Hen welfare in alternative systems

Animal welfare

"Animal welfare means how an animal is coping with the conditions in which it lives. An animal is in a good state of welfare if (as indicated by scientific evidence) it is healthy, comfortable, well nourished, safe, able to express innate behaviour, and if it is not suffering from unpleasant states such as pain, fear, and distress. Good animal welfare requires disease prevention and veterinary treatment, appropriate shelter, management, nutrition, humane handling and humane slaughter/killing. Animal welfare refers to the state of the animal; the treatment that an animal receives is covered by other terms such as animal care, animal husbandry, and humane treatment." (OIE, 2011).

The five freedoms define the ideal state for acceptable welfare: *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 appropriate environment including shelter and comfortable resting area), *3. Freedom from pain, injury or disease* (by prevention or rapid diagnosis and treatment), *4. Freedom to express normal behaviour* (by providing sufficient space, proper facilities and company of the animal's own kind), and *5. Freedom from fear & distress* (by ensuring conditions and care which avoid mental suffering). The freedoms encompass the physical wellbeing of the animal, its ability to perform innate or species-specific behaviours, and its psychological (affective) state. All three components are essential for good animal welfare and are discussed in relation to housing system below.

Physical wellbeing

Mortality and disease

Mortality in commercial indoor and free-range flocks in the UK ranged from 3 to 12% (NFU, 2003). Mortality is generally regarded to be higher in alternative systems than cages. On-farm mortality towards the end of lay was reported at five slaughter plants in the UK at 5.4% in cages compared to 9.4% in barn and free-range systems (Weeks et al., 2011), and 2.8% in furnished-cages compared to 8% in indoor floor and aviary systems in the Netherlands (Rodenberg et al., 2008).

Primary causes of mortality in non-cage systems were feather pecking and cannibalism, health problems, infections with red mites, and smothering (Rodenberg et al., 2008). Flies, beetles and permanent ectoparasites were considered least problematic in non-cage systems as the hens ingested and groomed away the organisms; red mite infestations however, were considered more problematic (Lay et al., 2011). Hens in free-range systems also had higher levels of helminths (Permin et al., 1999).

Management systems and an appropriate veterinary health plan (for vaccination and worming programmes) are vital to good health status and low mortality and both are very much determined by a positive producer attitude to the system he/she operates. Mortality in a new free-range system in Australia was reduced from 21.9% to 5.7%, comparable to that in caged systems, in three consecutive flocks after the introduction of good management practices (Shini et al., 2008). Twelve years of Swiss commercial data in litter systems showed a consistent fall in the incidence of viral disease, parasites, cannibalism and feather pecking as a result of better management (Kaufmann-Bart and Hoop, 2009); bacterial infections rose however, probably as a result of dust, bacteria, and ammonia loading.

Dust and ammonia levels may be higher in non-cage systems due to provision of litter material and higher levels of bird activity (David et al., 2015a and b). Good ventilation and heat exchange systems are important to extract air pollutants and keep the litter relatively dry. Many producers maintain a separation of the hens from their faeces, with the use of slatted floors and/or manure belts under drinkers, nest boxes and perches; at least one third of the floor area is then solid with friable litter for scratching and dustbathing. The design of the nest boxes and fittings are important for the control of red mite; sealed constructions prevent the mites nesting in cracks and crevices. Smothering can be reduced by the separation of flocks into smaller colonies and by providing pullets early experience of the environment in which they will lay to reduce fear. Predation, which can also be high in free-range systems, can be minimised through the use of high fences, dug into the ground and extended away from the fence line, whilst the provision of trees and shelters protects against aerial predators.

Skeletal health

Laying hens are selectively bred to increase egg yield and modern hybrids can now produce around 300 eggs/bird/year compared with 115 eggs/bird/year in 1930 (FAWC, 2010). Genetic selection of commercial layers for increased egg production has resulted in much weaker bones compared with traditional breeds (Budgell and Silversides, 2004). This is influenced by the fact that egg shell quality is maintained in genetically selected lines at the expense of bone strength and density (Hocking et al., 2003).

Osteoporosis is prevalent in caged birds due to lack of exercise and accounts for 20 to 35% of all mortality in caged hens (as cited by Lay et al., 2011). Despite wing and keel bones (but not leg bones) being stronger in hens from non-caged systems (Rodenberg et al., 2008), fractures of the keel bone are more prevalent in alternative systems (Sherwin et al., 2010). An incidence of 5 to 10% old fractures is cited for barren-caged hens (Richards et al., 2011a) compared to 49 to 67% in single tier wire floor systems (Nicol et al., 2006) and 50 to 78% in free-range flocks (Wilkins et al, 2004). Keel bone deformities were not found in rear, but appeared gradually in lay, reaching 35 and 43.8% at weeks 62 and 65, respectively (Kappelli et al., 2011). Lower levels have been reported in some countries, e.g. keel-bone fracture prevalence of 4.9% in single-tiered and 11.6% in multi-tiered systems at 62 weeks of age in Denmark (Riber and Hinrichsen, 2016) and further research is needed to elucidate the causal factors of this discrepancy in order to apply knowledge to reduce the level of keel-bone fractures in other countries. Also, a recent a longitudinal study of four consecutive flocks (Casey-Trott et al. 2017) and the prevalence of keel bone fractures and deviations showed that rearing laying hens in aviary systems influence the keel bone fractures and age as well, but not the system at laying age (cages vs aviary).

All moderate and severe keel bone deformities are likely to be painful (Kappelli et al., 2011). The bones undergo a period of healing of around 35 days (Richard et al., 2011a) during which time the hens are constrained and their behaviour modified by the physical characteristics of the fracture or pain (Nasr et al., 2012). Individual hen egg production and egg quality were also negatively affected by the presence of keel fractures (Nasr et al., 2012). Healed keel fractures continue to be a source of chronic pain (Nasr et al., 2013).

Birds are thought to break the anatomically exposed keel bone in collisions with perches or other obstacles, as they jump and fly between structures at different heights; failures of landing and collision with walls or fixtures close to nest boxes are also potential causes. The occurrence of new fractures is temporally linked to egg production, with more new fractures occurring when laying rates are highest (Gebhardt-Henrich and Frohlich, 2015). Genetic selection for bone strength and improved house and perch design are needed to improve the welfare of the laying hen, especially in alternative systems (Sandilands et al., 2009; Wilkins et al., 2011).

The risk of keel bone injuries can be reduced by providing ramps connecting the floor, tiers and perches (EFSA, 2015; Stratmann et al., 2015a; Heerkens et al., 2016a), using softer material for perches (e.g. softwood) or soft coverings (e.g. rubber, polyurethane) on metal perches (Scholz et al., 2014; EFSA, 2015; Stratmann et al., 2015b). Ramps should ensure that birds do not have to jump more than 80cm vertically, horizontally or diagonally, or more than an angle of 45° (EFSA, 2015). Also the risk can be reduced by providing early access to age-appropriate three-dimensional environmental features such as low perches, platforms and ramps/ladders (Kozak et al., 2016). Row-type aviaries and wire mesh flooring are associated with a higher risk of keel fractures compared with portal-type (stepwise design) aviaries and plastic mesh flooring respectively (Heerkens et al., 2016b). Pressure peaks were found to be five times higher on the keel bone than the single foot pad during perching and keel bone peak force was lower on square perches than oval or round perches (Pickel et al., 2011); keel bone peak force was also lower on two prototype perches (soft round polyurethane) than commercially available round steel tube perches. A perch width of 3 to 6cm is recommended to reduce peak force under the keel bone and foot pads (EFSA, 2015).

The findings above and practical experience highlight the need for house and perch design to take account of the physical attributes of the hen, including trajectory requirements for jumping and flying on and off perches and nest boxes; proximity of fixtures and walls; low pressure loading perches, and agility training of young pullets for moving in a three dimensional space as well as developing a strong bone structure in a non-caged system.

Foot health

Foot pad dermatitis, bumble foot, hyperketosis and excessive claw growth are the most common foot problems of laying hens. Caged birds suffer most from excessive claw growth, due to lack of abrasive materials to shorten the toe nails, and hyperkeratosis from increased compression of the toe or pad on the wire of the cage. Design is important for reducing hyperkeratosis due to compression loading while perching. Prototype perches (soft, round polyurethane perches) produced a lower peak force on the foot pad than commercially available steel perches, whilst commercially available square perches produced higher peak forces than standard oval and round perches while standing (Pickel et al., 2011).

Foot pad dermatitis (discoloration, necrosis and ulceration of the epidermis) is caused by wet litter, high ammonia content of the litter (Wang et al., 1998), as well as feed and genetic components. Infection with *Staphylococcus aureus* in deep litter systems leads to bumblefoot – a localised bulbous lesion in the ball of the foot, which causes severe lameness. Litter maintenance is therefore of paramount importance in all systems, but particularly deep litter systems.

It is important to note that high levels of plumage loss, emaciation, fractures and stress found across all systems (caged, barn and free-range) indicate the modern genotype has poor welfare (Sherwin et al., 2010) which needs to be addressed urgently through suitable breeding strategies.

Behavioural expression

The behaviour of the modern laying hen is not fundamentally different from its Red Junglefowl ancestor, despite many thousands of years of domestication or more recent intensive selective breeding. Selection for production traits has modified the frequency of behaviours (largely by reducing energy demanding behaviours) rather than adding behaviours to, or eliminating behaviours from, the animals' repertoire (Shutz and Jensen, 2001). The ability to perform this innate behaviour is dependent on the provision of adequate space and access to diverse resources provided by the housing system, and is modified by genetics, epigenetic factors, previous experience in the rearing house, and even environmental conditions in embryonic development (Janczak et al., 2007; Lindqvist et al., 2007).

The barren battery cage severely restricts all behaviour (locomotion, foraging, body maintenance, thermoregulatory behaviour) and leads to stereotypic pacing prior to oviposition due to lack of a nesting site. Whilst banned in the EU (barren cage), the 'enriched-cage' is permitted. Despite providing more individual space per hen (750cm^2 as opposed to 550cm^2), and shared space within a larger group, a nest, small amount of litter, and 15cm of perch space per hen, behavioural expression is still limited (Rodenberg et al., 2008; Shimmura et al., 2010; Lay et al., 2011), preventing the hen from expressing highly motivated behaviours for her entire lifespan. The enriched cage is therefore considered unacceptable (see Pickett, 2007 for full review). Alternative systems (barn, free-range and organic) allow for the full repertoire of locomotion, body maintenance and nesting, and provide enhanced opportunity for exploratory behaviour in a free-range environment.

Space for behavioural expression

Systems must provide sufficient space for hens to perform comfort and maintenance behaviours (including preening, stretching, wing-flapping) and locomotion (including running, walking, flying). Medium hybrid brown hens were found to use on average between 475cm^2 (standing) and 1876cm^2 (wing-flapping) of space when housed individually in small pens (Dawkins and Hardie, 1989), and preferred enclosures of 13,550cm^2 to wing-flap (Bubier and Bradshaw, 1990). Mench and Blatchford (2014) found similar values for lighter hybrid white hens (563cm^2 on average for standing and 1693cm^2 for wing-flapping). Caged systems provide a fraction of the space required by hens to express innate behaviour, whilst the legislative indoor space allowance for birds in barn and free-range systems is 1,111m^2 (9 birds/m^2) and for organic systems is 1,666m^2 (6 birds/m^2). Combined with a greater level of shared space, due to uneven distribution or use of functional areas, creating areas of lower stocking density, alternative systems allow birds to express a much wider behavioural repertoire. Savory et al (2006) concluded a space allowance <5000cm^2 per hen imposed some constraint to behavioural expression, but that this amount of space provided in a free-range environment with complex resources allowed a full range of natural behaviour. The ability of hens to nest, forage, dustbathe, perch and range are explored further.

Ability to nest

Nesting behaviour includes nest site investigation and selection, pre-laying behaviour (gathering, scraping, crouching, sitting and circling or keel rotation) followed by egg laying and post lay sitting. The sequence of behaviours takes up to 3 hours or more and occurs largely in the morning. Generally, hens prefer to lay in a discrete enclosed nest with loose material such as straw or a flexible nest liner on the floor; the nest must be perceived attractive and there must be sufficient numbers to service the number of hens in the house. Introducing nest boxes into the latter stages of pullet rearing helps to train the young hen to use the nest box and is vital to reduce the number of eggs laid on the floor, which is a source of economic loss.

Commercially, group nests are enclosed on three sides with front curtains and a plastic grid or perch in front; there is a roof and the floor is sloped (12 to 18%) and covered usually with Astroturf[R] or rubber pimple matting. Front curtains are an important component of group nests (Buchwalder and Frolich, 2011) and sliced curtains allowed for hen investigation along the length of the nest (Stampfi et al., 2012). A floor slope of 12% was recommended (Stampfli et al., 2011) as more hens were observed in the nests, with more sitting events and better alignment (back to rear of nests for egg roll away) than in nests with slopes of 18%; additionally, a greater number of visits led to egg laying. Integration of nests into the aviary (centre of building as opposed to against wall) led to a more even use of nests (Lentfer et al., 2011); hens tended to prefer nests high up when mounted against the wall and facing the walkway when integrated onto an aviary. Corner nests and nests closest to the entrance were preferred and the authors recommended the platforms in front of the nests be more than 30cm wide (Lentfer et al., 2011). A preference for nest boxes in corners (Riber and Nielsen, 2013) and nest boxes on the ends of rows (Clausen and Riber, 2012) can lead to gregarious nesting (where hens choose a nest that is already occupied even when there are other empty nests available). Enhancement of nests in less preferred locations, for example by the addition of preferred nesting material (e.g. straw), has been suggested as a possible solution to achieve more even utilisation of nest boxes (Ibid.). Group nests should not be too large to ensure they provide a sense of enclosure to cater for the egg-laying preferences of hens (Ringgenberg et al., 2014). Addition of a central partition to commercial group nests can make the nests more attractive to hens (Ringgenberg et al., 2015).

Foraging and dustbathing

In natural conditions hens spend 50 to 90% of their time foraging, which involves searching and scratching at the ground or litter for potential food items (seeds, earthworms, flying insects, grit), followed by investigation and selection of food items by pecking. Hens are highly motivated to forage even when provided with adequate food (Cooper and Albentosa, 2003). Foraging behaviour was performed significantly less in furnished cages than in barn systems (5.4% of the time compared to 16.6%, respectively; Rodenberg et al., 2008), indicating litter provision is inadequate in furnished cages.

Dustbathing is performed every 2 days in unrestricted conditions, and hens prefer fine particles like sand in which to dustbathe (Olsson and Keeling, 2005). Dustbathing involves the hen lying down and tossing loose substrate onto her back and wings, rubbing the substrate into her feathers and shaking it out. This combined with preening removes grease and dirt from the feathers and helps keep the plumage in good condition. In the absence of a suitable substrate (and quantity) or lack of early experience of substrate (Olsson et al., 2002), hens performed sham-dustbathing. Whilst 'going-through-the-motions' of a bathing routine, sham-dustbathing is not considered effective or particularly rewarding for the hen. Hens performed similar amounts of dustbathing and preening in furnished cages (7% preen, 2.5% dustbathe) as they did in floor and aviary housing systems (6% preen, ~4% dustbathe) (Rodenberg et al., 2008); most of the dustbathing in furnished cages was however sham-bathing.

Unable to forage and dustbathe, hens become frustrated, and redirect their pecking behaviour towards other birds (Huber-Eicher and Wechsler, 1997) leading to feather pecking and feather damage, and in extreme cases, vent pecking and cannibalism. In order to control feather pecking, hens are beak trimmed, which causes acute and chronic pain. Designing and managing systems that allow hens to fulfil their foraging and dustbathing needs, and reduce the risk of feather pecking and the need for beak trimming (see information sheet 4) are therefore important factors for the delivery of good hen welfare.

Perching

In natural conditions hens roost at night for protection against ground predators, and will struggle to secure perch space (Appleby et al., 1992). The legislative requirement of 15cm perch space per hen should be sufficient for medium weight hybrids (Appleby, 1995) but larger birds need more space. Perches should be elevated from the floor. For night-time roosting, birds show a preference for perches higher than 60cm (EFSA, 2015). This preference cannot be met in commercial cage systems due to the lack of available height. In aviary systems, hens prefer perches on the higher tiers for roosting at night, which can result in welfare risks from overcrowding of the higher tiers even when the total amount of perching space available meets legislative requirements (Brendler and Schrader, 2016; Campbell *et al*, 2016a). Perch design is important for keel bone integrity and foot health (see previous sections). Perches are also used for resting in daylight hours, and were used more in non-caged systems (53% of the observation period) than furnished cages (23%; Rodenberg et al., 2008). Provision of aerial perches in commercial free-range houses has been found to reduce levels of aggression and fearfulness and improve body condition (Donaldson and O'Connell, 2012).

Ranging behaviour

Free-range systems provide hens with enhanced opportunity to express their behavioural repertoire (Savory et al., 2006). Ranging behaviour is however affected by time of day, age, feeding system, weather conditions, previous experience, genetic strain, and importantly the quality of the outdoor environment provided. Extensive locomotion is observed in aviaries and free-range systems, with birds moving 1800m and 2500m per day, respectively (Keppler and Fölsch, 2000).

The percentage of the flock observed on the range at any one time is fairly low but highly variable, with most hens going outside on dry, overcast days (Keeling et al., 1988).Ranging decreased with increasing wind speed and precipitation (Hegelund et al., 2005; Richards et al., 2011b). Studies in northern/western Europe typically report an average proportion of birds observed on the range of 9-13% (Hegelund et al., 2005; Gilani et al., 2014; Chielo et al., 2016) but higher levels have been reported in more favourable climatic conditions, e.g. 32.6% in a study of three farms located on the north coast of the Basque Country in Spain (Rodriguez-Aurrekoetxea and Estevez, 2016). The proportion of hens on the range decreased with increasing flock size (Gebhardt-Henrich et al., 2014; Gilani et al., 2014; Chielo et al., 2016) and this effect is particularly marked when looking at flock sizes in the hundreds compared with those in the thousands, e.g. 42% with a flock size of 490 compared with <12% for flock sizes of 1500-2500 (Bubier and Bradshaw, 1998). Ranging was reduced with increasing stocking density indoors (Gilani et al., 2014) and outdoors (Campbell et al., 2017).

A high proportion of the hens outside tend to stay close to the house (~70%, Zeltner and Hirt, 2008). Chielo et al. (2016) recorded, on average, 5.4% of the flock within 10m of the shed, 4.3% in an enriched zone 10-50m from the shed and 2.8% >50m from the shed. Hens that ventured >50m from the shed engaged in more walking and foraging behaviour and had better feather condition. Rodriguez-Aurrekoetxea and Estevez (2016) reported improved feather condition and lower levels of footpad dermatitis in hens with a higher frequency of range use. The proportion ranging increased as more hens ventured further onto the range (Keeling et al., 1988) and when they were fed ad libitum (42.1% ranging) as opposed to several times a day (~7.5%, Bubier and Bradshaw, 1998), indicating the positive effect of social facilitation and the negative effect of behavioural restriction around meal times, respectively. Range use is enhanced with the provision of trees, bushes, and artificial shelters with a sand floor for dusbathing (Nicol et al., 2003; Zeltner and Hirt, 2008). Shelter provides shade and protection from wind, rain and overhead predators, and provides a more favourable environment for the hens than a vast expanse of open grass. Provision of tree cover on the range may also have economic benefits by improving certain production traits (Bright and Joret, 2012).

Some birds never go outside (6%) while others spend three quarters of daylight hours outdoors (3%) (Keeling et al., 1988). Sub-populations within flocks of Lohmann Brown hybrids were categorised via individual electronic tag recognition at the pophole (Richards et al, 2011b), into those that: never went outside (7.7%), used the popholes infrequently (7.9%), sat in the popholes (3.8%), and used the popholes frequently (80%). Hens that used the range more frequently were less fearful than those using the range less frequently or not at all (Campbell et al., 2016b; Hartcher et al., 2016). Regular exposure to an outdoor environment at an early age reduced fearfulness in laying hens, and those birds seen frequently outdoors were less fearful than those staying indoors (Grigor et al., 1995); free-range experience is therefore important for pullets destined for free-range laying systems.

Affective states

Affective states are basic emotions accompanied by behavioural, physiological and cognitive changes that humans label with terms such as happiness, sadness, fear, and anxiety. Most work in hens has concentrated on frustration (discussed in above sections), fear and pain. Hens were found to be less fearful in non-cage (aviary / barn) systems than furnished-cages (Rodenberg et al., 2008) and least fearful in free-range systems (Shimmura et al., 2010). Most work investigating pain has been associated with beak trimming (see information sheet 4) and keel fractures (see earlier in this document).

Summary

The right combination of house design, breed, rearing conditions, and management is essential to optimise hen welfare and productivity. Differences in welfare scores between housing systems are largely determined by the variation in the freedom to express normal behaviour (Shimmura et al., 2011). The following must therefore be maximised in the system operated: space for behavioural expression, and behavioural opportunity to nest, forage, dustbathe, perch and range.

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