Annex 11

draft CHAPTER 7.Z.  
  
**ANIMAL WELFARE AND LAYING HEN PRODUCTION SYSTEMS**

Article 7.Z.1.

**Definitions**

For the purposes of this chapter:

**Laying hens:** means sexually mature female birds of the species *Gallus* *gallus* *domesticus* kept for the commercial production of eggs for human consumption. Breeding hens are not included.

**End-of-lay hens:** means laying hens at the end of their productive lives.

**Layer pullets:** means female birds of the species *Gallus gallus domesticus* raised for commercial layer production purposes from hatch until the onset of sexual maturity.

Article 7.Z.2.

**Scope**

This chapter provides recommendations for the *animal welfare* aspects of commercial laying hen production systems. It covers the production period from the arrival of *day-old birds* onto the pullet-rearing farm through to the removal of end-of-lay hens from the laying production facilities. Laying hens kept in village or backyard flocks and used to produce eggs for personal consumption are not included.

Commercial laying hen production systems involve the confinement of layer pullets and laying hens, the application of *biosecurity* and trade in eggs or pullets.

These recommendations address the welfare aspects of layer pullets or laying hens kept in cage or non-cage systems, whether indoors or outdoors.

Commercial layer pullet or laying hen production systems include:

1. Completely housed systems

Layer pullets or laying hens are completely confined in a poultry house, with or without mechanical environmental control.

2. Partially housed systems

Layer pullets or laying hens are kept in a poultry house with access to a designated outdoor area.

3. Completely outdoor systems

Layer pullets or laying hens are not confined inside a poultry house during the day but are confined in a designated outdoor area.

This chapter should be read in conjunction with Chapters 6.5., 7.1., 7.2., 7.3., 7.4., 7.5. and 7.6.

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Article 7.Z.3.

**Outcome-based criteria (or measurables) for the welfare of layer pullets and** **laying** **hens**

The welfare of layer pullets and laying hens should be assessed using outcome-based criteria or measurables, preferably animal-based measurables, as described in Article 7.1.4. Outcome-based criteria or measurables are particularly useful for evaluating compliance and improving *animal welfare*. Animal-based outcomes are usually the most sensitive measurables (e.g. mortality rate). However, resource and management-based outcomes can also have important applications (e.g. interpretation of mortality rate data may be informed by decisions made to euthanise). There is no one single measurable that addresses all aspects of *animal welfare*. The use of measurables and the appropriate thresholds should be adapted to the different situations in which layer pullets and laying hens are kept, also taking into account the genetics used, resources provided, and the design and management of the system. Animal-based criteria or measurables can be considered as tools to monitor and refine these factors.

Criteria (or measurables) that can be used at farm level include conditions such as skeletal and foot problems, diseaseand *infection* or *infestation* that can be assessed during routine or targeted *monitoring*, or at depopulation. It is recommended that target values or thresholds for *animal welfare* measurables be determined by taking into account current scientific knowledge and appropriate national, sectorial or regional data and recommendations for layer pullets or laying hens. Determining the age and stage of production at which problems are detected may help to determine the cause.

The following animal-based and outcome-based measurables, in alphabetical order in English, may be useful indicators of layer pullet or laying hen welfare:

1. Beak condition

Evaluation of beak condition provides useful information about the extent to which layer pullets and laying hens are able to engage in normal behaviour, such as foraging, feeding, drinking and preening [Dennis and Cheng, 2012; Vezzoli *et al*., 2015]. Tools for assessing beak condition have been developed and implemented in *animal welfare* assessment programmes [e.g. Kajlich *et al*., 2016].

2. Behaviour

The presence or absence of certain behaviours may indicate either good *animal welfare* or an *animal welfare* problem, such as fear, pain or sickness. Some behaviours may not be uniquely indicative of one type of problem; they may be exhibited for a variety of reasons. *Gallus gallus domesticus* has evolved behaviours that ~~they~~ it is ~~are~~ motivated to perform, and~~,~~ a good understanding of ~~their~~ its normal behaviour [Nicol, 2015], including ~~their~~ its social interactions [Estevez *et al.*, 2007; Rodríguez-Aurrekoetxea A. and Estevez I., 2014], is required for appropriate management and decision-making. Opportunities to display these behaviours are influenced by the physical and social environment [Widowski *et al*., 2016; Lay *et al*, 2011; O'Connor *et al*, 2011].

*a)* Dust bathing

Dust bathing is a ~~complex~~ motivated behaviour providing body maintenance benefits. During dust bathing, layer pullets and laying hens ~~remove~~ ~~work~~ work loose substrate material, such as litter, through their feathers. This behaviour helps remove stale lipids [van Liere and Bokma, 1987], which contributes to the maintenance of plumage condition. ~~This~~ Good plumage condition helps to regulate body temperature and protect against skin injury. Reduced dust bathing behaviour in the *flock* may indicate problems with substrate or range quality, such as the substrate or ground being wet or not friable [Olson and Keeling, 2005; Van Liere and Bokma, 1987]. The ~~demonstration~~ performance of complete sequences of dust bathing may be associated with positive affect [Widowski and Duncan, 2000].

*b)* Fear behaviour

Fearful layer pullets and laying hens show high reactivity to various stimuli [Jones, 1987; Zeltner and Hirt, 2008] and this may result in traumatic injuries or suffocation if the layer pullets or laying hens pile on top of one another. Fearful layer pullets and laying hens be less productive [Barnett *et al.*, 1992] and more prone to injurious feather pecking behaviour [de Haas *et al.*, 2014]. Methods have been developed for evaluating fearfulness [Forkman *et al.*, 2007], for example by observing layer pullet and laying hen behaviour in response to novel objects or when people, including *animal handlers,* walk through the pullet and hen areas of the poultry house [Jones, 1996; Waiblinger *et al* 2006].

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*c)* Feeding and drinking behaviour

Changes in feeding or drinking behaviour ~~can~~ ~~may~~ may indicate management problems, including inadequate spacesfor, or inappropriate placement of, feeders or drinkers, dietary imbalances, poor *feed* or water quality, or *feed* contamination [Garner *et al.*, 2012; Thogerson *et al.*, 2009a; Thogerson *et al.*, 2009b]. *Feed* and water intake is often reduced when pullets or hens are ill. *Feed* or water intake may also change as a result of heat stress [Lara L. J. & Rostagno ~~M. H.~~, 2013; Lin H. *et al.*, 2006] or cold stress [Alves *et al.*, 2012] ~~stress~~.

*d)* Foraging behaviour

Foraging is a motivated behaviour [de Jong *et al.*, 2007, Nicol *et al.,* 2011]. Foraging is the act of searching for ~~food~~*feed*, typically by pecking or scratching the substrate. Reduced foraging activity may suggest problems with substrate quality or the presence of conditions that decrease foraging ~~ability~~ opportunity [Appleby *et al.*, 2004; Lay *et al.*, 2011; Weeks and Nicol, 2006]. When in the presence of an adequate substrate, laying hens spend a large amount of time foraging even when ~~food~~ *feed* is readily accessible [Weeks and Nicol, 2006].

*e)* Injurious feather pecking and cannibalism

Injurious feather pecking can result in significant feather loss and may lead to cannibalism. Cannibalism is the tearing of the flesh of another layer pullet or laying hen, and ~~can~~ may result in severe injury, secondary *infection* or death. These behaviours can have multifactorial causes and be difficult to control [Nicol, 2018; Hartcher, 2016; Estevez, 2015; Nicol *et al.*, 2013; Rodenburg, 2013; Lambton, 2013; Newberry, 2004].

*f)* Locomotory and comfort behaviours

Layer pullets and laying hens may display a variety of locomotory and comfort behaviours, including walking, running, leaping, turning, stretching legs and wings, wing flapping, feather ruffling, tail wagging~~,~~ and preening [Bracke and Hopster, 2006; Harthcher and Jones, 2017; Dawkins and Hardie, 1989; Shipov *et al.*, 2010; Norgaard, 1990]. Some of these behaviours have been shown to be important for skeletal, body and plumage development and maintenance. For example, walking and wing movements contribute to improved leg and wing bone strength [Knowles and Broom, 1990], and preening helps remove stale lipids from the skin [Vezzoli *et al.*, 2015] and keeps the feathers flexible and intact [Shawkey *et al.*, 2003].

*g)* Nesting

Nesting is a motivated behaviour that includes nest site selection, nest formation and egg laying [Cooper and Albentosa, 2003; Weeks and Nicol, 2006; Cronin *et al.*, 2012; Yue and Duncan, 2003]. Uneven nest box utilisation, delayed oviposition, increased pacing and egg laying outside the nest may be indicative of problems with environmental or social ~~behavioura~~l factors such as access to, or the suitability of nesting sites or disturbance by other layer pullets and laying hens [Cronin *et al.*, 2012; Cooper and Appleby, 1996; Gunnarsson *et al.*, 1999; Yue and Duncan, 2003; Widowski *et al.*, 2013].

*h)* Perching

Perching is a motivated behaviour. Layer pullets and laying hens may seek elevation during the day; however, the motivation to seek elevation is particularly strong at night when pullets and hens select a site for resting or sleeping [EFSA, 2015]. Reduced perching behaviour in the *flock* may indicate problems with environmental factors, such as inadequate perch or poor space design, injuries or pullet rearing experience [Janczak and Riber, 2015; Gunnarsson *et al.*, 1999].

*i)* Resting and sleeping

Sleep is an adaptive state that allows animals to recover from daily stress, conserve energy and consolidate memory [Siegel, 2009]. Layer pullets and laying hens display synchronised resting and sleeping behaviours, which can be disrupted by light intensity, photoperiod, environmental or social factors [Malleau *et al*., 2007; Alvino *et al.*, 2009].

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*~~i~~j)* Social behaviour

Layer p~~P~~ullets and laying hens are social and engage in synchronised behaviour [Olsson *et al.*, 2002; Olsson and Keeling, 2005]. Social behaviour may differ according to the characteristics of the social environment [Estevez *et al*., 2002; 2007]. Problems in social behaviour can be assessed using scoring systems for measuring the degree of damage caused by aggression and competition for resources [Estevez *et al*., 2002; Blatchford *et al.*, 2016].

*~~j~~k)* Spatial distribution

Uneven spatial distribution of layer pullets and laying hens may indicate fear reactions, thermal discomfort or, uneven availability or use of resources such as light, *feed* or water, shelter, nesting areas or comfortable resting locations [Rodríguez-Aurrekoetxea and Estevez, 2016; Bright and Johnson, 2011].

*~~k~~l)* Thermoregulatory behaviour

Prolonged or excessive panting and wing spreading are observed during heat stress [Mack, 2013; Lara and Rostagno, 2013]. Indicators of cold stress include feather ruffling, rigid posture, trembling, huddling and distress vocalisations.

*~~l~~m)* Vocalisation

Vocalisation ~~can~~ may indicate emotional states, both positive and negative. A good understanding of *flock* vocalisations and their causes is useful for good *flock* management ~~good~~ *~~animal welfare~~* [Zimmerman *et al.*, 2000; Bright, 2008; Koshiba *et al*., 2013].

3. Body condition

Poor body condition ~~is reflective~~ may indicate ~~of~~ *animal welfare* problems for individual layer pullets and laying hens. At *flock* level, uneven body condition may be an indicator of poor *animal welfare*. Body condition can be evaluated using on-farm sampling methods for body weight or body condition scores [Gregory and Robins, 1998; Craig and Muir, 1996, Elson and Croxall, 2006; Keeling *et al.*, 2003]. The choice of sampling methods should take into account the fact that feather cover can mask actual body condition.

4. Eye conditions

Conjunctivitis ~~can~~ may indicate disease or the presence of irritants such as dust and ammonia. High ammonia levels ~~can~~ may also cause corneal burns and eventual blindness. Abnormal eye development ~~can may~~ may be associated with very low light intensity (<5 lux) [Jenkins *et al.*, 1979; Lewis and Gous, 2009; Prescott *et al.*, 2003].

5. Foot problems

Hyperkeratosis, bumblefoot, contact dermatitis, excessive claw growth, broken claws and toe injuries are painful conditions associated with, amongst other things, inappropriate flooring, poorly designed perches, poorly maintained substrate [EFSA, 2005; Lay *et al.*, 2011; Abrahamsson and Tauson, 1995; Tauson and Abrahamson, 1996; Abrahamsson and Tauson, 1997] and inadequate maintenance ~~of aspects~~ of the production system.

If severe, the foot and hock problems may contribute to locomotion problems and lead to secondary *infections.* Scoring systems for foot problems have been developed [Blatchford *et al.*, 2016].

6. Incidence of diseases, infections, infestations and metabolic disorders ~~and infestations~~

Ill-health, regardless of the cause, is an *animal welfare* concern~~,~~ and may be exacerbated by poor environmental or husbandry management.

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7. Injury rate and severity

Injuries are associated with pain and risk of *infection*. They ~~can~~ may be a consequence of the actions of other layer pullets and laying hens (e.g. scratches, feather loss or wounding), management (e.g. nutritional deficits leading to skeletal problems), environmental conditions (e.g. ~~fractures and keel bone deformation~~ poor flooring leading to foot injury), genetics used or human intervention (e.g. during handling and catching). It is important to assess both the rate and severity of injuries.

8. Mortality, culling and morbidity rates

Daily, weekly and cumulative mortality, culling and morbidity rates should be within expected ranges. Any unforeseen increase in these rates may reflect an *animal welfare* problem. Recording and evaluating causes of morbidity and mortality can be useful aids in diagnosing and remediating *animal welfare* problems.

9. Performance ~~indicators~~

Daily, weekly and cumulative performance should be within expected ranges. Any unforeseen reduction in these rates may reflect an *animal welfare* problem. Types of measure~~s~~ that can be used include:

*a)* pullet growth rate, which measures average daily mass gain per pulletand *flock* uniformity;

*b)* pullet feed conversion, which measures the quantity of *feed* consumed by a *flock* relative to the total live mass produced, expressed as the mass of *feed* consumed per unit of body mass;

*c)* hen feed conversion, which measures quantity of *feed* consumed by a *flock* relative to the unit of egg production;

*d)* egg production, which measures the number, ~~and~~ size and weight of eggs per hen housed;

*e)* egg quality and downgrades, which can be measured by, for example, grade percentage, shell strength, Haugh units, abnormalities and mis-laid or floor eggs.

10. Plumage condition

Evaluation of plumage condition provides useful information about aspects of *animal welfare* in terms of feather pecking and cannibalism, ability to thermoregulate, illness, and protection from injury [Rodriguez-Aurrekoetxea and Estevez, 2016; Drake *et al.*, 2010]. Dirty plumage may be associated with illness, environmental conditions or the layer pullet and laying hen housing system. Plumage cover and cleanliness scoring systems have been developed for these purposes [Blokhuis, 2007; Blatchford *et al.*, 2016].

11. Water and feed consumption

Monitoring and evaluating daily water and *feed* consumption is a useful tool which may indicate thermal stress, disease*, infection* or *infestation* and other conditions impacting *animal welfare* ~~conditions~~, taking into consideration ambient temperature, relative humidity and other related factors. Changes in intake, crowding at feeders and drinkers and wet substrate may be associated with problems with the quality or supply of water, or *feed*.

Article 7.Z.4.

**Recommendations** for layer pullets and laying hens

Ensuring good welfare of layer pullets and laying hens is contingent upon several management factors, such as system design, environmental management practices, and animal management practices including responsible husbandry and provision of appropriate care, and the genetics used. Serious problems ~~can~~ may arise in any system if one or more of these ~~elements~~ factors are lacking. ~~Although pullets and hens can adapt to a range of thermal environments, particularly if appropriate breeds and housing are used for the anticipated conditions, sudden fluctuations in temperature can cause heat or cold stress.~~

Articles 7.Z.5. to 7.Z.29. provide recommendations for layer pullets and laying hens.

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Each recommendation includes a list of relevant outcome-based criteria or measurables derived from Article 7.Z.3. and when appropriate other criteria or measurables. The suitability of some of these criteria or measurables should be determined in accordance with the system in which the layer pullets and laying hens are housed.

Article 7.Z.5.

**Location, design, construction and equipment of establishments**

The location of layer pullet and laying hen *establishments* should be safe from the effects of fires and floods and other natural disasters to the extent practicable. In addition, *establishments* should be located or designed to avoid or minimise disease risks and exposure of layer pullets and laying hens to chemical and physical contaminants, noise and adverse climatic conditions.

Good welfare outcomes for layer pullets and laying hens can be achieved in a range of housing systems. Houses, outdoor areas and accessible equipment should be designed after considering the opportunities for layer pullets and laying hens to perform motivated behaviours, as well as health, environmental factors, and animal management capability. They should also be maintained to avoid injury or discomfort. Layer p~~P~~ullet and laying hen houses should be constructed with materials, electrical and fuel installations that minimise the risk of fire and other hazards and are easy to clean and maintain. Producers should have a maintenance programme in place, including record-keeping for all equipmentand contingency plans to addressfailures that could jeopardise the welfare of layer pullets and laying hens ~~welfare~~.

Outcome-based measurables include: body condition~~,~~ ~~culling and morbidity rates~~, dust bathing, fear behaviour, feeding and drinking behaviour, foot problems, foraging behaviour, incidence of diseases, *infections* and *infestations* and metabolic disorders, injury rates and severity, locomotory and comfort behaviours, ~~mortality rates~~, mortality, culling and morbidity rates, nesting, perching, performance ~~indicators~~, plumage condition, resting and sleeping, social behaviour and spatial distribution, thermoregulatory behaviour and vocalisations.

Article 7.Z.6.

**Matching the layer pullets and laying hens with the housing and production system**

*Animal welfare* and health considerations should balance any decisions on performance when choosing the genetics to be used for a particular location, housing and production system. The pullet rearing system should pre-adapt the bird for the intended production system [Aerni *et al.*, 2005].

Outcome-based measurables include: dust bathing, feeding and drinking behaviours, foraging behaviour, incidence ofdiseases, *infections*, ~~and~~ *infestations* and metabolic disorders, injurious feather pecking and cannibalism, injury rate and severity, locomotory and comfort behaviours, mortality ~~rate~~, culling and morbidity rates, nesting, perching, performance ~~indicators~~, plumage condition, resting and sleeping, social behaviour, and spatial distribution.

Article 7.Z.7.

**Space allowance**

Layer pullets and laying hens should be housed with a space allowance that allows them to have adequate access to resources and to adopt normal postures. Providing sufficient space for the expression of locomotory and comfort behaviours that contribute to good musculoskeletal health and plumage condition is desirable. Problems with space allowance may increase stress and the occurrence of injuries.

The following factors, in alphabetical order in English, should be considered when determining space allowance:

‒ age and ~~mass~~ weight of layer pullets and laying hens,

‒ ambient conditions,

‒ *biosecurity* strategy,

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‒ equipment selection,

‒ feed and watering systems,

‒ flooring substrate,

‒ genetics,

‒ housing design,

‒ management capabilities,

‒ production system,

‒ usable space,

‒ ventilation.

Outcome-based measurables include: dust bathing, feeding and drinking behaviour, foraging behaviour, incidence of diseases, *infections*, *infestations* and metabolic disorders, injurious feather pecking and cannibalism, *~~infections~~* ~~and~~ *~~infestations~~*~~,~~ injury rate and severity, locomotory and comfort behaviours, mortality rate, culling and morbidity rates, nesting, perching, performance ~~indicators~~, plumage condition, resting and sleeping, social behaviour, and spatial distribution.

Article 7.Z.8.

**Nutrition**

Layer pullets and laying hens should ~~always~~ be fed a diet appropriate to their age, production stage and genetics. The form of the *feed* should be acceptable to the layer pullets and laying hens and contain adequate nutrients to meet requirements for good *animal welfare* and health. *Feed* and water should be free from contaminants, debris and microorganisms or other potential *hazards*.

The feeding and watering systems should be inspected regularly and cleaned as needed, to prevent the growth of hazardous microorganisms.

Layer pullets and laying hens should be provided with adequate access to *feed* on a daily basis. Water should be continuously available except under veterinary advice. Special provisions should be made to enable newly hatched layerpullets to access appropriate *feed* and water.

Outcome-based measurables include: body condition, foraging behaviour, incidence of diseases, *infections*, i*nfestations* and metabolic disorders, ~~injurious feather pecking, injury rate and severity,~~ ~~metabolic disorders,~~ mortality, culling and morbidity rates, performance, plumage condition, vocalisations and water and *feed* consumption.

Article 7.Z.9.

**Flooring**

The slope, design and construction of the floors should provide adequate support for the locomotion of layer pullets and laying hens, prevent injuries and entrapments, ~~ensure~~ promote good health and allow the performance of ~~normal~~ behaviours, such as comfort and locomotory behaviours. Changes of flooring types from pullet to hen housing should be avoided. Manure contamination from other layer pullets and laying hens within the house should be minimised through appropriate floor design and other elements of system design. The flooring should be easy to clean and disinfect.

When ~~litter~~ substrate is provided, it should allow the performance of behaviours, such as comfort and locomotory behaviours and be managed to remain dry and friable, and adequately treated or replaced when required to prevent disease and minimise any detrimental effects on *animal welfare*.

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Outcome-based measurables include: dust bathing, foot problems, foraging behaviour, incidence of diseases, *infections*,~~and~~ *infestations* and metabolic disorders, injurious feather pecking, injury rate and severity, locomotory and comfort behaviours, performance, plumage condition and resting and sleeping.

Article 7.Z.10.

**Dust bathing areas**

Access to friable, dry substrate to encourage dust bathing is desirable. When provided, dust bathing areas should be designed and positioned to encourage dust bathing, allow synchronised behaviour, prevent undue competition and not cause damage or injuries. Dust bathing areas should be easy to inspect and maintain [Weeks and Nicol, 2006].

Outcome-based measurables include: dust bathing, incidence of diseases, *infections*,~~and~~ *infestations* and metabolic disorders*,* injurious feather pecking and cannibalism, injury rate and severity, plumage condition and, spatial distribution.

Article 7.Z.11.

**Foraging areas**

Access to substrate that encourages foraging behaviour ~~activity~~ is desirable. When provided, foraging areas should be designed and positioned to encourage synchronised behaviour, prevent undue competition and not cause damage or injuries. Foraging areas should be easy to inspect and maintain.

Outcome-based measurables include: foraging behaviour, incidence of diseases, *infections*,~~and~~ *infestations* and metabolic disorders*,* injurious feather pecking and cannibalism, injury rate and severity and spatial distribution.

Article 7.Z.12.

**Nesting areas**

Access to nesting areas is desirable. When provided nesting areas should be built of suitable materials, and designed and positioned to encourage nesting, prevent undue competition and not cause damage or injuries. Nesting areas should be easy to inspect, clean and maintain.

Outcome-based measurables include: incidence of diseases, *infections*,~~and~~ *infestations* and metabolic disorders*,* injurious feather pecking and cannibalism, injury rate and severity, nesting, performance (mis-laid or floor eggs), and spatial distribution.

Article 7.Z.13.

**Perches**

Access to perches is desirable. When provided, perches should be built of suitable materials, designed, elevated and positioned to encourage perching by all layer pullets and laying hens, prevent undue competition, minimise keel bone deformation, foot problems or other injuries, and to ensure stability during perching. In the absence of designated perches, other structures such as platforms, grids or slats that are perceived by the layer pullets and laying hens as elevated and that do not cause damage or injuries, may be a suitable alternative. When provided, perches or their alternatives should be made available from an early age, be easy to clean and maintain, and be positioned to minimise faecal fouling [Hester, 2014; EFSA, 2015].

Outcome-based measurables include: foot problems, injurious feather pecking and cannibalism, Incidence of diseases, *infections*, *infestations* and metabolic disorders, injury rate and severity, perching, plumage condition, resting and sleeping and spatial distribution.

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Article 7.Z.14.

**Outdoor areas**

Layer pullets and laying hens may be given access to outdoor areas when they have sufficient feather cover and can range safely. Where layer pullets and laying hens are partially housed, there should be sufficient appropriately designed openings to allow them to leave and re-enter the poultry house freely.

Management of outdoor areas is important. Land and pasture management measures should be taken to reduce the risk of layer pullets and laying hens becoming infected by pathogenic agents or infested by parasites or being injured. This may include limiting the stocking density or using several pieces of land consecutively in rotation.

Outdoor areas should be located on well-drained ground and managed to minimise stagnant water and mud. The outdoor area should be able to contain the layer pullets and laying hens and prevent them from escaping. Outdoor areas should be designed, built and maintained to allow layer pullets and laying hens to feel safe outdoors and to encourage them to utilise the range optimally, while mitigating predation, disease risks, and adverse climatic conditions [Gilani *et al.*, 2014; Hegelund *et al.*, 2005; Nagle and Glatz, 2012]. Layer p~~P~~ullets and laying hens should be habituated early to the outdoor area [Rodriguez–Aurrekoetxea and Estevez, 2016]. Outdoor areas should be free from harmful plants and contaminants.

Outcome-based measurables include: fear behaviour, foot problems, foraging behaviour, incidence of diseases,*infections*,~~and~~ *infestations* and metabolic disorders, injury rate and severity, locomotory and comfort behaviours, mortality, culling and morbidity ~~and~~ ~~mortality~~ rates, performance, plumage condition, social behaviour, spatial distribution, thermoregulatory behaviour and vocalisation.

Article 7.Z.15.

**Thermal environment**

Thermal conditions for layer pullets and laying hens should be maintained within a range that is appropriate for their stage of life and the genetics used; extreme~~s~~ heat, humidity and cold should be avoided. A heat index can assist in identifying the thermal comfort zones for layer pullets and laying hens at varying temperatures, air velocities and relative humidity levels [Xin and Harmon, 1998], and can be found in management guidelines provided by laying hen genetics companies.

Although layer pullets and laying hens can adapt to a range of thermal environments, particularly if appropriate breeds and housing are used for the anticipated conditions, sudden fluctuations in temperature can cause heat or cold stress.

When environmental conditions move outside of these zones, strategies should be used to mitigate the adverse effects on the layer pullets and laying hens. These may include adjusting air speed, provision of heat or evaporative cooling [Yahav, 2009].

The thermal environment should be monitored regularly so that ~~failure of~~ problems with the system ~~can~~ be detected and corrected before they cause ~~an~~ an *animal welfare* problem.

Outcome-based measurables include: mortality, culling and morbidity ~~rate, mortality~~ rates, performance, spatial distribution, temperature and humidity, thermoregulatory behaviours and water and *feed* consumption.

Article 7.Z.16.

**Air quality**

Ventilation, housing, space allowance and manure management can affect air quality. Actions are required to maintain air quality at levels required for good *animal welfare*, including the removal or mitigation of noxious gases such as carbon dioxide and ammonia, dust and excess moisture in the environment.

Ammonia concentrations should not routinely exceed 25 ppm at layer pullet and laying hen level [David *et al.*, 2015; Miles *et al.*, 2006; Olanrewaiu, 2007].

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Dust levels should be kept to a minimum [David *et al.*, 2015].

Outcome-based measurables include: ammonia level, carbon dioxide level, dust level, eye conditions, incidence of diseases, *infections*, *infestations* and metabolic disorders, morbidity, culling and mortality rates, plumage condition, performance ~~indicators~~, temperature, ~~and~~ humidity and thermoregulatory behaviours.

Article 7.Z.17.

**Lighting**

There should be an adequate period of continuous light. The light intensity during the light period should be sufficient and homogeneously distributed to promote normal development, to allow layer pullets and laying hens to find *feed* and water, to stimulate activity, to stimulate onset of lay, to minimise the likelihood of injurious feather pecking and cannibalism, and to allow adequate inspection [Prescott *et al.*, 2003; Prescott and Wathes, 1999; Green *et al.*, 2000].

There should also be an adequate period of darkness during each 24-hour cycle to allow layer pullets and laying hens to rest and sleep, to reduce stress and promote circadian rhythms [Malleau *et al*., 2007].

Changes in lighting should occur gradually or in a step-wise fashion, as needed, except if ~~during induced~~ moulting is practised, during which ~~when~~ rapid adjustments to lighting should be considered [Tanaka and Hurnik, 1990; Kristenson, 2008].

Outcome-based measurables include: eye conditions, injurious feather pecking and cannibalism, injury rate and severity, locomotory and comfort behaviour, nesting, perching, performance, plumage condition, resting and sleeping and spatial distribution.

Article 7.Z.18.

**Noise**

Although layer pullets and laying hens can adapt to different levels and types of noise, exposure of layer pullets and laying hens to unfamiliar noises, particularly those that are sudden or loud, should be minimised to prevent stress and fear reactions, such as piling up [Bright and Johnson, 2001]. Ventilation fans, machinery and other indoor or outdoor equipment should be constructed, placed, operated and maintained in such a wayas to causes the least possible amount of noise [Chloupek *et al.*, 2009].

Location of *establishments* should, where possible, consider existing local sources of noise. Strategies should be implemented to acclimatise the layer pullets and laying hens to the conditions [Candland *et al.*, 1963; Morris, 2009].

Outcome-based measurables include: fear behaviours, injury rate and severity, morbidity, culling and mortality rates, performance ~~indicators~~, resting and sleeping, and vocalisation.

Article 7.Z.19.

**Prevention and control of** **injurious feather pecking and cannibalism**

Injurious feather pecking and cannibalism are challenges in layer pullet and laying hen production systems.

Management methods that may reduce the risk of occurrence include:

‒ adapting the diet and form of *feed* during rearing and lay [Lambton *et al.*, 2010],

‒ choosing genetics associated with a low propensity for injurious feather pecking [Craig and Muir, 1996; Kjaer and Hocking, 2004],

‒ increasing age at onset of lay [Pötzsch, 2001],

‒ increasing space allowance during rearing [Jung and Knierim, 2018],

‒ managing light ~~in~~ during rearing and lay [Nicol *et al.*, 2013; van Niekerk *et al.,* 2013],

‒ minimising fear-related stimuli [Uitdehaag K. A. *et al.*, 2009],

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‒ providing elevated perches during rearing and lay [Green *et al.*, 2000],

‒ providingforaging or other manipulable materials during rearing and lay [Huber-Eicher and Wechsler, 1998; de Jong *et al.*, 2010; Daigle *et al.*, 2014; Dixon *et al.*, 2010; Nicol, 2018],

‒ reducing group size during rearing and lay [Bilcik and Keeling, 1999].

Management methods should be implemented, where applicable, and in the event of injury affected layer pullets and laying hens should be promptly removed and treated or euthanised.

If these management methods are unsuccessful, partial beak removal [Gentle *et al.*, 1997] may be considered as a final course of action.

Outcome-based measurables include: foraging behaviour, injurious feather pecking and cannibalism, injury rate and severity, mortality, ~~and~~ culling and morbidity rates, plumage condition, and vocalisation.

Article 7.Z.20.

**Moulting**

Induced moulting ~~can~~ may lead to *animal welfare* problems if not well managed [Nicol *et al.,* 2017; Sariozkan *et al.,* 2016; Holt, 2003, Ricke, 2003, Webster, 2003]. When induced moulting is practised, methods that do not involve withdrawal of *feed* and are consistent with Article 7.Z.8. should be used. Laying hens should have access to lights and ~~to~~ water at all times [Anderson, 2015]. Only laying hens in good body condition and health should be moulted. During the moulting period, loss of body mass should not compromise the welfare of laying hens ~~welfare~~, including their welfare during the subsequent laying period. Total mortality and culling rates during the moulting period should not exceed normal variations in *flock* mortality and culling rates.

Outcome-based measurables include: body condition, feeding and drinking, foraging behaviour [Biggs *et al.*, 2004; Saiozkan *et al.*, 2016; Petek and Alpay, 2008], injurious feather pecking and cannibalism, injury rate and severity, ~~morbidity~~ ~~rate,~~ mortality, ~~and~~ culling and morbidity rates, performance, plumage condition and social behaviour.

Article 7.Z.21.

**Painful procedures**

Painful procedures should not be practised unless necessary and should be performed in such a way as to minimise any pain, distress and suffering. If used, partial beak removal should be carried out at the earliest age possible and care should be taken to remove the minimum amount of beak necessary using a method that minimises pain and controls bleeding. If management methods to control injurious feather pecking and cannibalism are not successful, therapeutic partial beak removal may be considered as a final course of action [Gentle *et al.*, 1991; Marchand-Forde *et al.*, 2008; Marchand-Forde *et al.*, 2010; McKeegan and Philbey, 2012; Freire *et al.*, 2011; Glatz *et al.*, 1998]. Partial beak removal at a mature age ~~can~~ may cause chronic pain. Dubbing, toe trimming and other mutilations should not be performed in layer pullets and laying hens.

Potential options for improving *animal welfare* in relation to these procedures include: ceasing the procedure, reducing or eliminating the need for the painful procedures through management strategies, using genetics that do not require the painful procedures, or replacing the current procedures with less painful or invasive alternatives.

Outcome-based measurables include: beak condition, body condition, feeding and drinking behaviour, foraging behaviour, injurious feather pecking and cannibalism, locomotory and comfort behaviours, mortality, culling ~~rate,~~ and morbidity rates, performance, plumage condition and vocalisations.

Article 7.Z.22.

**Animal health management, preventive medicine and veterinary treatment**

*Animal handlers* responsible for the care of layer pullets and laying hens should have knowledge of normal layer pullet and laying hen behaviour, and be able to detect signs of ill-health or distress, such as a change in *feed* or water intake, reduced production, changes in behaviour and abnormalities in plumage condition, faeces or other physical features.

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If *animal handlers* are unable to identify the cause of disease, ill-health or distress, or are unable to correct these, or if they suspect the presence of a *notifiable* *disease*, they should seek advice from a *veterinarian* or other qualified advisers. Veterinary treatments should be prescribed by a *veterinarian*.

There should be an effective programme for the prevention of diseases that is consistent with the programmes established by *Veterinary Services* as appropriate, and which includes record-keeping.

*Vaccinations* and treatments should be administered by personnel skilled in the procedures and with consideration for the welfare of the layer pullets and laying hens.

Sick or injured layer pullets and laying hens should be placed in a hospital area for observation and treatment, or euthanised in accordance with Chapter 7.6. as soon as possible.

Outcome-based measurables include: body condition, incidence of diseases, *infections*, ~~metabolic disorders~~ ~~and ,~~*infestations* and metabolic disorders, injury rate and severity, mortality ~~morbidity~~, culling ~~rate,~~ ~~and~~ ~~mortality~~ and morbidity rates and performance.

Article 7.Z.23.

**Biosecurity plans**

*Biosecurity plans* should be designed, implemented, and reviewed regularly, commensurate with the best possible layer pullet and laying henhealth status. The *biosecurity plan* should be sufficiently robust to be effective in addressing the current disease *risks* that are specific to each epidemiological group of layer pullets and laying hens and in accordance with relevant recommendations in the *Terrestrial Code*.

These programmes should address the control of the major routes for *infection* and *infestation* such as:

‒ aerosols,

‒ direct transmission from other *poultry*, domestic *animals* and *wildlife* and humans,

‒ *feed*,

‒ fomites, such as equipment, facilities and *vehicles*,

‒ *vectors* (e.g. arthropods and rodents),

‒ water supply.

Partially restocking (back filling), in a response to catastrophe or incomplete *flock* placement, should only be practised with due consideration to *biosecurity* and in a manner that prevents co-mingling of *flocks*.

Outcome-based measurables include: mortality, culling and morbidity rates, incidence of diseases, *infections*, *infestations* and metabolic disorders~~, mortality rate~~~~,~~ and performance ~~indicators~~.

Article 7.Z.24.

**Euthanasia of individual layer pullets or laying hens**

Individual layer pullets or laying hens may be euthanised. Techniques used should be performed, in accordance with Chapter 7.6.

Reasons for euthanasia ~~may~~ include:

‒ bone fractures or other injuries,

‒ diagnostic purposes,

‒ disaster management,

~~‒~~ ~~diagnostic purposes,~~

‒ emaciation,

‒ rapid deterioration of a medical condition for which treatment has been unsuccessful,

~~‒~~ ~~bone fractures or other injuries,~~

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~~‒~~ ~~emaciation,~~

‒ severe pain that cannot be alleviated.

The decision to euthanise a layer pullet or a laying hen ~~an animal~~ and the procedure itself should be undertaken by a competent person. The *establishment* should have documented procedures and appropriate equipment.

Outcome-based measurables include: injury rate and severity.

Article 7.Z.25.

**Depopulation of layer pullet and laying hen facilities**

This article refers to the removal of *flocks* of layer pullets and laying hens from facilities for whatever reason and should be read in conjunction with Article 7.Z.24.

The period of *feed* withdrawal prior to depopulation of layer pullets and laying hens should be minimised.

Water should be available up to the time of depopulation.

Layer pullets and laying hens that are not fit for *loading* or transport should be euthanised. Laying ~~H~~hens with poor plumage condition are at risk of thermal stress and injury during transport [Broom, 1990; Fleming *et al.*, 2006; Gregory and Wilkins 1989; Newberry *et al.,* 1999; Webster, 2004; Whitehead and Fleming, 2000]. On-farm *killing* should be performed in accordance with Chapter 7.6.

Catching should be carried out by competent *animal handlers* in accordance with Article 7.Z.28. and every attempt should be made to minimise stress, fear reactions and injuries. If a layer pullet or laying hen is injured during catching, it should be euthanised.

Layer pullets and laying hens should be handled and placed into the transport *container* in accordance with Chapter 7.3.

Catching should preferably be carried out under dim or blue light to calm the layer pullets and laying hens.

Catching should be scheduled to minimise the transport time as well as climatic stress during catching, transport and holding.

The stocking density in transport *containers* should be in accordance with Chapters 7.2., 7.3. and 7.4.

Outcome-based measurables include: fear behaviour, injury rate and severity, mortality, culling and morbidity rates ~~at depopulation and on arrival at the destination~~, spatial distribution, and vocalisation.

Article 7.Z.26.

**Contingency plans**

Layer pullet and laying henproducers should have contingency plans to minimise and mitigate the consequences of natural disasters, disease *outbreaks* and the failure of mechanical equipment. Planning should include a fire safety plan, evacuation procedures and, where relevant, include the provision, maintenance and testing of backup generators and fail-safe alarm devices to detect malfunctions, access to maintenance providers, alternative heating or cooling arrangements, ability to store water on farm, access to water cartage services, adequate on-farm storage of *feed,* ~~an~~ alternative *feed* supply and a plan for managing ventilation emergencies.

The contingency plans should be consistent with national programmes established or recommended by *Veterinary Services*. ~~Humane~~ ~~e~~Emergency *killing* procedures should be a part of the plan and be in accordance with the methods recommended in Chapter 7.6.

Outcome-based measurables include: mortality, culling~~,~~ and morbidity ~~and~~ ~~mortality~~ rates.

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Article 7.Z.27.

**Competencies of personnel**

*Animal handlers* should have the ability, knowledge and competencies necessary to maintain the welfare and health of the layer pullets and laying hens.

All people responsible for layer pullets and laying hens should have received appropriate training and be able to demonstrate that they are competent to carry out their responsibilities, which should include the assessment of layer pullet and laying hen behaviour, handling techniques, *euthanasia* and *killing* procedures, implementation of *biosecurity*, and the detection of general signs of diseases and indicators of poor *animal welfare* and procedures for their alleviation.

Outcome-based measurables include: body condition, ~~culling and morbidity rate,~~ fear behaviour, incidence of diseases, *infections*, *infestations* and metabolic disorders, locomotory and comfort behaviours, performance, mortality, culling and morbidity rates, spatial distribution and vocalisation.

Article 7.Z.28.

**Inspection and handling**

Layer pullets and laying hens, and the facilities and equipment within their poultry house or in outdoor facilities should be inspected at least daily. Inspection should have the following objectives:

‒ to collect and remove dead layer pullets and laying hens and dispose of them in accordance with Chapter 4.13.;

‒ to identify sick or injured layer pullets and laying hens and treat or euthanise them in accordance with Article 7.Z.24.;

‒ to detect and correct any *animal welfare* or health problems in the *flock*; and

‒ to detect and correct malfunctioning equipment and otherproblems with the facility.

Inspections should be done in such a way that layer pullets and laying hens are not unnecessarily disturbed, for example *animal handlers* should move quietly and slowly through the *flock*.

When layer pullets and laying hens are handled, particularly when placed into or removed from the poultry house or outdoor facilities, they should not be injured, and should be held in a manner that minimises fear and stress [Gregory & Wilkins, 1989; Gross & Siegel, 2007; Kannan & Mench, 1996]. The distance over which layer pullets and laying hens are carried should be minimised. Laying hens are prone to bone fractures when not handled properly.

Outcome-based measurables include: ~~culling and morbidity rates,~~ fear behaviour, injury rate and severity, mortality, culling and morbidity rates, performance, spatial distribution and vocalisation.

Article 7.Z.29.

**Protection from predators**

Layer pullets and laying hens should be protected from predators in indoor and outdoor areas. All production systems should be designed and maintained to prevent access by predators and *wild* birds.

Outcome-based measurables include: ~~culling and morbidity rates,~~ fear behaviour, injury rate and severity, locomotory and comfort behaviours, mortality, culling and morbidity rates, performance, spatial distribution and vocalisation.

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Annex 11 (contd)

**References**

Abrahamsson P. & Tauson R. (1995). Aviary systems and conventional cages for laying hens. Effects on production, egg quality, health and bird location in three hybrids. Acta Agriculturae Scandinavica Section A Animal Science 45:191-203.

Abrahamsson P. & Tauson R. (1997). Effects of group size on performance health and birds' use of facilities in furnished cages for laying hens. Acta Agriculturae Scandinavica, Section A Animal Science 47:254-260.

Aerni V, Brinkhof,M.W.G., Wechsler, B., Oester, H. & Fröhlich, E. (2005). Productivity and mortality of laying hens in aviaries: a systematic review. World’s Poultry Science Journal 61(1):130-42.

Alves, F.M.S., Felix G.A., Almeida Paz, I.C.L., Nääs, I.A., Souza, G.M., Caldara, F.R. & Garcia R.G. (2012). Impact of Exposure to Cold on Layer Production, Brazilian Journal of Poultry Science, Jul - Sept 2012, v.14, n.3, 159-232 ISSN 1516-635X.

Alvino G.M., Blatchford, R.A., Archer, G.S. & Mench, J.A., (2009). Light intensity during rearing affects the behavioural synchrony and resting patterns of broiler chickens. British Poultry Science 50:275-283.

Anderson, K.E. (2015). Induced Molting of Commercial Layers. http://content.ces. ncsu.edu/print/induced-molting-of-commercial-layers

Appleby, M. C., Mench, J. A. & Hughes B. O., (2004). Poultry behaviour and welfare Poultry behaviour and welfare. p x + 276 pp.

Barnett, J, Hemsworth, P., Newman, E., (1992). Fear of humans and its relationships with productivity in laying hens at commercial farms. British Poultry Science 33: 699-710. doi: 10.1080/00071669208417510.

Biggs P. E., Persia, M. E. Koelkebeck, K. W. &., Parsons C. M., (2004). Further Evaluation of Nonfeed Removal Methods for Molting Programs, Poultry Science 83:745–752.

Bilcik, B., Keeling L.J., (1999) Changes in feather condition in relation to feather pecking and aggressive behaviour in laying hens. British Poultry Science 40, 444-451.

Blatchford, R. A., Fulton, R. M. & Mench, J. A., (2016). The utilization of the Welfare Quality® assessment for determining laying hen condition across three housing systems. Poultry Science, 95, 154-163. 10.3382/ps/pev227.

Blokhuis, H.J. (1983). The relevance of sleep in poultry. World’s Poultry Science Journal 39:33-37.

Blokhuis, H. J., Van Niekerk, T. F., Bessei, W., Elson, A., Guemene, D., Kjaer, J. B., Levrino, G. a. M., Nicol, C. J., Tauson, R., Weeks, C. A. & De Weerd, H. a. V., (2007). The LayWel project: welfare implications of changes in production systems for laying hens. Worlds Poultry Science Journal, 63, 101-114. Doi 10.1079/Wps2006132.

Bracke, M.B.M. & Hopster, H. (2006). Assessing the importance of natural behaviour for animal welfare. Journal of Agricultural and Environmental Ethics 19:77-89.

Bright, A., (2008). Vocalisation and acoustic parameters of flock noise from feather pecking and non-feather pecking laying flocks. Poultry. Sci. 2008, 49, 241–249.

Bright A. & Johnson E.A. (2011). Smothering in commercial free-range laying hens: A preliminary investigation. Veterinary Record 168:512-513

Broom, D.M. (1990) Effects of handling and transport on laying hens. World’s Poultry Science Journal 6: 48-50.

Candland D.K., Nagy Z.M. & Conklyn D.H., (1963). Emotional behaviour in the domestic chicken (White Leghorn) as a function of age and developmental environment. Journal of Comparative and Physiological Psychology 56:1069-1073.

Chloupek, P., Voslarova, E., Chloupek, J., Bedanova, I. Pistekova, V. & Vecerek, V., (2009). Stress in Broiler Chickens Due to Acute Noise Exposure ACTA VET. BRNO 2009, 78: 93–98.

Annex 11 (contd)

Cooper, J. & M.J. Albentosa (2003). Behavioural Priorities of Laying Hens. Avian and Poultry Biology Reviews. 14. 127-149. 10.3184/147020603783637508.

Cooper, J. J. & Appleby, M. C. (1996). Individual variation in prelaying behaviour and the incidence of floor eggs. British Poultry Science, 37, 245-253.

Craig J.V. & Muir W.M. (1996). Group selection for adaptation to multiple-hen cages: beak-related mortality, feathering, and body weight responses. Poultry Science 75:294-302.

Cronin, G.M., Barnett, J.L. & Hemsworth, P.H. (2012). The importance of pre-laying behaviour and nest boxes for laying hen welfare: a review. Animal Production Science 52: 398-405.

Daigle, C. L., Rodenburg, T. B., Bolhuis, J. E., Swanson, J. C. & Siegford, J. M. (2014). Use of dynamic and rewarding environmental enrichment to alleviate feather pecking in non-cage laying hens. Applied Animal Behaviour Science, 161(0), pp. 75-85.

David, B., Mejdell, C., Michel, V., Lund, V. & Moe, R. O. (2015). Air Quality in Alternative Housing Systems may have an Impact on Laying Hen Welfare. Part II-Ammonia. Animals: an open access journal from MDPI, 5, 886-96. 10.3390/ani5030389

Dawkins, M. S. & Hardie, H. (1989). Space needs of laying hens British Poultry Science 30 Pages 413-416. Published online: 08 Nov 2007. <http://dx.doi.org/10.1080/00071668908417163>.

de Jong, I., Gunnink, H., Rommers J. & van Niekerk, T. (2010). Effect of substrate during early rearing of laying hens on the development of feather pecking behavior, Wageningen UR Livestock Research, rapport 333.

de Jong, I.C., Wolthuis-Fillerup, M. & Van Reenen, C.G. (2007). Strength of preference for dustbathing and foraging substrates in laying hens. Appl. Anim. Behav. Sci. 104, 24-36.

de Haas E.N. Bolhuis J. E.,.de Jong, I. C, Kemp, B., Janczak, A.M. & Rodenburgd, T. B (2010). Predicting feather damage in laying hens during the laying period. Is it the past or is it the present? Applied Animal Behaviour Science Volume 160, November 2014, Pages 75-85. <https://doi.org/10.1016/j.applanim.2014.08.009>

Dennis, R. L. & H. W. Cheng. (2012). Effects of different infrared beak treatment protocols on chicken welfare and physiology, Poultry Science, Volume 91, Issue 7, July 2012, Pages 1499–1505. <https://doi.org/10.3382/ps.2011-01651>

Dixon, L.M., Duncan, I.J.H. & Mason, G.J. (2010). The effects of four types of enrichment on feather-pecking behaviour in laying hens housed in barren environments. Animal Welfare 19:429-435

Drake, K. A., Donnelly, C. A. & Dawkins, M. S. (2010). ’Influence of rearing and lay risk factors on propensity for feather damage in laying hens’, Brit. Poultry Sci., 51, 725-733.

EFSA (2005) The welfare aspects of various systems of keeping laying hens. Report of the Scientific Panel on Animal Health and Welfare. EFSA Journal 197, 1–23. 197.

EFSA, (2015) Scientific Opinion on welfare aspects of the use of perches for laying hens. Panel on Animal Health and Welfare. EFSA Journal: EFSA Journal 2015;13(6):4131 [71 pp.]. doi: 10.2903/j.efsa.2015.4131.

Elson H.A. & Croxall R. (2006). European study on the comparative welfare of laying hens in cage and non-cage systems. Archiv für Geflügelkund 70:194-198.

Estevez, I., (2015). Análisis multifactorial del picaje en avicultura. LII Simposio Científico de Avicultura, Málaga, Spain, October 28-30, pp 67-80.

Estevez, I., Andersen, I. L. & Nævdal E. (2007). Group size, density and social dynamics in farm animals. Applied Animal Behaviour Science, 103:185-204.

Estevez, I., Newberry, R. C. & Keeling, L. J. (2002). Dynamics of aggression in the domestic fowl. Applied Animal Behaviour Science, 76:307-325.

Annex 11 (contd)

Fleming, R.H., McCormack, H.A., McTeir, L. & Whitehead, C.C. (2006). Relationships between genetic, environmental and nutritional factors influencing osteoporosis in laying hens. British Poultry Science. Taylor & Francis, 47: 742–755.

Forkman B, Boissy, A, Meunier-Salaun M.-C., Canali, E. & Jones RB. (2007). A critical review of fear tests used on cattle, pigs, sheep, poultry and horses. Physiology and Behaviour 92: 340-374.

Freire R., Eastwiir M.A. & Joyce M. (2011) Minor beak trimming in chickens leads to loss of mechanoreception and magnetoreception. Journal of Animal Science 89:1201-1206.

Garner J.P., Kiess A.S., Mench J.A., Newberry R.C. & Hester P.Y. (2012) The effect of cage and house design on egg production and egg weight of White Leghorn hens: an epidemiological study. Poultry Science 91:1522-1535.

Gentle M.J., Hunter L.N. & Waddington D., (1991). The onset of pain related behaviours following partial beak amputation in the chicken. Neuroscience Letters 128:113-116.

Gentle M.J., Hughes B.O., Fox A. & Waddington D. (1997). Behavioural and anatomical consequences of two beak trimming methods in 1- and 10-day-old chicks. British Poultry Science 38:453-463.

Gilani A.M., Knowles T.G. & Nicol, C.J., (2014). Factors affecting ranging behaviour in young and adult laying hens. British Poultry Science 55:127-135.

Glatz P.C., Lunam C.A., Barnett J.L. & Jongman E.C., (1998). Prevent chronic pain developing in layers subject tobeak-trimming and re-trimming. A report to Rural Industries Research and Development Corporation.

Green, L.E., Lewis, K., Kimpton A. & Nicol, C.N. (2000). Cross-sectional study of the prevalence of feather pecking in laying hens in alternative systems and its associations with management and disease. Veterinary Record, 147:233-238.

Gregory, N. G. & Robins J. K. (1998) A body condition scoring system for layer hens, New Zealand Journal of Agricultural Research, 41:4, 555-559, DOI: 10.1080/00288233.1998.9513338.

Gregory, N.G. & Wilkins L.J., 1989. Broken bones in domestic fowls handling and processing damage in end of lay battery hens. Br. Poult. Sci. 30:555-562.

Gross, W.B. & Siegel, P.B., 2007. General principles of stress and welfare. In: Livestock Handling and Transport, T. Grandin (Editor), CAB International, Wallingford, UK, p. 19-29.

Gunnarsson, S., Keeling, L. J. & Svedberg, J. (1999). Effect of rearing factors on the prevalence of floor eggs, cloacal cannibalism and feather pecking in commercial flocks of loose housed laying hens. British Poultry Science, 40, 12-18. Doi 10.1080/00071669987773.

Hartcher, K.M. & Jones, B. (2017). The welfare of layer hens in cage and cage-free housing systems. World’s Poultry Science Journal 73:782-767.

Hartcher K., Wilkinson S., Hemsworth P. & Cronin G (2016). Severe feather-pecking in non-cage laying hens and some associated and predisposing factors: a review. World’s Poultry Science Journal 72: 103-114. doi: 10.1017/S0043933915002469.

Hegelund L., Sørensen J.T., Kjær J.B. & Kristensen I.S. (2005) Use of the range area in organic egg production systems: effect of climatic factors, flock size, age and artificial cover. British Poultry Science 46(1):1-8.

Hester P. (2014). The effect of perches installed in cages on laying hens. World’s Poultry Science Journal 2014, 70(2): 27-264.

Holt, P.S. (2003). Molting and Salmonella enterica serovar enteritidis infection: The problem and some solutions. Poultry science. 82: 1008-10.

Huber-Eicher, B. & Wechsler, B. (1998). The effect of quality and availability of foraging materials on feather pecking in laying hens. Animal Behaviour 55: 861-873.

Annex 11 (contd)

Janczak, A. M. & Riber, A. B. (2015). Review of rearing-related factors affecting the welfare of laying hens. Poultry Science, 94, 1454-1469. 10.3382/ps/pev123.

Jenkins, R.L., Ivey, W.D., Mcdaniel, G.R. & Albert, R.A. (1979). A darkness induced eye abnormality in the domestic chicken. Poultry Science, 58: 55–59.

Jones R.B. (1996). Fear and adaptability in poultry: insights, implications and imperatives. Worlds Poult Sci J; 52:131–74.

Jung, L. & Knierim, U. (2018). Are practice recommendations for the prevention of feather pecking in laying hens in non-cage systems in line with the results of experimental and epidemiological studies? Applied Animal Behavior Science 200:1-12.

Kajlich, A. S., Shivaprasad, H. L., Trampel, D. W., A. Hill, R. Parsons, S. Millman & J. Mench, (2016). Incidence, Severity, and Welfare Implications of Lesions Observed Postmortem in Laying Hens from Commercial Noncage Farms in California and Iowa. Avian Diseases. 60. 8-15. 10.1637/11247-080415-Reg.1.

Kannan, G. & Mench J.A., (1996). Influence of different handling methods and crating periods on plasma corticosterone concentrations in broilers. Br. Poult. Sci. 37:21-31.

Keeling L.J., Estevez I., Newberry R.C. & Correia M.G. (2003). Production-related traits of layers reared in different sized flocks: The concept of problematic intermediate group size. Poultry Science 82:1393-1396.

Kjaer J.B. & Hocking P.M. (2004). The genetics of feather pecking and cannibalism. In Perry, G.C. (ed.), Welfare of the Laying Hen (pp. 109-121). Wallingford, UK: CABI.

Koshiba, M., Shirakawa, Y., Mimura, K., Senoo, A., Karino, G. & Nakamura, S. (2013). Familiarity perception call elicited under restricted sensory cues in peer-social interactions of the domestic chick. PLoS ONE 8: e58847. doi: 10.1371/journal.pone.0058847.

Kristenson, H.H. (2008). The effects of light intensity, gradual changes between light and dark and definition of darkness for the behaviour and welfare of broiler chickens, laying hens, pullets and turkeys. Scientific Report for the Norwegian Scientific Committee for Food Safety.

Lambton, S.L., Knowles, T.G., Yorke, C. & Nicol, C.J. (2010). The risk factors affecting the development of gentle and sever feather pecking in loose housed laying hens. Applied Animal Behaviour Science 123: 32-42.

Lambton, S. L., Nicol, C. J., Friel, M., Main, D. C. J., Mckinstry, J. L., Sherwin, C. M., Walton, J. & Weeks, C. A. (2013). A bespoke management package can reduce levels of injurious pecking in loose-housed laying hen flocks. Veterinary Record, 172, 423-+. Doi 10.1136/Vr.101067.

Lara, L., Rostagno, M. (2013). Impact of Heat Stress on Poultry Production. Animals 2013, 3, 356-369.

Larsen, H., Cronin, G., Smith, C.L., Hemsworth, P. & Rault J-L., (2017). Behaviour of free-range laying hens in distinct outdoor environments. Animal Welfare 2017, 26: 255‐264.1

Lay, D. C., Fulton, R. M., Hester, P. Y., Karcher, D. M., Kjaer, J. B., Mench, J. A., Mullens, B. A., Newberry, R. C., Nicol, C. J., O'Sullivan, N. P. & Porter, R. E. (2011). Hen welfare in different housing systems. Poultry Science, 90, 278-294. DOI 10.3382/ps.2010-00962.

Lewis P.D. & Gous R.M. (2009). Photoperiodic responses of broilers. II. Ocular development, British Poultry Science, 50:6, 667-672.

Lin, H., Jiao, H.C., Buyse J. and Decuypere, E. (2006). Strategies for preventing heat stress in poultry. World’s Poultry Science Journal, Vol. 62, March 2006

Mack, L.A.; Felver-Gant, J.N.; Dennis, R.L. & Cheng, H.W. (2013). Genetic variation alter production and behavioral responses following heat stress in 2 strains of laying hens. Poult. Sci., 92, 285–294.

Malleau A.E., Duncan I.J.H. & Widowski T.W. (2007). The importance of rest in young domestic fowl. Applied Animal Behaviour Science 106:52-69.

Annex 11 (contd)

Marchant-Forde R.M., Fahey M.A.G. & Cheng H.W. (2008). Comparative effects of infrared and one-third hot- blade trimming on beak topography, behavior, and growth. Poultry Science 87:1474-1483.

Marchant-Forde, R.M. & Cheng H.W. (2010). Different effects of infrared and one-half hot blade beak trimming on beak topography and growth. Poultry Science 89:2559-2564.

McKeegan D.E.F. & Philbey A.W. (2012). Chronic neurophysiological and anatomical changes associated with infra-red beak treatment and their implications for laying hen welfare. Animal Welfare 21:207-217.

Miles, D.M.; Miller, W.W.; Branton, S.L.; Maslin, W.R. & Lott, B.D. (2006). Ocular responses to ammonia in broiler chickens. Avian Dis., 50, 45–49.

Morris H.M. (2009). Effects of Early Rearing Environment on Learning Ability and Behavior in Laying Hens. M.Sc. Thesis. Corvallis, Oregon: Oregon State University.

Nagle, T.A.D. & Glatz, P.C. (2012). Free range hens use the range more when the outdoor environment is enriched. Asian-Aust. J. Anim. Sci. 25(4):584-591.

Newberry, R.C., Cannibalism. (2004). In Welfare of the Laying Hens (Perry, GC. ed.), pp. 239-258.CABI Publishing, Oxfordshire, UK.

Newberry, R.C., Webster, A.B., Lewis, N.J., Van Arnam, C. (1999). Management of spent hens. Journal of Applied Animal Welfare Science 2(1):13-29

Nicol, C.J. (2015). The behavioural biology of chickens - Wallingford, Oxfordshire, UK; Boston, MA: CABI, c2015. - vii, 192 p.: ill. ISBN:9781780642505 1780642504

Nicol, C.J. (2018). Feather pecking and cannibalism: Can we really stop beak trimming? Mench, J.A. (ed.) Advances in Poultry Welfare. Woodhead Publishing, UK pp. 175 - 190

Nicol, C.J., Bestman, M., Gilani, A-M., De Haas, E.N., De Jong, I.C., Lambton, S., Wagenaar, J.P., Weeks, C.A. & Rodenburg, T.B. (2013). The prevention and control of feather pecking in laying hens: application to commercial systems. World Poultry Science Journal 69: 775-787.

Nicol, C.J., Bouwesema., J., Caplen, G., Davies, A.C., Hockenhull, J., Lambton, S.L., Lines, J.A., Mullan, S. & Weeks, C.A. (2017) Farmed Bird Welfare Science Review. Agriculture Victoria, Department of Economic Development, Jobs, Transport and Resources, Victoria.

Nicol, C.J., Caplen, G., Statham, P., Browne, W.J. (2011). Decision about foraging and risk trade-offs in chickens are associated with individual somatic response profiles. Animal Behaviour 82:255-262.

Norgaard-Nielsen, G. (1990). Bone strength of laying hens kept in an alternative system, compared with hens in cages and on deep-litter. British Poultry Science 31(1):81-89.

O'Connor, E. A., Parker, M. O., Davey, E. L., Grist, H., Owen, R. C., Szladovits, B., Demmers, T. G. M., Wathes, C. M. & Abeyesinghe, S. M. (2011). Effect of low light and high noise on behavioural activity, physiological indicators of stress and production in laying hens. British Poultry Science, 52(6), pp. 666-674.

Olanrewaju, H.A.; Miller, W.W.; Maslin, W.R.; Thaxton, J.P.; Dozier, W.A., 3rd; Purswell, J. & Branton, S.L. (2007). Interactive effects of ammonia and light intensity on ocular, fear and leg health in broiler chickens. Int. J. Poult. Sci., 6, 762–769.

Olsson, I.A.S. and Keeling, L.J. (2005). Why in earth? Dust bathing behaviour in jungle and domestic fowl reviewed from a Tinbergian and animal welfare perspective. Applied Animal Behaviour Science 93: 259-282.

Petek M. & Alpay F. (2008). Utilization of grain barley and alfalfa meal as alternative moult induction programmes for laying hens: body weight losses and egg production traits, Bulgarian Journal of Veterinary Medicine, 11, No *4:* 243*−249.*

Annex 11 (contd)

Pötzsch, C.J., Lewis, K., Nicol, C.J. & Green, L.E. (2001). A cross-sectional study of the prevalence of vent pecking in laying hens in alternative systems and its associations with feather pecking, management and disease. Applied Animal Behaviour Science 74(4): 259 – 272

Prescott N.B. & Wathes C.M. (1999) Spectral sensitivity of the domestic fowl (*Gallus g. domesticus*). British Poultry Science 40:332-339.

Prescott N.B., Wathes C.M. & Jarvis, J.R. (2003) Light, vision and the welfare of poultry. Animal Welfare 12:269- 288.

Ricke, S. (2003). The gastrointestinal tract ecology of Salmonella Enteritidis colonization in molting hens. Poultry science. 82: 1003-7.

Rodenburg, T.B., Van Krimpen, M.M., De Jong, I.C., De Haas, E.N. Kops,M.S., Riedstra, B.J. Nordquist, R.E., Wagenaar, J.P. Bestman, M. & Nicol, C.J. (2013). The prevention and control of feather pecking in laying hens: identifying the underlying principles. World Poultry Science Journal 69: 361-374.

Rodríguez-Aurrekoetxea, A. & Estevez, I. (2014). Aggressiveness in the domestic fowl: Distance versus ´attitude´. Applied Animal Behaviour Science, 153:68–74

Rodríguez-Aurrekoetxea, A. & Estevez, I. (2016). Use of space and its impact on the welfare of laying hens in a commercial free-range system. Poultry Science, 95:2503-2513 <http://dx.doi.org/10.3382/ps/pew238>.

Saiozkan, S.I., Kara, K.II., & Guclu, B.K. (2016). Applicability of Non-Feed Removal Programs to Induce Molting Instead of the Conventional Feed Withdrawal Method in Brown Laying Hens, Brazilian Journal of Poultry Science 18: 535-542.

Shipov, A., Sharir, A., Zelzer, E., Milgram, J., Monsonego-Ornan E, & Shahar, R. (2010). The influence of severe prolonged exercise restriction on the mechanical and structural properties of bone in an avian model. The Veterinary Journal 183:153-60.

Siegel, J.M., (2009). Sleep viewed as a state of adaptive inactivity. Nature Reviews Neuroscience 10:747-753

Tanaka, T. & Hurnik, J.F. (1990). Behavioural responses of hens to simulated dawn and dusk periods. Poultry Science 70:483-488.

Tauson, R. & Abrahamson, P. (1996). Foot and keel bone disorders in laying hens Effects of artificial perch material and hybrid. Acta Agric. Scand. Sect. A 46: 239-246.

Thogerson C.M., Hester P.Y., Mench J.A., Newberry R.C., Pajor E.A. & Garner J.P. (2009a). The effect of feeder space allocation on behaviour of Hy-line W-36 hens housed in conventional cages. Poultry Science 88:1544-1552.

Thogerson C.M., Hester P.Y., Mench J.A., Newberry R.C., Okura C.M., Pajor E.A., Talaty P.N. & Garner J.P. (2009b). The effect of feeder space allocation on productivity and physiology of Hy-Line W-36 hens housed in conventional cages. Poultry Science 88:1793-1799.

Uitdehaag, K. A., T. B. Rodenburg, J. E. Bolhuis, E., Decuypere, & H. Komen, (2009). Mixed housing of different genetic lines of laying hens negatively affects feather pecking and fear related behaviour. Applied Animal Behaviour Science. 116, 58-66

van Liere D.W. & Bokma S. (1987). Short-term feather maintenance as a function of dust bathing in laying hens. Applied Animal Behaviour Science 18:197-204.

van Niekerk, T., de Jong, I., van Krimpen, M., Reuvekamp & B., de Haas, E. (2013). Effect of UV-light, high fiber feed or litter provision in early rearing on feather pecking in rearing and laying period, Wageningen UR Livestock Research, rapport 671.

Vezzoli, G., Mullens B.G. & J. Mench (2015). Relationships between beak condition, preening behavior and ectoparasite infestation levels in laying hens. Poultry science. 00. 1-11. DOI 10.3382/ps/pev171

Annex 11 (contd)

Waiblinger, S., Boivin, X., Pedersen, V., Tosi, M-V., Janczak, A.M., Visser, E.K. & Jones, R.B. (2006) Assessing the human-animal relationship in farmed species: A critical review. Applied Animal Behaviour Science 101: 185-242

Webster, A. B. (2003). Physiology and behavior of the hen during induced molt. Poult. Sci. 82:992–1002.

Webster, A.B. (2004). Welfare implications of avian osteoporosis. Poultry Science 83(2): 184-92

Weeks C.A. & Nicol C.J. (2006). Behavioural needs, priorities and preferences of laying hens. World's Poultry Science Journal 62:296-307.

Whitehead, C.& Fleming, R.H. (2000). Osteoporosis in caged layers. Poultry Science 79: 1033-1041

Widowski, T.M. &, Duncan, I.J. (2000). Working for a dustbath: are hens increasing pleasure rather than reducing suffering? Appl Anim Behav Sci. 2000 May 5;68(1):39-53.

Widowski, T., Classen, H., Newberry, R., Petrik. M., Schwean-larder, K., Cottee, S., Cox, B. (2013). Code of practice for the care and handling of pullets, layers and spent fowl: Poultry (layers). Review of scientific research on priority areas.

Widowski, T., Hemsworth, P., Barnett J & Rault, J-L (2016). Laying hen welfare I. Social environment and space. World's Poultry Science Journal 72: 333-342. doi: 10.1017/S0043933916000027.

Xin, H. and Harmon, J., (1998). Livestock industry facilities and environment: heat stress indices for livestock. Agricultural and Environmental Extension Publications. 163. Iowa State University. Accessed online: <http://lib.dr.iastate.edu/extension_ag_pubs/163>

Yahav, S. (2009). Alleviating heat stress in domestic fowl: different strategies. Worlds Poultry Science Journal 65:719-732.

Yue, S. & Duncan, I.J.H. (2003). Frustrated nesting behaviour: relation to extra-cuticular shell calcium and bone strength in White Leghorn hens. British Poultry Science 44:175-181.

Zeltner, E. & Hirt, H. (2008). Factors involved in the improvement of the use of hen runs. Applied Animal Behaviour Science 114 (2008) 395–408 .

Zimmerman, P.H.; Koene, P. & Van Hooff, J.A. (2000). The vocal expression of feeding motivation and frustration in the domestic layinh hens *Gallus gallus domesticus*. Appl. Anim. Behav. Sci. 2000, 69, 265–273.

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