfare.

Summary

» Hens have a strong motivation to use perches, and most birds will perch at night if given the option.

» The provision of perches:
  - improves bone strength
  - reduces fearfulness and aggression
  - gives places for refuge
  - reduces injurious pecking
  - enhances the use of space and reduces
  - stocking density on the floor.

» The inability to perch decreases musculoskeletal health. Rearing without early access to perches causes low muscle strength, a lack of motor skills, the inability to keep balance, and impaired cognitive spatial skills, with long-lasting effects on welfare.

» Hens show signs of unrest when they are deprived of the opportunity to perch at night, and experience frustration and reduced welfare if perching is not possible.

» The inclusion of perches in all housing systems is relatively straightforward, and has the potential to yield large improvements in welfare if placed and managed correctly.

2.2.5 Nesting

Red jungle fowl typically move away from flock mates to nest and incubate their clutch in a safe and secluded site. Modern day layer hens have been genetically selected to lay high numbers of eggs, and the motivation to sit on the eggs (broodiness) has been selected against. However, regardless of the lack of broodiness, hens retain the innate nesting behaviour exhibited by their ancestors (Cronin et al. 2012).

Layer hens have a strong motivation to perform 'nest-building' behaviour, which is triggered by hormones at ovulation (Wood-Gush and Gilbert 1973). Prior to egg-laying, hens perform pre-laying behavioural patterns which include searching for a nest site, nest-building, and sitting on a nest. Nesting behaviour is a priority for hens (Weeks and Nicol 2006; Lay et al. 2011), and is vital to their welfare (Cooper and Albentosa 2003; Weeks and Nicol 2006; Cronin et al. 2012; Widowski et al. 2013), and there is a growing trend for animal welfare standards to require that hens be allowed to nest (Fraser et al. 2013).

The need for layer hens to perform pre-laying behaviour and utilise a nest has been assessed by motivation tests, which have consistently demonstrated that it is a high priority. In battery cages, where there are no opportunities to perform pre-laying behaviours, hens have expressed frustration in the form of repetitive, stereotyped pacing (Yue and Duncan 2003; Lay et al. 2011), and the retention of eggs beyond the expected time of lay (Yue and Duncan 2003; Widowski et al. 2013). Hens prefer to lay eggs in a moulded nest rather than on a sloping wire floor, and the lack of a moulded nest may reduce welfare (Hughes et al. 1989; Lay et al. 2011). In addition to satisfying a behavioural demand, a closed nest area can reduce cloacal cannibalism. (Newberry 2004; Lay et al. 2011).

While there have been a number of studies which assessed the behavioural motivation for hens to access nest boxes, taking physiological measurements is not as straightforward. Complications associated with taking physiological measurements of stress include the highly variable peak in the plasma corticosterone prior to egg-laying which may confound measurements, and the fact that handling hens for blood sampling causes an increase in plasma corticosterone (Cronin et al. 2012).

Studies have assessed the correlation between the concentration of corticosterone in the plasma and egg albumen. Downing and Bryden (2008) found that it is positively correlated, and that corticosterone in egg albumen may provide a non-invasive measure of stress. However, Engel et al. (2011) found few correlations between corticosterone concentrations in plasma, albumen, yolk, and faeces. Corticosterone may be deposited into egg albumen over an 8-hour period each day, while hens typically display pre-laying behaviours 1–2 hours prior to egg laying.

There is, a lack of information on the physiological stress responses of hens when nest boxes are denied (Cronin et al. 2012). Hens which spent more time sitting during the 2 hours prior to egg laying had lower plasma corticosterone concentrations when sampled 4–5 hours post egg laying, and the hens which had more bouts of sitting, suggesting frequent disturbance, had higher corticosterone concentrations. Therefore, nest boxes may provide hens with a location where they are less disturbed, and therefore less stressed, before egg laying (Cronin et al. 2012).

Corticosterone in egg albumen may not be useful in determining the stressfulness associated with the inaccessibility of nest boxes for layer hens, but rather provide a measure of longer-term stress (Cronin et al. 2012). The correlation between corticosterone concentrations in plasma and egg albumen needs further validation, and research on the stress physiology of hens in relation to egg-laying behaviour is very limited (Cronin et al. 2012).

Cronin et al. (2012) states that the majority of layer hens prefer to lay their eggs in a discrete enclosed nest box, which is a strong argument for the provision of nest boxes (Appleby et al. 2002; Weeks and Nicol 2006), and that the strength of the motivation to access a nest box has been demonstrated in a number of different ways. In fact, (Cooper and Appleby 2003) concluded that hens' work-rate to access a nest 20 minutes prior to egg-laying was twice the work-rate to access food after 4 hours of confinement without feed. This was indicated by the amount hens were willing to work by pushing a push-door for resources (Cooper and Appleby 2003). Cronin et al. (2012) referred to a number of studies which point out the importance of nest boxes for hen welfare. These include:

- Duncan (2001) stated that the absence of a nest box was perhaps the most serious welfare issue for laying hens
- LayWel (2006b) concluded that hens should be provided with a discrete, enclosed nest site for egg laying
- Studies which equated reduced welfare and the performance of frustration behaviours such as pacing and vocalisations with the lack of a suitable nest site and the consequent inability to perform nesting behaviour (Zimmerman et al. 2000; Cooper and Albentosa 2003; Weeks and Nicol 2006)
- Weeks and Nicol (2006) concluded that hens place a high value on access to a discrete and enclosed nest site for egg laying
- Keeling (2004) stated that a hen would probably have a welfare problem if it could not find an appropriate site for egg laying
- Cooper and Appleby (1995) and Freire et al. (1996) found that the motivation of hens to access a nest site increases as the time of egg laying approaches
- Yue and Duncan (2003) found that hens with access to a nest box spent significantly less time pacing in the hour before egg laying (7%) compared with hens that had no experience of a nest box (23%), or that had their nest box blocked (20%), and that there was no change as the birds aged, suggesting that they did not adapt to the lack of a nest box.

Nesting has been identified as a behavioural priority for layer hens, particularly immediately prior to egg laying. If denied a nest, birds can become frustrated, pace, and retain their eggs. There must be a sufficient number of appropriately-sized enclosed nests for the strain and number of laying hens. Worldwide, there is a growing trend for animal welfare standards to require that hens be allowed to nest. New Zealand, Canada, and the European Union all require hens to be provided with nests, or are bringing in that requirement.

Summary

» Nesting is a high priority for hens.

» The need for hens to use a nest has been consistently demonstrated by motivation tests.

» Hens have been found to work harder to access a discrete nest site prior to egg laying than they do gaining access to food following 4 hours of food deprivation.

» An enclosed nest area can reduce cannibalism.

» If denied a nest, hens can become frustrated, pace, and retain their eggs beyond the expected time of lay.

2.2.6 Dustbathing

Dustbathing, where hens distribute substrate through their feathers, is typically performed every other day. Hens are highly motivated to dustbathe, and their welfare is compromised in systems in which they cannot perform this behaviour (Olsson and Keeling 2005). Dustbathing is one of the major behaviours that poultry perform, and is prevented in battery cages (Widowski and Duncan 2000).

Functionally, dustbathing is performed to clean the feathers and remove stale lipids (Lay et al. 2011). It acts to remove skin parasites, regulate the amount of feather lipids, and maintain plumage condition (Olsson and Keeling 2005). Dustbathing is strongly affected by the presence of litter, as well as litter quality. Normal patterns of dustbathing behaviour are disturbed in cages. Hens are willing to work to obtain a dustbathing substrate, and after deprivation of dustbathing are more motivated to dustbathe. Welfare is improved when hens are able to dustbathe (Widowski and Duncan 2000).

Some studies have not found evidence of a motivation to dustbathe, and it has been suggested that the methodology used, for example, whether or not hens can see the litter in the experiments, may affect differences between studies (Olsson and Keeling 2005). Olsson and Keeling (2005) reported that besides the direct effect of thwarting the activity of dustbathing, which leads to frustration, preventing dustbathing may also affect animal welfare indirectly if it leads to the development of feather pecking (Vestergaard et al. 1993).

Battery cages have no provisions for dustbathing. Sham dustbathing can occur, where hens perform dustbathing movements which would normally include scooping dust into the plumage. However, the dustbathing sequence is unable to be completed, as there is no substrate, nor shaking off lipid-saturated dust. Sham dustbathing lacks positive feedback (Widowski and Duncan 2000), does not satisfy birds' motivation for dustbathing (Olsson and Keeling 2005), and indicates a reduced state of welfare (Lay et al. 2011). Further, when birds are unable to dustbathe, plumage is in a poorer condition as it is dirtier, less waterproof, and less insulative (Scholz et al. 2014).

Furnished cages have some provisions for dustbathing (Appleby et al. 2002; Lay et al. 2011). Some furnished cages deliver small amounts of feed as litter material onto an Astroturf mat in the main area of the cage to allow foraging and dustbathing. The hens' propensity to forage keeps the mat relatively clean and minimises its use for egg laying (Lay et al. 2011). However, litter is provided in small quantities and is often quickly depleted. Restricted litter access may be stressful, and subordinate hens may be excluded from the litter area by more dominant hens (Shimmura et al. 2008). The extent to which dustbathing is accommodated in furnished cages is variable, and significant variation has been found between different types of furnished cages in the use of dustbaths (Tauson 2005). Restricted access to litter, and the small amounts of litter provided can cause stress (Lay et al. 2011).

Summary

» Hens typically perform dustbathing every other day to clean their feathers.

» Hens have an instinctive motivation to dustbathe.

» Hens are unable to dustbathe in battery cages, and can perform sham dustbathing in lieu of this normal behaviour. Sham dustbathing lacks positive feedback, does not satisfy birds, and can indicate a reduced state of welfare.

» When hens are unable to dustbathe, their plumage is in a poorer condition as it is dirtier and less insulative.

2.2.7 Foraging and exploration

Foraging is a key element of the normal behavioural repertoire of hens (LayWel 2006a). When litter is available, it is used extensively by hens for scratching and pecking (Ekesbo 2011). Hens perform foraging behaviours even when feed is provided ad libitum in feed troughs (Lay et al. 2011; Widowski et al. 2013), demonstrating an innate behavioural motivation to forage for food. Further, studies have found that hens spend the majority of their time ground pecking and ground scratching if litter is available (Hartcher et al. 2015).

Litter is an important element of the birds' environment. It is preferred over wire mesh by hens and is necessary for the normal expression of some behaviour patterns (Dawkins 1981). Studies have found that birds will work for litter (Widowski and Duncan 2000), and even enter smaller cages in order to gain access to litter, indicating that it is a high priority. Gunnarsson et al. (2000) found that caged hens have a high demand for a litter substrate.

Allowing hens to access an outdoor area improves opportunities for behavioural expression including foraging, exercising, and exploring. If the range area is well-maintained, easily accessible from the shed, offers shade, and is attractive to birds, this will enhance its use. When birds utilise outdoor areas, this lowers the stocking density inside the shed, and can result in increased locomotion and exercise, and improve inter-individual distances and normal social behaviours (Knierim 2006).

Foraging behaviour is not possible in battery cages, and is only partially accommodated in furnished cages, where substrate may be insufficient, or quickly depleted. Environmental complexity is severely limited in both battery and furnished cage systems, which limits the hens' ability to explore their environment and forage (LayWel 2006a).

Poultry are motivated to forage, and access to litter is critical to their welfare to maintain good plumage condition, improve the feeling of satisfaction, and potentially reduce adverse behaviours such as severe feather-pecking (Rodenburg et al. 2013). In order to ensure good welfare, hens should have appropriate access to good quality litter. Inherently, opportunities for exploration, foraging and exercising are limited in cages.

Summary

» Foraging is a significant part of the normal behaviour of hens.

» Studies have found that when litter is available hens spend the majority of their time pecking and scratching the ground.

» Hens perform foraging behaviours even when feed is freely available in feed troughs, demonstrating an instinctive behavioural motivation to forage for food.

» Hens will work to have litter and even enter smaller cages in order to have access to litter, indicating that it is a high priority.

2.2.8 Severe feather pecking and cannibalism

Severe feather pecking is an injurious behaviour where birds vigorously peck at and pull out the feathers of other birds. It has been associated with cannibalism, and is identified as one of the most obvious and serious welfare problems in layer hens worldwide (Savory 1995; Bilčík and Keeling 1999; Bestman et al. 2009). Severe feather-pecking and cannibalism have been reported in several surveys as the primary causes of mortality in layer hens (Savory 1995; Abrahamsson and Tauson 1997; Weitzenbürger et al. 2005; Lay et al. 2011).

Severe feather pecking is linked with elevated stress levels (El-Lethey et al. 2000), and negative welfare states in both the recipient and the bird performing the pecking (Gentle and Hunter 1990; El-Lethey et al. 2001). The pulling out of feathers is painful for the recipients (Gentle and Hunter 1990), which then face a higher risk of receiving further pecking (McAdie and Keeling 2000). It can lead to feather damage, extensive feather loss, wounds, cannibalism and death (Savory 1995). Essentially, severe feather pecking is a significant welfare concern due to three main reasons:

1. The pain (Gentle and Hunter 1990) and fear (Hughes and Duncan 1972) that the recipients of severe feather pecking may experience.
2. Subsequent injury due to the feather loss incurred by severe feather pecking (Savory 1995).
3. The occurrence of cannibalism as an indirect result of severe feather pecking, and subsequent mortality (Allen 1975).

A small proportion of birds in a flock can become repeatedly victimised by birds performing severe feather pecking. Repeatedly victimised birds suffer reduced welfare due to the physical consequences of severe feather pecking including feather loss and injuries. These birds consistently attempt to seek shelter from other birds. They can fail to adequately access resources, including feed and water, due to chronic victimisation, fear and stress (Freire et al. 2003; Nicol et al. 2013).

Recent research suggests that there is a small proportion of birds which initiate severe feather pecking, and that the behaviour may then spread throughout a flock (Bessei and Kjaer 2015). Severe feather pecking has been documented in all types of housing systems including cage, litter-based, free-range, and aviary systems (Appleby and Hughes 1991; Huber-Eicher and Sebö 2001; Bestman et al. 2009). However, housing birds in large groups may contribute to an increase in the prevalence of severe feather pecking due to the spread of the behaviour throughout a flock of birds (Hughes 1995; McAdie and Keeling 2000; Potzsch et al. 2001). Thus, the risk of severe feather pecking does not appear to vary between housing systems, rather, it is the management of the spread of the behaviour which differs. Managing the risk and spread of severe feather pecking is critical in determining hen welfare. Indeed, mortality is highly variable in both single-tier and multi-tier cage-free systems (between 1 and 37%). More research, as well as the refinement of system design and management strategies are needed to control and prevent severe feather pecking and associated mortality (LayWel 2006a).

Severe feather pecking is a heritable trait (Savory 1995; Kjaer and Bessei 2013; Bessei and Kjaer 2015). Current studies are selecting against traits which may predispose birds to initiate severe feather pecking. Good management, which includes adequate nutrition, providing high-fibre diets and suitable litter from an early age onwards, no sudden changes in diet or environmental conditions, minimising stress and fear in the birds, appropriate rearing conditions, matching rearing and laying environments, and good husbandry, should be paired with genetic selection programs. This approach has the potential to reduce the prevalence of severe feather pecking in the future (LayWel 2006a; Rodenburg et al. 2013; Bessei and Kjaer 2015; Hartcher et al. 2016b).

Summary

- Severe feather pecking is an injurious behaviour where hens vigorously peck at and pull out the feathers of other birds. It is a widespread and serious welfare concern in the egg industry.
- Severe feather pecking is multifactorial, and is affected by genetics, the environment, and nutrition.
- Large group sizes are thought to be a risk factor in the spread and subsequent prevalence of severe feather pecking.
- Research, genetic selection, and good management strategies are required to address the expression of severe feather pecking.

2.2.9 Beak trimming

Beak trimming, the partial removal of the tip of the beak, is one of the most common methods utilised by the poultry industry to control severe feather pecking (Petek and McKinstry 2010). In Australia, beak trimming is commonly performed when chicks are one day of age, with a follow-up beak trim occurring later in life, between 8 and 12 weeks of age. Birds are often re-trimmed in order to prevent re-growth of the beak tip and subsequent damage due to severe feather pecking.

However, while beak trimming is relatively effective in preventing damage caused by severe feather pecking (Lambton et al. 2010), it is an invasive procedure, and heavily criticised from a welfare perspective (Gentle 1986; Freire et al. 2011). A prohibition on beak trimming currently exists in Norway, Sweden and Finland, with heavy regulation and impending bans in others, including Austria, Belgium, Denmark, Germany, the Netherlands, and the United Kingdom (Van Horne and Achterbosch 2008; Petek and McKinstry 2010).

Beak trimming is acutely painful. It stimulates nociceptors in the beak causing acute pain during the procedure (Breward and Gentle 1985), including during infrared trimming (Marchant-Forde et al. 2008; Janczak and Riber 2015), chronic pain in the stump of the beak if performed on older birds due to the formation of neuromas (Breward and Gentle 1985; Gentle 1986; Gentle et al. 1990), and a reduction in feed intake (Glatz 1987). Beak trimming is also likely to result in incomplete sensory feedback, which affects sensory perception (Hughes and Michie 1982). It can cause problems in younger birds due to the rapid growth and the small size of the beak. If too much of the beak is removed during trimming it can lead to feeding problems and increased mortality. If too little is removed, the beak can re-grow rapidly and the effectiveness in minimising severe feather pecking is reduced.

As well as being criticised from a welfare perspective, there has been some controversy in the effectiveness of the procedure and the effects on the bird. It is currently unknown exactly how beak trimming affects severe feather pecking. Possible explanations include learned inhibition, incomplete sensory feedback (Hughes and Michie 1982), and chronic pain (Breward and Gentle 1985; Gentle 1986).

Most studies have reported a decrease in cannibalism (Hartini et al. 2002) and plumage damage (Blokhuis and Van Der Haar 1989; Bolhuis et al. 2009). However, some have found that beak trimming does not change pecking preferences, nor the frequency of severe feather pecking (Blokhuis and Van Der Haar 1989; Freire and Cowling 2012). In a study of 25 free-range farms, Whay et al. (2007) found no effect of the extent of beak trimming on severe feather pecking, body condition or feather loss at 70 weeks of age, and Blokhuis et al. (2007) reported that beak trimming did not affect plumage damage.

Management and stockpersonship are crucial in controlling feather pecking. There is a need for an uptake of strategies to manage severe feather pecking without the need for beak trimming. These include the provision of appropriate environmental enrichment, good litter management, appropriate stocking densities, appropriate diet formulation and form, reducing stress and fearfulness, selecting strains of birds with lower propensities to perform severe feather pecking, matching the rearing and laying environments as closely as possible, and providing environmental complexity and the ability for birds to escape aggressors.

Minimising the impact of severe feather pecking can be achieved through proactive monitoring, regular feather scoring, and early interventions by implementing management strategies including all of the aforementioned factors as soon as any signs of feather pecking are observed (LayWel 2006b; Rodenburg et al. 2013; Janczak and Riber 2015; Hartcher et al. 2016b).

Summary

- » Beak trimming is the partial removal of the tip of the beak, and one of the most common methods utilised by the poultry industry to control the impacts of severe feather pecking.
- » Beak trimming can cause both acute and chronic pain, and can lead to difficulty feeding.
- » While relatively effective in controlling severe feather pecking, beak trimming is an invasive procedure which affects birds' sensory capabilities and normal behaviour, and is prohibited in several countries.
- » There is a need to move away from beak trimming and instead focus on good management strategies, environmental complexity and enrichment, the selection of appropriate genetics, small group sizes, and more research to elucidate the causes of severe feather pecking.

2.2.10 Rearing – early life experiences

Early life experiences have been shown to affect behaviour later in life. Learning and memory affect the use of resources, and a bird's previous experience may help it to effectively utilise the resources provided during the laying period (Lay et al. 2011). Early access to elevated perches and flooring encourages their proper use later in life. Pullets reared without perches and complex spatial environments have difficulty adapting later in life, which can result in reduced access to feed, water, perches, and nests (Widowski et al. 2013).

Exercise during the rearing period is critical for bone strength later in life (EFSA 2005), and early perching improves skeletal development and later use of the perches (Yan et al. 2014). Providing chicks with the ability to perch and forage can also prevent the development of injurious pecking (LayWel 2006a; Widowski et al. 2013), and increasing environmental complexity can reduce fearfulness.

Early life experiences significantly affect fearfulness in hens later in life (Jones and Faure 1981; Gunnarsson et al. 1999; Gunnarsson et al. 2000; Janczak and Riber 2015). Early handling and exposure to humans in a positive way, such as picking up and stroking, or the visual exposure to a stockperson, can reduce fearfulness in hens (Widowski et al. 2013). Chicks brooded with a hen have been found to be less fearful than chicks brooded under a heat lamp (Rodenburg et al. 2009; Shimmura et al. 2010). Chicks brooded by a hen can also show more active behaviours including dustbathing and ground pecking, and less time performing feather pecking.

Fearfulness in hens is an important concern. Apart from the subjective experience for the hen, fearfulness is linked to the expression of severe feather pecking (de Haas et al. 2014), can increase the risk of injury during handling and depopulation, the incidence of smothering and flightiness in a flock, and can also affect air quality and the level of dust in the air due to bird activity. Reducing fearfulness therefore has notable psychological and physical improvements for the hens (Widowski et al. 2013). Regular exposure to humans, human handling, and more complex environments during rearing can all significantly reduce fearfulness in pullets and hens (Jones and Faure 1981; Janczak and Riber 2015).

Matching the rearing and laying environments as closely as possible has been found to be vital, particularly when aiming to minimise the expression of severe feather pecking and cannibalism. Other aspects to consider in the rearing environment include:

- *Lighting* – simulated brooding cycles of light and dark periods synchronise activity and increase resting behaviour of chicks
- *Space* – increasing space allowance during rearing improves feed intake, body weight, and feed conversion (Widowski et al. 2013)
- *Brooders* – Gilani et al. (2013) found that chicks raised with access to a dark area (dark brooders) showed lower levels of feather pecking and better feather condition in the rearing and laying periods
- *Housing system* – Blokhuis et al. (2007) reported that birds reared in floor systems had better plumage condition than birds reared in cages.

Perches and complex environments are required during rearing for pullets to develop adequately. In addition, they can reduce fearfulness and the risk of severe feather pecking. Hens in cage-free systems experience more varied stimulation than those in cages, and experience lower levels of fear compared with those in cages (Jones and Faure 1981; Hansen et al. 1993).

Summary

- Early life experiences have large impacts on hens later in life.
- Matching the rearing and laying environments as closely as possible allows birds to effectively utilise the resources provided during the laying period and reduce the risk of severe feather pecking.
- Hens that do not have access perches during their early lives can have difficulty adapting later in life, which can result in reduced bone strength, increased severe feather pecking and reduced access to feed, water, perches, and nests.
- Exercise during rearing is linked with skeletal health later in life. The opportunity to forage in early life can prevent the development of severe feather pecking in adulthood.

2.2.11 Foot health

The main welfare issues relating to foot health are the incidence of foot conditions including pododermatitis, hyperkeratosis, bumblefoot, and overgrown claws. Foot pad dermatitis, or pododermatitis, is a condition where the bottom of the foot becomes inflamed and sometimes ulcerated. Contact with wet or damp litter is a primary cause of pododermatitis (Widowski et al. 2013; Elson 2015). Rodenburg et al. (2008b) found no differences in foot pad dermatitis between furnished cages and cage-free systems. This may be because the cage-free systems sampled in that study maintained the litter in a dry condition.

Bumblefoot originates from a local infection and causes the formation of abscesses on the foot which result in severe inflammation and swelling of the footpad. It can cause lameness, and is considered to be painful (EFSA 2005; Widowski et al. 2013). Perch design, hygiene and moisture have big impacts on the incidence and severity of bumblefoot (Struelens and Tuyttens 2009; Pickel et al. 2011; Widowski et al. 2013). One study showed that moisture on perches or litter increases the incidence of bumblefoot by three times compared to these areas being kept dry (Wang et al. 1998; EFSA 2005). Studies have found bumblefoot to occur in less than 5% of hens in furnished cages, and three to four times more frequently in aviaries and litter floor housing systems (Widowski et al. 2013). Management should therefore focus on keeping flooring dry, and avoiding manure build-up.

Hyperkeratosis is hypertrophy of the outer layer of the skin on the underside of the feet and toes, and occurs most frequently in battery cages (Lay et al. 2011; Widowski et al. 2013). Lower incidences of hyperkeratosis have been reported in furnished cages and aviaries when compared to battery cages (Abrahamsson and Tauson 1995; 1997; Widowski et al. 2013). Sloping wire floors may exacerbate hyperkeratosis in battery cages (Lay et al. 2011). Factors which contribute to the incidence of hyperkeratosis include poor galvanising of the cage floor, and steep floor slope (Weitzenbürger et al. 2005; Fraser et al. 2013).

Claw length is another welfare issue which occurs primarily in battery cage systems. Claws can become overgrown due to the lack of solid flooring and the inability for birds to scratch the ground. Excessive claw length can lead to breakage or trapping of the claw, and can result in damage to the foot tissue. This issue can be partially addressed by providing abrasive strips for scratching, as done in furnished cages. The addition of low perches and the inclusion of litter to facilitate scratching behaviour have also been found to prevent excessive claw growth (Lay et al. 2011; Hester et al. 2013; Widowski et al. 2013).

Summary

- Foot pad dermatitis, the ulceration of the bottom of the foot, is largely attributable to contact with damp or wet litter.
- Bumblefoot, abscesses on the foot and swelling, is affected by moisture on perches or litter.
- Hyperkeratosis, the hypertrophy of the feet and toes, occurs most frequently in hens in battery cages.
- Battery cages can cause excessive claw length due to the lack of solid flooring and the inability for birds to scratch the ground. This can lead to trapping of the claw and damage to the foot.
- Dry litter can prevent foot pad dermatitis and bumblefoot, as well as excessive claw length.

2.2.12 Group size and space allowance

Complex environments, such as those in cage-free systems, allow hens to have greater control over their situation and to make more choices. The ability for animals to make choices and have control over their environment is known to positively affect welfare (Sambrook and Buchanan-Smith 1997; Lay et al. 2011).

Group size affects whether hens are able to recognise flock mates and form social hierarchies. Allowing animals to form and maintain stable associations can create a positive social environment and improve their ability to cope with new stressors (Fraser et al. 2013). Therefore, establishing the optimum group size is critical for hen welfare. The maximum number of flock mates that hens can recognise may be less than 100 (Nicol et al. 1999).

Studies suggest that in groups of 15, hens may be able to establish stable social hierarchies, and in groups of 60 and 120 hens, while unable to establish social hierarchies, hens may develop a tolerant social system (Hughes et al. 1997; Estevez et al. 2002; Keeling et al. 2003). As group size increases there is more free space for behavioural expression as hens cluster in groups. While research is not definitive, group sizes between 10 and 60 appear adequate (Widowski et al. 2013).

In cage-free systems, hens have more opportunities to escape aggressors compared with battery cage systems. When birds are housed in small groups, this may result in positive social behaviours. Conversely, it may lead to aggression, injuries, and chronic fear, where victimised birds are unable to escape aggressors in enclosed areas such as cages. The social hierarchy in cages may also negatively affect hens' access to resources. In both cage and cage-free systems, some individual birds can be consistently victimised by other birds. Detrimental behaviours including severe feather pecking may be spread via social facilitation in large groups (Cloutier et al. 2002; Newberry 2004; Lay et al. 2011).

Group sizes can be improved in furnished cages compared to battery cage or cage-free systems. The larger group sizes than in battery cages can allow more social interactions, as well as the ability to escape aggressors. Larger group sizes can also contribute to higher mortality due to severe feather pecking and cannibalism, although it is suggested that mortality is low in groups of 40 and 60 hens (LayWel 2006a). Barnett et al. (2009) found that group size appeared to be potentially more valuable to hen welfare than space allowance. However, some studies investigating group size are confounded with space availability, and more research is required to ascertain the optimum group size (Widowski et al. 2013).

As space availability per bird increases, hens generally engage in a greater range of behaviours. Adequate space allows hens to perform basic movements and comfort behaviours such as stretching and preening, and increased opportunities for nesting, dustbathing and foraging (Widowski et al. 2013).

Summary

- Group size and social preferences have big impacts on hen welfare.
- In battery cages, where group sizes are small, there is very limited opportunity for subordinate hens to escape aggressive hens. This can lead to chronic fear, injuries, and sometimes death due to cannibalism.
- Hens in larger groups in more complex environments may have a greater ability to escape aggressive birds and seek refuge. However, severe feather pecking can spread rapidly throughout large groups.
- Hens should be housed in complex environments at low densities and in optimum group sizes, to enable them to make choices about their environmental and social preferences and adequately perform normal behaviours.
- As space allowance increases, hens engage in a greater range of behaviours. Sufficient space allows hens to perform basic movements and comfort behaviours such as stretching and preening, as well as unrestricted opportunities for nesting, dustbathing and foraging.
- While research is not definitive, group sizes between 10 and 60 appear to be optimal for hen welfare.

2.2.13 Husbandry and handling

Good stockpersonship is crucial to animal welfare in any housing system. The selection and training of those responsible for the care of hens represents a vital opportunity to improve and enhance animal welfare as well as productivity. Key considerations include: that animals are handled in a gentle manner which minimises distress, that those responsible for management and husbandry are able to identify sick or injured animals and carry out appropriate treatment, that they are able to monitor for optimal health and any changes in health and behaviour, and have a good understanding of animal behaviour, as well as access to professionals such as veterinarians.

Harsh handling may depress immune function and can cause bruises, dislocated joints, and broken bones. Handlers with positive attitudes towards animals often achieve improved commercial productivity (Fraser et al. 2013). Good stockpersonship is essential in monitoring and intervening where necessary.

Management and stockpersonship as well as staff training should be standardised in order for industry to optimise management practices and hen welfare. Animal handling and productivity can be improved through training programs, and training in specific skills can also be beneficial (Fraser et al. 2013).

Summary

- Good animal husbandry and management are crucial to animal welfare in any type of system.
- Those responsible for hen welfare should be appropriately trained, handle hens gently to minimise distress, be able to identify sick or injured animals and administer appropriate treatment, and proactively monitor hens for health and behaviour.
- Husbandry and stockpersonship are particularly important in cage-free systems, where there is a heightened need to monitor for severe feather pecking and infectious diseases.

2.2.14 Access to feed and water

The social and physical environment can have major effects on feed and water intake. Inadequate space at the feed trough can create competition that limits feed intake in hens (Bell et al. 2004; Fraser et al. 2013). Hens can experience difficulty accessing feed and water in cages where there is a high density of birds. Additionally, dominant birds can aggressively defend the feeder, resulting in lower-ranking birds obtaining less feed. This occurs more frequently in some genetic strains (Hughes 1983; Lay et al. 2011).

High stocking densities in cage-free systems can also lead to reduced movement and ability to access resources including feed and water (Lay et al. 2011). Good positioning of feeders, drinkers, perches and nest boxes throughout the shed is important, as birds become frustrated if they cannot reach resources easily due to the placement of objects such as perches (DEFRA 2005).

It has been suggested that feeders which are run on automatic timers (chain feeders) should be run to allow a greater gap of time in the middle of the day in free-range systems. This is to encourage birds to go outside rather than stay indoors near the feed, and to ensure that the smaller particles are consumed, as these are often the last part of the feed to be ingested by birds. The sound of the running chain feeder during the day can inadvertently cause birds to come inside and therefore decrease use of the range. However, birds should not be short of feed, as hunger can cause frustration, and also trigger injurious pecking (FeatherWel, 2013).

Summary

- Adequate access to feed and water is affected by stocking densities, positioning of the feeders and drinkers and the positioning of other objects within the housing environment.

2.2.15 Diet

Diet formulation, composition, or sudden changes in diet can have big impacts on behaviour. Changes in the diet can cause stress and therefore induce severe feather pecking (Dixon and Nicol 2008; Lambton et al. 2010). Low levels of insoluble fibre in the diet, and the absence of structural components or roughage in the feed may also enhance the risk of severe feather pecking (Hetland et al. 2004; Hetland et al. 2005; Kalmendal and Bessei 2012).

The expression of severe feather pecking can be affected by levels of sodium, protein, phosphorous, fibre, and essential amino acids (including arginine, methionine, and tryptophan) in the diet. Dietary deficiencies can stimulate exploratory behaviour which may result in redirected pecking and the occurrence of severe feather pecking (Kjaer and Bessei 2013).

Mashed feed, as opposed to pellets, may reduce the incidence of severe feather pecking due to the length of time it takes to ingest the same amount of nutrients from the lower nutrient density in mashed feed. The lower nutrient density is thought to result in more time eating, and respectively less time for other activities (Dixon and Nicol 2008; Lambton et al. 2010).

Dietary levels of calcium, phosphorous, Omega 3 fatty acids or vitamin D3 have been shown to affect bone health and fractures. The timing of the inclusion of different nutrients is also significant for bone health (Widowski et al. 2013).

Diets should be assessed with regards to their ability to meet nutritional requirements in terms of egg production, but also for health and welfare. The health status and behaviour of birds should be continually monitored, and diets adjusted according to the needs of the birds, in consultation with nutritionists. However, sudden changes in diet should be avoided, as this may trigger severe feather pecking.

Summary

- Diet formulation, composition, and changes in diet have big impacts on the expression of severe feather pecking.
- Feed ingredients and structural composition of the feed (e.g. pellets versus mash) affects behaviours including severe feather pecking.
- The health and behaviour of hens should be monitored, and the diet adjusted where appropriate to meet the needs of the birds.

2.2.16 Air quality

Air quality is a large determinant of hen welfare, particularly in intensive systems where there can often be high concentrations of ammonia and dust in the air. Ammonia has significant effects on the respiratory tract at high concentrations, and high levels of ammonia can damage the lungs and trachea (Al-Mashhadani and Beck 1985; Fraser et al. 2013). Poor air quality can also increase the risk of infectious disease (Fraser et al. 2013).

Poultry avoid high levels of atmospheric ammonia, even if they have been exposed to those levels throughout their lives (Jones et al. 2005; Fraser et al. 2013). Birds have been shown to choose fresh air over compartments with 10, 20, 30 and 40 ppm ammonia (EFSA 2005), avoid ammonia at concentrations of 20 ppm, prefer environments with lower ammonia concentrations, and seek out fresh air after exposure to ammonia (Knierim 2006).

Humans can also be affected by ammonia exposure. Humans exposed to ammonia at 12 ppm experienced significant reductions in pulmonary function (Donham et al. 2000). Poultry standards should minimise ammonia concentrations to avoid welfare issues in hens as well as stockpersons.

Summary

- In indoor, intensive housing systems, there can be high concentrations of ammonia in the air.
- Atmospheric ammonia is aversive to the hen and can result in damage to the respiratory system and a higher risk of infectious disease.

2.2.17 Light

Low light intensities are often used to reduce severe feather pecking. However, low levels of light may negatively affect welfare by restricting movement and discouraging the expression of normal behaviours. Dim lighting discourages hens from jumping between perches, which they appear to find frustrating in low lighting (Taylor et al. 2003). The difficulty for hens in jumping between perches in dim lighting may also affect the risk of fractures (Widowski et al. 2013).

Light intensity affects eye health. Many studies have found that poultry reared in dim (5 lux or less) light may have impaired vision (Blatchford et al. 2009; Deep et al. 2010; EFSA 2010). Eye size has been found to be greater in lower light intensities, a negative welfare consequence of light intensities less than 5 lux. Light intensities of 5 lux may also reduce preening and foraging behaviours, and increase resting (de Jong et al. 2012).

Keeping hens in permanently dim or monochromatic lighting can result in ocular disorders, abnormal behaviour, and increased mortality (Prescott et al. 2003; Widowski et al. 2013). Hens also prefer to feed in well-lit environments (Prescott and Wathes, 2002; Widowski et al. 2013). Light intensity may be used strategically; shading nesting areas and having brighter light in other areas can have positive effects by increasing foraging behaviours, and decreasing floor laying and cloacal cannibalism (Widowski et al. 2013).

When comparing layer hen behaviour in 3 versus 30 lux, it was suggested that lower light intensities may impair the ability for birds to identify environmental cues due to a higher rate of gentle feather pecking in low light intensities (Kjaer and Vestergaard 1999; Janczak and Riber 2015). In addition, a light intensity above 5 lux may be necessary to allow adequate inspection of birds by workers.

To allow adequate rest periods, it has been suggested that within seven days from the time when the birds are placed, and until three days before the time of slaughter, the lighting should follow a 24-hour pattern which includes periods of uninterrupted darkness (de Jong et al. 2012).

In the European Union, a minimum light intensity of 20 lux is required during the light period at all ages. A temporary reduction in the lighting level may be allowed when necessary following veterinary advice. Brighter light is often provided in the first week of life to stimulate feeding. Similarly, the New Zealand Code of Welfare for layer hens stipulates that chicks must be provided with a minimum of 50 lux for at least the first seven days. Following the first seven days, lighting must be at least 20 lux at hen level so that hens can see each other and their surroundings. However, the New Zealand National Animal Welfare Advisory Committee recommended best practice is that light levels should be a minimum of 50 lux (NAWAC 2012).

Summary

- Poultry reared in dim light can have impaired vision.
- Birds show less preening and foraging behaviours under low lighting.
- Low light intensities can be inadequate for workers to effectively inspect birds.
- Adequate light intensities should be provided to allow healthy eye development and normal behaviours as well as aid inspection of birds.

3. WELFARE BY HOUSING SYSTEM

This report has summarised what animal welfare is, how it may be assessed, key welfare issues which occur in the layer hen industry, and the main types of housing systems currently in use in Australia. The following sub-sections briefly summarise the main hen welfare issues in relation to each of the different housing systems encompassed in this report.

3.1 Battery cages

When the industry was intensified in Australia in the 1950s, cages were introduced as a means to reduce the transmission of diseases. Today, birds housed in cages still exhibit the lowest risk of contracting and transmitting infectious diseases and there is also a lower risk of the transmission of severe feather pecking. Hens in cages also suffer fewer fractures during the laying period (as opposed to at depopulation), which is likely due to the lack of environmental complexity in battery cage systems. However, hens in battery cages have very little choice in their environment and the ability to experience positive welfare states.

Hens in battery cages suffer extreme behavioural inhibition, and due to their inability to walk, flap their wings, or perch, they suffer the poorest bone strength of all housing systems and the highest number of fractures at depopulation. Hens in battery cages experience the highest rate of some non-infectious diseases, including fatty liver and disuse osteoporosis, compared with housing systems which allow greater opportunities for behavioural expression.

Since the introduction of battery cages, scientific assessment of welfare has improved. While cages allow greater control over the environment and bird health, the full impact on the welfare of the hens needs to be considered. Hens not only possess physiological needs for food, water, thermal comfort, and freedom from disease, they also have innate behavioural needs, such as those for nesting and dustbathing. The opportunity to perform the behaviours which they are motivated to perform is central to positive welfare states in poultry. Many reports, international legislation, and scientific studies have concluded that good welfare cannot be achieved in battery cages.

Summary

» Hens in cages experience a lower risk of infectious diseases, and the small group sizes means there is a lower transmission of severe feather pecking.

» Hens in battery cages experience the highest rate of some non-infectious diseases including fatty liver and disuse osteoporosis due partly to the lack of movement.

» The extreme behavioural restriction in battery cages which includes the inability for hens to walk, nest, dustbathe, forage, flap their wings or perch, causes the poorest bone strength of all housing systems, and the highest number of fractures at depopulation.

» The welfare disadvantages of battery cages are inherent in the infrastructure design and cannot be overcome by management.

» Battery cages prevent hens from carrying out innate behaviours such as laying their eggs in a nest, dust bathing and foraging.

3.2 Furnished cages

Furnished cages were developed to improve the behavioural expression that birds experience in cages. They retain the benefits of battery cages in terms of hygiene and disease control, whilst offering some benefits of cage-free systems in terms of increased behavioural expression. Behavioural expression is increased due to the provision of perches, substrate, claw-shortening devices, and nest boxes. Group sizes can also be improved in furnished cages compared to battery cage or cage-free systems. Hens in furnished cages have improved musculoskeletal health compared with battery cages, and suffer the fewest fractures compared to cage-free and battery cage systems.

Furnished cages offer some provision for dustbathing, although their use varies between different types of furnished cages, and hens are often unable to dustbathe satisfactorily due to the depletion or inadequate provision of dustbathing materials. There is a very limited ability for hens to forage, and areas provided for dustbathing and foraging are not adequate to meet the birds needs.

While there are some provisions to allow greater behavioural expression, the hens full behavioural repertoire is not able to be expressed satisfactorily in furnished cages. Therefore, furnished cages do not offer a complete solution with regards to hen housing. The ultimate aim for egg production systems should be to house hens in systems in which they are able to adequately perform all behaviours which they are motivated to perform, with a focus on optimising management, minimising the risk of disease, severe feather pecking and fractures.

Summary

- Furnished cages offer the benefits of battery cages in terms of hygiene and disease control, whilst offering some benefits of cage-free systems in terms of increased behavioural expression and improved musculoskeletal health.
- Hens in furnished cages have increased opportunities for behavioural expression with the inclusion of perches, substrate, claw-shortening devices, and nest boxes, but the full range of behaviours is not able to be expressed satisfactorily.

3.3 Cage-free systems (barn, multi-tiered aviaries and free range)

Hens in cage-free systems have the best musculoskeletal health, and a decreased incidence of osteoporosis and fractures which occur during depopulation. The increased environmental complexity can also allow subordinate birds to escape aggressive birds more effectively than in cages.

Cage-free systems generally allow greater behavioural expression, and, potentially, the ability for hens to express their full behavioural repertoire. This is dependent on appropriate stocking densities, flooring material and maintenance, as well as the provision of adequate resources such as suitable nest boxes and ample perch space. Foraging and dustbathing in particular are able to be fully expressed in cage-free systems: these activities are impossible for hens to perform in battery cages, and are extremely limited in furnished cages.

Allowing hens to access an outdoor area improves opportunities for behavioural expression including foraging, exercising, and exploration. If the range area is well maintained, easily accessible from the shed, offers shade, and is attractive to birds, this will enhance its use. When birds utilise outdoor areas, this lowers the stocking density inside the shed as well as outside, and can result in increased locomotion and exercise.

The larger group sizes and ability to perform a greater variety of behaviours also contributes to the shortcomings of cage-free housing systems. One of the major welfare concerns in cage-free housing systems is the extent to which severe feather pecking and cannibalism can occur. It is the ability for severe feather pecking to spread throughout a flock that can make it a serious welfare risk in large group sizes.

Another factor which affects welfare is the higher total incidence of fractures in cage-free housing systems. The occurrence of fractures is not well understood, but it may be due to birds colliding with perches, nest boxes and other structures. These issues may be addressed by good management, placement and design of structures in the shed. Genetic selection programs may be utilised to decrease the sensitivity of hens to osteoporosis and fractures.

Similar to cage systems, there is a risk that subordinate birds may have reduced access to feed and water depending on stocking densities. Other disadvantages which occur in cage-free systems include the risk of smothering, a higher risk of infectious disease transmission, and higher total mortality. Multi-tiered systems encompass extra considerations in terms of the ability to inspect and monitor hens due to the increased environmental complexity in these systems and a higher rate of fractures.

Although the environmental complexity in cage-free systems increases behavioural opportunities, it also increases the risk of fractures during the production period, and larger group sizes can allow the spread of severe feather pecking and transmissible diseases. Cage-free systems should therefore focus on appropriate design and placement of objects in the shed, improved management, and genetic selection.

Summary

- Cage-free systems can allow hens to perform all of their behaviours including nesting, perching, and dustbathing, if litter is provided and well maintained. This contributes to hens in these systems experiencing the best musculoskeletal health, and a lower incidence of osteoporosis, and fractures during depopulation.
- Cage-free systems pose a higher risk of transmissible diseases and severe feather pecking, and hens experience a higher rate of fractures during the laying period.
- There is more variability between cage-free farms, and these systems are highly susceptible to management practices to improve welfare.

3.4 Housing system conclusion

There are advantages and disadvantages to hen welfare in each type of housing system. The main risks to hen welfare in cage-free systems are, at present, highly variable. However, the disadvantages in cage-free systems may be addressed and improved by good management practices, genetic selection, and further research. Conversely, the welfare issues in battery cages are inherent to the system, and are therefore largely not affected by management and thus cannot be avoided. Furnished cages offer welfare advantages over both systems but do not allow full behavioural expression. What this means in terms of future standards for layer hen welfare in Australia will be addressed in the next section.

4. LAYER HEN WELFARE STANDARDS

The above examination of the relevant animal welfare science in this report has indicated two key areas for improvement to layer hen welfare standards in Australia. The first is to remove the extreme behavioural restriction inherent to battery cages by phasing out their use. The second is to improve management practices, genetic selection and minimum standards for cage-free systems.

This section examines the background to the animal welfare standards setting process in Australia and looks at reforms to layer hen housing regulation in other countries. It also explains the current situation in Australia and suggests a way forward to ensure that the way in which layer hens are housed in Australia in the future reflects current science and meets community expectations.

4.1 Setting animal welfare standards

The discipline of animal welfare science treats animal welfare as the primary concern, with productivity and efficiency as correlated benefits. However, the economic value of farm animals is determined by their productivity. For hens kept for egg production, this is the number, quality, and size of eggs that they produce in relation to the amount of feed that they consume. Improvements in productivity will result in an increase in profit, but this is not necessarily the case with improvements in welfare. Consequently, from an economic perspective, farm animal welfare improvements are viewed as an added, and independent, element of human value (McInerney 2004).

The welfare of farm animals carries no specific price and is therefore regarded by economists as an 'externality'. Consistent with the nature of externalities, improvements to animal welfare are not adequately handled through normal market processes because they are not always associated with improved productivity or increased profit. There is a clear need for governments to intervene when market processes fail to adequately protect animals from poor welfare practices, and there is an obvious role for government policy in establishing and enforcing minimum standards of care (McInerney 2004).

The process for setting minimum animal welfare standards and guidelines in Australia acknowledges that such standards should reflect current science, recommended industry practice and community expectations (Animal Health Australia 2016).

A recent study which surveyed over 1000 Australians found that 90% of respondents regarded the welfare of farm animals as important, and 67% believed that battery cages for layer hens should be prohibited (Ford 2016). A similar-sized survey, commissioned by RSPCA in 2015, found that 85% of respondents believe it is important that meat, eggs and dairy products are from animals farmed in a humane and ethical way (McCrindle 2015a). Concern for keeping layer hens in battery cages is high and has increased over time. In 2009, 65% of respondents in an RSPCA-commissioned survey of over 2000 representative Australians were concerned about the welfare of layer hens in battery cages; this had risen to 73% in 2015.

Public concern for the welfare of layer hens is reflected in supermarket purchasing choices, with almost half of consumers (47%) buying cage-free eggs at retail (AECL 2015). The proportion of eggs from cage-free housing systems sold in retail has been growing steadily for many years. Cage-free eggs now represent the highest value to the egg industry in Australia in terms of grocery sales market share (AECL 2011–2015). A Canstar Blue survey showed that 90% of consumers who buy eggs from hens in battery cages would happily switch to free range if the price difference was not so great (Canstar Blue 2016).

The major supermarkets Woolworths, Coles, and Aldi, as well as major food service companies such as McDonald's, Subway, and Hungry Jacks are contributing to this trend. Coles no longer sells cage eggs under its brand, Woolworths is phasing out the sale of eggs from hens housed in cages altogether by 2018, and Aldi is phasing out cage eggs by 2025.

However, the wholesaling and manufacturing sectors largely use eggs from hens in battery cages and there is little opportunity for consumers to purchase manufactured products that only use cage-free eggs. Due to this, despite many consumers purchasing cage-free eggs at the supermarket, the majority of layer hens in Australia are still housed in battery cages. It is estimated that cage layer farming constitutes 68% of total egg production, which means between 11 and 12 million hens continue to be housed in battery cages (IBISWorld 2015).

The poultry industries in Australia experienced deregulation in the late 1980s and early 1990s. This resulted in the industries becoming largely self-regulated, with recent efforts to differentiate products based on production methods and branding (IBISWorld 2015). In recent years, independent welfare accreditation schemes have emerged in response to the increasing consumer concern for animal welfare and the lack of adequate layer hen welfare regulation. However, these schemes are primarily used to verify cage-free production standards for eggs sold in retail outlets. While battery cages remain legal and there continues to be a significant price difference between cage and cage-free eggs, consumer demand alone will not be sufficient to end the use of battery cages in Australia.

While an understanding of community expectations is crucial to guiding the direction and pace of animal welfare reform, if animals are to be provided with good welfare then it is science that should have the key role in determining animal welfare standards. Scientific evidence on animal welfare should pre-empt decisions or debates on the use of animals (Hemsworth et al. 2015). Animal welfare standards should be developed by incorporating the most recent scientific developments and improvements in management. They should account for the health and biological functioning of animals, their emotional states, and their ability to express normal behaviours (Fraser et al. 2013). Often, these considerations coincide, although there are circumstances in which one or more of those considerations may be compromised.

The manner in which animal welfare standards are developed has large impacts on their acceptability and the extent to which they are supported by stakeholders and the wider community. For standards to be legitimate and science-based, it is widely recognised that they should be based on scientific reviews conducted by independent scientific advisory committees. Examples of such reviews are the Review of Scientific Research on Priority Issues for the Code of Practice for the Care and Handling of Pullets, Layers, and Spent Fowl: Poultry (layers) in Canada (Widowski et al. 2013), the Report on the Welfare of Laying Hens by the Scientific Veterinary Committee for Animal Welfare in the European Union (1996), and the report by the National Animal Welfare Advisory Committee (NAWAC) of New Zealand (NAWAC 2012).

At present, the development of Australian standards for the welfare of livestock, including poultry, is not governed by independent bodies, and the process lends itself to being aligned with the current investments of industry. This process has been criticised by animal welfare organisations for its lack of independence and the lack of focus on animal welfare science. In order for the welfare of layer hens to improve, the development of poultry welfare standards needs to be based on independent, internationally recognised science and be independent of industry productivity goals. This separation has been achieved in other countries by establishing independent scientific welfare committees and animal welfare frameworks (Ford 2016) and has led to the phasing-out of battery cage production in a growing number of countries.

Summary

- The welfare of farm animals is not adequately improved when relying solely on market processes. Hence there is an obvious role for government in establishing and enforcing minimum standards.
- Public concern over the treatment of layer hens in battery cages in Australia is consistently high and has increased over time (73% in 2015).
- The Australian egg industry is largely self-regulated, with independent welfare accreditation schemes emerging in response to the lack of adequate poultry welfare regulation and increasing consumer concern for farm animal welfare.

» Animal welfare standards should be developed by incorporating the most recent scientific developments and improvements in management.

» For standards to be recognised as legitimate and science-based, they should be based on scientific reviews conducted by independent scientific advisory committees, which does not currently occur in Australia.

4.2 Phasing out battery cages

In 1990, the Australian Senate recommended the prohibition of battery cages once viable alternatives were developed, based in part on the large amount of scientific literature on the welfare of laying hens, dating back to the mid-1960s. When the *Australian Model Code of Practice for the Welfare of Animals – Domestic Poultry* was last reviewed in 2000, there was an even greater body of scientific evidence available on the welfare of layer hens, and cage-free production systems were already well-established in Australia. Some members of the Working Group responsible for drafting the Code agreed that the scientific literature identified major problems with battery cages, in particular, 'the lack of suitable nest-sites and foraging materials to meet the birds' behavioural needs' were flagged as key indicators that 'an end date for the use of battery cages in Australia should be set' (SCARM Working Group 2000). However, the main outcome of the 2000 review was not to end the use of battery cages, but to increase the minimum floor space allowance per hen from 450cm^2 (as specified in the 1995 edition of the Code) to 550cm^2. Egg producers were given until 1 January 2008 to fully comply with the new requirements.

Internationally, by the early 2000s many countries had recognised the inherent welfare problems with battery cages and had already introduced prohibitions on their use. In Switzerland, cage systems for laying hens were prohibited in 1992. In Sweden in 1989, egg farmers were given a period of 10 years to phase out battery cages, which was later extended, and battery cages were no longer used from 2002. In Austria, battery cages were prohibited in 2009. In the European Union, the adoption of Directive 1999/74/EC prohibited housing laying hens in battery cages, effective from 1 January 2012. The Directive was based on a report from the European Union's independent Scientific Veterinary Committee. All countries in the European Union have now prohibited the use of battery cages. This included Austria, Belgium, Bulgaria, Croatia, Republic of Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

The phase out of battery cages in the European Union was affected by public pressure as well as by all sectors of society including producers, retailers, consumers, legislators, and the media (Appleby 2003). Since 2012, each hen in the European Union is legally required to be provided with at least 750cm^2 of floor space (of which 600cm^2 is 45cm high), a nest, a littered area for scratching and pecking, 15cm of perch, 12cm of food trough space, and a claw-shortening device (Appleby et al. 2002).

More recently, in 2012 in New Zealand, an independent scientific review of layer hen welfare led by the National Animal Welfare Advisory Committee (NAWAC)resulted in a legislative phase-out of battery cages by 2022 (NAWAC 2012). This change was in response to scientific evidence and strong public opinion, despite over 80% of eggs in New Zealand being produced in battery cages at the time.

Earlier this year, Canada announced a phase-out of battery cages by 2036. This change is being led by the industry group, the Egg Farmers of Canada, and represents a voluntary phase out. Since this industry-led announcement, the draft *Code of Practice for the Care and Handling of Pullets and Laying Hens* has been released which, if implemented, will mandate the phase-out of conventional cages in Canada by 2036.

It is expected that 50% of hens in Canada will be transitioned to alternative housing systems within 8 years. The draft code states that the proposed transition strategy represents an approach which balances the public's desire to phase-out battery cages, with the industry's ability to do so in a manner that is practical, feasible and cost-efficient for farmers and consumers, and ensures that the market demand for eggs can continue to be met, while significantly improving the welfare of millions of hens (National Farm Animal Care Council 2016).

Approximately 90% of Canadian egg production is currently occurring in battery cage systems. The code states that the phase-out of conventional cages represents the most significant change ever to egg production in Canada. The Egg Farmers of Canada have said that this change is in response to the best available scientific research, as well as changing consumer preferences, and that the industry plans to diversify production practices in line with these developments (Heppner 2016). Similarly, the code states that hens are restricted from engaging in many natural behaviours due to limited space and amenities in battery cages, which is cause for their phase-out across Canada (National Farm Animal Care Council 2016).

In the United States, Michigan passed a law to prohibit battery cages in 2009. Ohio, the nation's second-largest egg-producing state, prohibited the construction of new cage production facilities, and legislation to prohibit cages may be introduced in Massachusetts this year. In addition to legislative changes, nearly a hundred major companies have stopped sourcing eggs from battery cages in the United States. These include McDonald's, Denny's, IHOP, Kroger, Albertson's, and Walmart (Pacelle 2016).

4.2.1 Current situation in Australia

Australia is now behind much of the developed world in layer hen welfare standards and regulation. To date, the only jurisdiction in Australia which has prohibited the use of battery cages is the Australian Capital Territory (ACT Government 2014). However, due to market competition legislation (the Commonwealth Mutual Recognition Act 1992), this does not prevent eggs from hens housed in battery cages in other states being sold in the ACT (Productivity Commission 1998). Tasmania passed a regulation prohibiting any new battery cages being constructed from 2013 (Animal Welfare (Domestic Poultry) Regulations 2013 (TAS), r 5)), but this does not affect existing battery cage production. No other state has proposed any similar legislation.

The difficulty of an individual state or territory legislating to end cage production without being able to prevent battery cage eggs being sold, highlights the importance of a national approach to this issue. The current review of the Australian Model Code of Practice for the Welfare of Animals – Domestic Poultry offers legislators the first opportunity in more than 15 years to implement a national phase-out of battery cages and introduce uniform minimum standards for cage-free systems that reflect current animal welfare science.

Unfortunately, in stark contrast to recent international developments, the first draft of the Australian Animal Welfare Standards and Guidelines for Poultry (Animal Health Australia 2016) does not propose any such changes. Despite the overwhelming scientific evidence of the extreme behavioural restriction in battery cages, which includes the inability for hens to walk, flap their wings, perch, forage, dustbathe or lay their eggs in a nest, such cages were still permitted in the first draft of these standards.

The lack of progress towards ending the use of battery cages in Australia is a reflection of the lack of independence and focus on science in the animal welfare standards-setting process. To improve poultry welfare and ensure layer hens have a good quality of life, Australian animal welfare standards for poultry must be underpinned by current welfare science and reflect the high level of public concern that battery cages cannot meet the needs of layer hens.

Summary

» In 1990, the Australian Senate recommended prohibiting battery cages once viable alternatives were developed.

» Battery cages have been prohibited in Switzerland since 1992; in Sweden since 2002; in Austria since 2009 and in every country in the European Union since 2012.

» New Zealand has implemented a legislative phase-out of battery cages by 2022.

» Canada has announced an industry-led phase-out of battery cages by 2036 and the Canadian Government has proposed a mandatory phase-out by 2036.

» In the United States, the state of Michigan banned battery cages in 2009; Ohio in 2016 and similar legislation is proposed in Massachusetts. Nearly 100 major food companies in the US have stopped sourcing eggs from battery cages.

» Australia is behind much of the developed world in layer welfare standards and regulation; the only jurisdiction so far to prohibit the use of battery cages is the ACT.

» The development of the Australian Animal Welfare Standards and Guidelines for Poultry offers legislators the first opportunity for more than 15 years to implement a national phase-out of battery cages.

» Despite the overwhelming scientific evidence battery cages were still permitted in the first draft of these standards

» The lack of progress in Australia is a reflection of the lack of independence and focus on science in the animal welfare standards setting process.

» To improve poultry welfare and ensure layer hens have a good quality of life, Australian animal welfare standards for poultry must be underpinned by current welfare science and reflect the high level of public concern that battery cages cannot meet the needs of layer hens.

4.3 Improving cage-free systems

The main welfare risks in cage-free systems are the transmission of infectious diseases and severe feather pecking, both of which can lead to mortality. Hens can also experience fractures due to collision with objects such as perches and nest boxes. These issues, and the extent to which they occur, are largely affected by the management and stockpersonship on each farm.

Addressing severe feather pecking requires an integrated approach comprising of genetic selection, the provision of appropriate housing conditions, and good management. The transmission of infectious diseases is strongly affected by biosecurity and health management practices. The incidence of fractures may be addressed by the design, maintenance, and placement of structures within the shed, and complemented by genetic selection for improved bone strength. Overall, management is a very large determinant of welfare in cage-free systems.

Housing conditions and management in cage free systems can be improved by setting appropriate minimum standards. The rearing environment requires significant attention in order to improve hen welfare in cage-free systems, and good management practices and stockpersonship are essential to ensure that hen welfare needs are met. The increase in space and allowing more natural behaviours does not necessarily result in desired improvements to welfare if the system is not well constructed, maintained and managed (National Farm Animal Care Council 2016). Therefore, any poultry welfare standards must include robust specifications for housing and management in cage-free housing systems.

There is work being conducted to optimise the long-term management of cage-free systems. LayWel and Hennovation at the University of Bristol in the United Kingdom are examples of these. LayWel is a research project which studies the welfare implications of changes in production systems for laying hens. The objective of the project is to produce a series of reports and information packages to ensure the findings are well publicised and that the knowledge is exploited.

LayWel states that the disadvantages of battery cage systems, which include severe behavioural restriction and disuse osteoporosis, outweigh the advantages of reduced parasitism, good hygiene and simpler management. Therefore, with the exception of battery cage systems, LayWel states that all production systems have the potential to offer acceptable hen welfare (LayWel 2006c).

In cage-free systems, there are a number of factors which vary within and between farms, which can compromise hen welfare. Hence, LayWel produced a manual which facilitates monitoring and improving the welfare status of hens in these housing systems. This management guide offers practical strategies to reduce the risk of injurious feather pecking and is based on scientific evidence as well as industry experience (see Laywel.eu).

Hennovation aims to address the problems associated with injurious pecking and the transport and use of hens at end of lay. It is a project that came about due to the changes in the layer hen industry, the recognised gap between research and practice, and that transfer of knowledge acquired from scientific research into industry practice is not always effective. Its objectives are to develop practice-driven innovation networks in the layer hen industry, develop and disseminate technical innovations to increase sustainability of the layer hen sector, produce and distribute support packages, and to develop policy recommendations. Innovation networks are established between producers to proactively develop new ideas to improve hen welfare, and are supported by veterinarians, farm advisors, researchers, and other stakeholders (Hennovation n.d.).

While the presence of litter in cage-free systems and access to the outdoors are factors which can increase the risk of disease transmission, there has been a consistent decline in the proportion of birds with viral diseases (Marek's disease), parasitic (coccidian and helminths), diseases as well as feather pecking and cannibalism during the 12 years after the prohibition on battery cages in Switzerland. This change is thought to be due to improved vaccination, and greater emphasis on management in barn and free-range systems (Kaufman-Bart 2009; Fraser et al. 2013; Widowski et al. 2013).

In the Netherlands, a new alternative system of production has been developed, the Rondeel™. This is an enriched barn system which has a circular design, with specific areas to address concerns regarding bird welfare and practicality of management for producers. Different areas include an area for birds to roost at night, day quarters, a wooded area, and a central core, which contains the main working area for the producer. It was designed to address the issues of feather pecking and cannibalism seen in non-beak-trimmed birds, and aims to combine issues including animal welfare, environmental care and consumer demand (see Rondeel.org). Since it is a new system, data is required on its effects on welfare outcomes (van Niekerk and Reuvekamp 2011).

In Australia, a number of universities, research centres and organisations have been investing in and are planning further investment in research to address welfare challenges in cage-free systems. The increase in cage-free egg production and the acknowledgement that battery cages are not a viable type of housing for layer hens, has led to this work. This type of research and investing in research into cage-free systems is fundamental for the improved welfare of layer hens in Australia.

In addition to a focus on appropriate housing and management in cage-free housing systems, there are some welfare issues which may be improved by genetic selection. Both bone strength and severe feather pecking are heritable. Studies have found that genetic selection is extremely effective in improving bone strength and resistance to osteoporosis. The issues related to musculoskeletal health should therefore be addressed through appropriate environmental conditions (including perch design and placement), as well as genetic selection for improved bone strength. Similarly, there are a number of studies investigating the traits which may be selected against to prevent severe feather pecking. Good management and stockpersonship, appropriate housing, and adequate nutrition should therefore be paired with genetic selection programs to minimise the risk of severe feather pecking.

Summary

» The main welfare risks in cage-free systems are the transmission of infectious diseases and severe feather pecking, both of which can lead to mortality.

» Addressing severe feather pecking requires an integrated approach comprising of genetic selection, the provision of appropriate housing conditions, and good management.

» Housing conditions and management in non-cage systems can be improved by setting appropriate minimum standards.

» Projects such as Laywel and Hennovation are being conducted across Europe to optimise the long-term management of cage-free systems.

» Research projects in the United Kingdom have produced manuals which facilitate the monitoring and improving the welfare status of hens. These management guides look at practical strategies to reduce the risks to welfare and are based on scientific evidence as well as industry experience.

» In Switzerland, a study reported a consistent decline in the proportion of infectious diseases in the 12 years since cages were prohibited. This is thought to be through improved vaccination, and greater emphasis on management.

» Innovative housing systems are being developed to address concerns with welfare and productivity.

» In Australia, a number of universities, research centres and organisations have been investing in and are planning further investment in research to address welfare challenges in cage-free systems.

4.4 Layer hen welfare standards conclusions

Each type of housing system exhibits advantages and disadvantages in terms of hen welfare. However, the severe behavioural inhibition in battery cages is inherent to the system, and not affected by management. It is widely acknowledged that battery cages cannot provide good welfare for layer hens. This has led to their prohibition across the European Union, and their phase out in New Zealand and Canada, as well as some states in the United States. In Australia, public concern over the use of battery cages is consistently high and has increased further in recent years, with many consumers purchasing eggs from hens in cage-free systems.

In 2000, the Synopsis Report on Layer Hen Housing and Labelling of Eggs in Australia by the SCARM Working Group concluded that there was an urgent requirement to identify the successful principles in managing cage-free systems to facilitate their successful adoption, and that research and development in alternatives to battery cages be prioritised. Further, some Working Group members agreed that there are major problems with battery cages, particularly the inability to meet birds' behavioural needs, and that battery cages should be phased out in Australia. These conclusions were made 16 years ago, and since then, there has only been growing evidence to support the fact that battery cages cannot provide good hen welfare. To ensure layer hens have a good quality of life, Australian animal welfare standards for poultry must be underpinned by current welfare science and reflect the high level of public concern that battery cages cannot meet the needs of layer hens by setting an end date for their use.

There is a need for innovative and proactive changes in the layer hen industry worldwide, in order to effectively respond to changing demands and challenges. Projects like LayWel and Hennovation demonstrate that there is potential for producers and industry to establish networks and adopt new ideas to contribute to the sustainability of the industry, as well as improve the efficiency of individual enterprises. The egg industry in Australia needs to embrace a proactive approach to implementing higher welfare methods of farming, including the phase-out of battery cages. This should be paired with a commitment to research and support for extension activities in order to improve the management of cage-free systems for long-term improvements in poultry welfare.

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