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SCIENTIFIC OPINION

Scientific Opinion on welfare aspects of the use of perches for laying hens[1]

EFSA Panel on Animal Health and Animal Welfare (AHAW)[2,3]

European Food Safety Authority (EFSA), Parma, Italy

This scientific output, published on 07 July 2015, replaces the earlier version published on 1 June 2015.[4]

ABSTRACT

This opinion investigated the use of perches for laying hens in cage and non-cage systems. It is based on various activities reviewing the effects of perch height and design on hen health and welfare. Systematic and extensive literature reviews were conducted to assess the scientific evidence about hen motivation to grasp and seek elevation, and the appropriate height of perches as well as other features (position, material, colour, temperature, shape, width and length). In addition, an expert knowledge elicitation (EKE) exercise was run with technical hearing experts to discuss and prioritise the various design aspects of perches. Overall, the body of literature on perches is limited. Relevant features of perches are often confounded with others. In the literature, the most commonly used animal-based measures to assess perch adequacy are keel bone damages, foot pad lesions and perch use by hens. Overall, hens seek elevation during the day as well as during the night, when they select a site for roosting. Elevated perches allow hens to monitor the environment, to escape from other hens, avoid disturbances and improve thermoregulation. For night-time roosting hens show a preference for perches higher than 60cm compared with lower perches. However, elevated perches can have negative consequences with increased prevalence of keel deformities and fractures. The risk of injury increases when hens have to jump a distance of more than 80cm vertically, horizontally or diagonally to reach or leave a perch, or jump an angle between 45 and 90° (measured at the horizontal plane). Material, shape, length and width of the perch also influence perch preference by hens. The EKE exercise suggests that an adequate perch is elevated, accessible and functional (providing sufficient overview). The opinion concludes that for the design of an adequate perch, different features of perches need to be further investigated and integrated.

KEY WORDS

laying hens, perches, height, behaviour, welfare, cage systems, aviary systems

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[4] The updated version of this scientific opinion includes changes of an editorial nature that do not materially affect the contents. The changes relate to the suggested citation and short title, where an error in the original title: "Welfare aspects of the use of perches for poultry" has been corrected: "Welfare aspects of the use of perches for laying hens". To avoid confusion, the original version of the output has been removed from the EFSA Journal, but is available on request, as is a version showing all the changes made.

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INTRODUCTION

1.1. Background and Terms of Reference as provided by the European Commission

Council Directive 1999/74/EC about laying hens requires that all birds are provided with adequate or appropriate perches irrespective of housing system. This requirement was adopted on the basis of scientific knowledge indicating that roosting was a high behavioural priority of the birds.

The 1996 Report of the Scientific Veterinary Committee highlighted in point 3.1.6 that 'the height of a perch is an important factor as perch only 5 cm high is not considered as a perch and has no attractive nor repulsive value in floor pens', while the EFSA opinion stated that 'roosting at night on an elevated perch is a behavioural priority' and that 'perches should be raised above the level of the ground'.

In short, scientific assessment appears to suggest that poles intended to serve as resting places need to be elevated to be 'adequate' in the sense of the objective of Council Directive 1999/74/EC.

The majority of the Member States have ensured that birds are provided with perches which are elevated. However, some discussion has arisen as to which height and design of perches may be considered appropriate from the perspective of the birds' behavioural needs. Likewise some allege that there may be negative welfare implications (e.g. injury or increased occurrence of bone fractures) due to either the height or the design of the perch. To ensure a uniform implementation across the Union it is necessary to review available scientific knowledge in this area so as to properly elaborate what we believe is an adequate perch, also from a legal perspective.

Therefore, it would be opportune to identify the height and design of perches which according to scientific knowledge may be considered to satisfy the birds' needs without impairing their welfare and health.

The Commission requests EFSA to review the scientific data available on this issue and any developments which have ensued since the previous opinion was published and on this basis to assess which perch height and design would best satisfy the legal requirement and could be considered adequate from a welfare point of view both in enriched cage and alternative systems.

EFSA is therefore requested to:

1) Identify to which degree a minimum and maximum height and the position of the perch are important factors for the birds' welfare.

2) Identify the design criteria of the perch, such as material, shape, length, which may influence the birds' welfare and to assess which design is best suited to satisfy the birds' behavioural needs without impacting negatively on their health.

3) Propose the minimum and maximum height and most suitable design of the perch according to the above data which may be considered appropriate or adequate. If these data do not enable an assessment of the exact minimum and maximum height or range of heights which are appropriate from a welfare point of view, indicate a set of design criteria of the perch and animal-based welfare measures which may be used to assess whether a perch is adequate.

The assessment should be based on and linked to the previous EFSA scientific opinion on the welfare of laying hens.

1.2. Interpretation of the Terms of Reference

The mandate focuses on defining perch characteristics related to design and height to best satisfy the birds' behavioural needs without impacting negatively on their health. Although the question itself seems relatively straightforward, answering it relies heavily on the interpretation of what is meant by perch adequacy.

The opinion therefore starts by considering the different meanings of the term 'perch', the underlying behavioural motivations of hens to use perches and the possible consequences for bird health. From this, it can be deduced which welfare consequences and which animal-based welfare measures are relevant when designing perches (e.g. frequency of use, and level of keel bone damage). How the various design parameters (e.g. height, shape, length, etc) affect the welfare consequences can be determined through research, and the available knowledge is summarised in this opinion.

However, to compare the impact of perch design across different welfare consequences, the relative importance of these consequences needs to be weighted. Furthermore, to decide when their level can be considered acceptable, thresholds of acceptability have to be agreed upon. Neither weightings across different parameters, nor thresholds of acceptability of single measures can be scientifically determined, because they involve ethical, political and financial considerations. To illustrate this, an example from another area of welfare science may be useful. It is well known that group housing of sows leads to an increase in aggression between the animals, compared to individual housing. A decision on whether group housing or individual housing is the most adequate way to keep sows depends to a large extent on the relative weighting assigned to behavioural freedom (in group housing), versus protection from injurious behaviours (in individual housing) (e.g. Fraser, 2003; Spoolder et al., 2003). Cut-off values or thresholds are required when welfare consequences do not show a clear peak (or trough) in response to a gradual change in design parameters. Clear examples can be found when developing legislation or certification systems for animal friendly products: what constitutes an acceptable level of 'dead on arrivals (DOA's) following long distance transportation is a matter of opinion, rather than science (Spoolder et al., 2014).

Secondly, although the mandate asks for use of perches in birds, following clarification with the EC and given that Directive 1999/74/EC refers to laying hens only, we interpreted this scientific opinion to apply to laying hens.

Furthermore, it is important to consider that perch design and height affect other aspects of laying hen husbandry, in addition to animal welfare and health. Several practical aspects, e.g. egg safety, cleanliness, costs, worker safety, labour requirements should also be taken into account when identifying the adequacy of perches for implementation in current practice. This opinion does not address these additional issues.

Finally, this opinion also considers that even though the mandate requests the most adequate design of perches, there may very well be more than one design (or combination of design aspects) which result in an adequate solution in terms of animal health and welfare. In addition, a combination of heights might be better suited to meet the requirements of hens that may differ in health condition or jumping ability.

1.3. Additional information

1.3.1. Definition of a perch

Directive 1999/74/EC requires that perches are provided to meet the roosting needs of laying hens. However, an etymological search shows that 'perching' has at least three nuanced meanings, all of which are relevant to the scientific consideration of an adequate perch for laying hens.

First, birds can be said to perch on structures (rods, poles, branches) that they can grasp with their feet.

Second, birds can be said to perch on the edge of structures from which they have a vantage point and can survey their surroundings.

Third, birds can be said to perch on structures which are elevated.

This Scientific Opinion will use these meanings as a starting point for further elaboration on the adequacy of perches to provide good welfare.

1.3.2. What does 'adequate' mean?

If and to what degree perches can be regarded as 'adequate' depends on their properties and on the arrangement of the perches within the laying house. These factors are the height of the perches, their material and shape (cross section), their width and diameter, the length of the perch per hen, the colour of the perches and their spatial arrangement in relation to other perches and to other furniture within the laying houses. These different characteristics affect whether perches meet hens' behavioural priorities as described below. Drawing conclusions on adequate perch material, shape and diameter is difficult because, in most studies (see Chapter 3.3), these different features of perches (e.g. material, shape and diameter) were often confounded.

Although there are some indicators of adequate height, an important aspect of height has not yet been tested, making interpretation of the few results that do exist difficult. How hens perceive height is unknown. In multi-tier systems, it may be possible that a perch at the edge of an upper tier is perceived as being higher than a perch in the middle of the same tier if the distance to the floor just below the perch is the only important factor for the hens. The same might apply for perches at the edge and the middle of a furnished cage. In most experimental studies on perch height, the height is measured from the floor of the stable, but this might be confounded with the distance to the roof. Unless information is gained about the perception of height by hens, it is difficult to make practical suggestions for measuring height.

In addition to finding out if perch properties and their height will meet birds' behavioural priorities, looking at how perches affect aspects of their health is also important. In particular, the health of the keel bone and of the feet and the risk of vent pecking can be affected by both the properties and the height of perches.

The keel bones of laying hens are extremely vulnerable to damage because of their prominent and unprotected anatomical position; this is the result of the fact that layer hens that are intensively selected for high egg yield do not have large breast muscles. Keel bone deformities are observed in pullets and young laying hens, but, as hens get older, the risk of fracture increases because of bone strength deterioration. Fractures often heal rapidly (Richards et al., 2011), but there is evidence of residual pain (Nasr et al., 2012). This will further be addressed in the following chapters.

1.3.3. Description and effects of perches in different housing systems

A wide variety of systems, ranging from enriched/colony cages to mobile systems, are used in commercial egg production across European Union (EU) countries. Despite variability in design, space availability and access (or not) to outdoor space, they have common features, as they have to meet the minimum requirements as established by the directive for the protection of laying hens (1999/74/EC), such as access to a nest box, a dust bathing area and perches.

For enriched/colony cages, current legislation requires a minimum of 15 cm of perch space per hen. Additional requirements for non-cage housing systems include perches not being mounted above the litter, a horizontal distance between perches of at least 30 cm and a horizontal distance between the perch and the wall of at least 20 cm. However, the directive does not state a minimum perch height requirement and does not specify perch shape or diameter, allowing variability in the interpretation of these aspects across countries (see, for example, Defra, 2013). In some countries, specific governmental assessment guidelines clarify the minimum characteristics for a structure to be considered a perch (e.g. Assessment guidelines for the interpretation of Real Decreto 3/2002, Spain).

The EFSA report on the welfare aspects of housing systems for laying hens specifies that perches should be raised above the level of the floor and that perch material, design and position should also be considered (EFSA, 2005). The provision of inadequate perches may compromise perch use, limit mobility or cause health issues and/or other behavioural problems (Tauson and Abrahamsson, 1994). Of greatest concern is that perch provision has been associated with a higher incidence of keel bone damage, although other aspects of housing design may also be important.

Housing design has a substantial effect on the risk of damage, with the lowest prevalence of keel damage reported in conventional cages (17.7 %, Sherwin et al., 2010), intermediate levels of keel damage reported in furnished cages (62 %, Rodenburg et al., 2008; 31.7 %, Sherwin et al., 2010; 36 %, Wilkins et al., 2011), greater levels of keel damage reported in single-tier non-cage systems (50–78 %, Wilkins et al., 2004; 60 %, Nicol et al., 2006; 82 %, Rodenburg et al., 2008; 59–67 %, Wilkins et al., 2011) and the highest level of fractures in systems with the greatest combined available heights suitable for perching (97 %, Rodenburg et al., 2008; 86 %, Wilkins et al., 2011). Solving the problem of keel bone damage will require a multi-disciplinary approach, including the input of geneticists, but good perch design could play an important role in reducing the risks associated with sustained or sudden impact with solid structures.

1.3.3.1. Enriched cages/colony cages

Since the introduction of Directive 1999/74/EC, enriched cage designs have greatly evolved. Current available models are quite homogeneous regarding location of the enrichments compared with initial furnished cage designs. The most recently designed commercially available enriched cages are provided with square or mushroom-type plastic perches with polished edges or rounded steel perches (Figure 1) , usually placed in two or more parallel rows along the length of both sides of the cage, depending on the size of the cage. This set up for the perches is widespread in the latest models, but designs with perches located perpendicular to the front of the cage or in a T-shape arrangement are still currently available. In larger cage units, additional perch space may be provided over the line of drinkers and/or over the feeder if supplementary feeding space must be provided to fulfil the feeding space requirements. Some manufacturers have designed dual-function perches, where the perching requirements are met by structural cage elements, feeders, drinkers or ventilation tubes.

Figure 1a Figure 1b

Figure 1c Figure 1d

Figure 1: Examples of plastic (a and b) and metal perches (c) in enriched cages (photos: I. Estevez, Big Dutchman). (d) Plastic ventilation tube used as perch (in the front) and an elevated perch in a colony cage (photo: FLI)

Legislation requires the height of an enriched cage to be no less than 45-cm high in the lowest part, and this is a limiting factor for the maximum height at which perches can be placed while still providing sufficient head space for the hens to perch comfortably. It has been shown experimentally that a reduction of cage height from 55 to 45 cm affects perch preferences, forcing hens to use lower perches and reducing perch use (Struelens et al., 2008b). Therefore, having less than 20 cm between the highest perch and the ceiling could restrict access to the highest perch. Larger enriched cages, or colony systems used in Germany and the Netherlands that are no less than 60-cm high in the lowest side, allow for higher perch placement.

When considering perch height, it is also important that a minimum height is assured to prevent foot trapping between the perch and the floor. In addition, perch height should allow eggs to pass under the perches. Generally, no specifications on perch characteristics (height, shape or diameter of the perches) are included in manufacturers' brochures, other than perch availability per hen (15 cm). Occasionally, perch materials are described when designed to prevent mite infestations (e.g. close-end plastic perches or specially designed non-porous polyvinyl chloride (PVC) solid perches).

Group sizes in enriched cages can vary greatly from 6 to over 100–120 hens in large colony cage systems. In Northern European countries, groups of 8 to 10 hens are most commonly used, while groups of 40 to 80 hens are used in many other EU countries. Large cage units can be adapted to smaller groups, if necessary, by partitioning the cage with a central panel, with perch access divided equally between both sections. Not much scientific information is available regarding the effect of group size on the use of the perches in enriched cages.

To meet all of the requirements, space availability and height in an enriched cage system may be quite restrictive. Normal hen movement between nesting and dust bathing areas, or feeders and drinkers, may cause disruption of perching. In addition, perches have to be passed by moving hens and may constitute obstacles. Disruption of perching may be related to the number of hens in the cage. On the other hand, space in larger groups at constant density appears to be more efficiently used, providing hens with greater mobility. Perch height is necessarily restricted by the dimension of the enriched cage, which in some cases may not be ideal for maximising perch use.

1.3.3.2. Single-tier systems

Single-tier systems are often used in conjunction with access to free-range, quality labelling or organic production programmes. In single-tier systems, a wide variety of perch positions, structures and materials are used. Perches are commonly placed over the slatted area in an A-frame (Figure 2a), square (Figure 2b) or vertical structure (Figure 2c) with multiple levels, although perches can be positioned in other places, such as close to the nest boxes (Figure 2d). Depending on the size of the flock, supplementary perching spaces are provided, usually at the edge of the slatted area. Rounded steel (about 3 cm in diameter) and square or rectangular wooden perches are the most commonly used materials in single-tier systems, but other combinations such as rectangular metal perches are also used.

Although few studies are available, perch use for single-tier systems is high, especially at night where up to 90 % were observed roosting in the top-level perch (Abrahamsson and Tauson, 1995; Oden et al., 2002). Although no scientific evidence is available, field experience suggests that there are major known differences between flocks in the frequency of perch use. The reasons for this are unknown, but management and the opportunity to experience the third dimension during rearing could help to reduce variability in perch use.

Figure 2a

Figure 2b

Figure 2c

Figure 2d

Figure 2: Wooden and steel perches mounted on (a) A-frame structure (photo: V. Michel), (b) square structure (photo: I. Estevez) or (c) vertical structure over the slatted area (photo: L. Wilkins). (d) In some countries, single-tier systems are not provided with additional perches (photo: J. McKinstry)

Suitable locations to place perches are quite limited, as perches should not be placed above the litter, drinker or feeding areas for sanitary reasons. If perches are placed too high in the house, depending on the house structure and ventilation, use of perches at the top levels might be reduced owing to wind currents. It is also possible that weak, injured hens or hens with poor jumping ability may be less able or may be reluctant to use high perches. In addition, the risk of vent pecking was increased in single-tier systems when perches were placed at more than 50 cm above the slats, compared with less than 50 cm or no perches (Lambton et al., 2015). The lack of guidance on the combination of proper location, height and angle of the perches may result in more accidents.

1.3.3.3. Multi-tiered systems

Multi-tiered systems are the most intensive of the non-cage housing systems: they have the highest number of hens in comparison to the available ground surface. Available designs can be quite complex, as feed, water and nest boxes are provided at different levels and arrangements can be different. There are multiple options for the arrangement of these elements. Perches used in multi-tiered systems are mainly steel round perches (approximately 3 cm in diameter) but other shapes and materials can also be used (Figure 3). Because the system is normally compartmentalised in units, perches are placed over the slats on the sides of each unit, and over the top floor, which is mainly a large perching area. However, perches are also placed over feeders and drinkers. Some systems provide aerial perches that are connected sideways to the sides of the units.

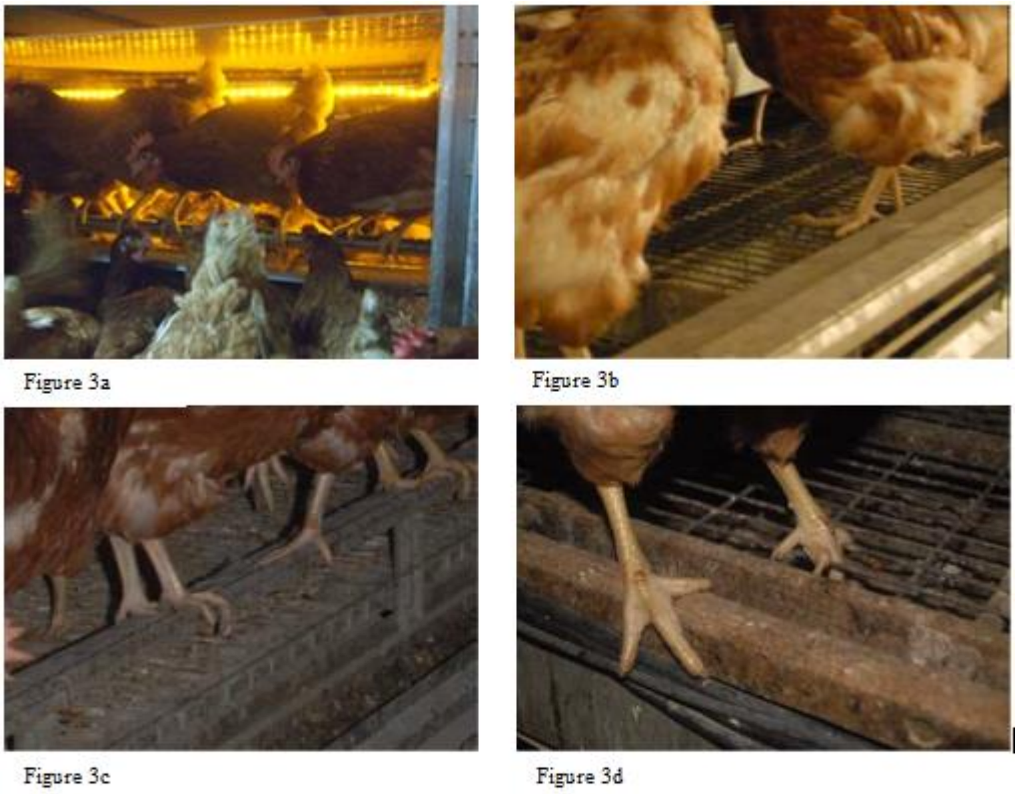


Figure 3: (a) Round steel perches mounted over a feeder line (photo: I. Estevez), (b, c) steel profiles of different shapes at the edges of tiers (photos: FLI) and (d) wooden perches in a multi-tier system (photo: FLI)

As these systems are designed to house high hen densities, frequent disturbances among hens may imply reduced quality perching, at least during the daytime owing to hen activity.

There are constraints on the possible height of the perches in the interior of the unit, especially regarding the ones over drinkers and feeders. Like single-tier systems, there could be differences in perch use among flocks depending on previous experience in the use of the third dimension. Provision of ramps to facilitate hen movement between tiers is also relatively common in multi-tiered systems (Figure 4). Early experience in a three-dimensional space may facilitate the transition from rearing to the production environment as a result of perch usage and possibly as a result of bone strength.

Figure 4: Ramps to facilitate transit in multi-tier systems (photo: FLI)

1.3.3.4. Mobile systems

Mobile systems are small production units which can be moved or regularly rotated on a pasture as needed, depending on the production scheme. Generally, such systems are used almost exclusively for organic egg production. The ability to move the shed produces a more equal distribution of dung across the pasture, reducing pollution and facilitating soil regeneration.

The housing conditions provided in mobile systems are very variable (Wilkins et al., 2011). They can range from commercially available systems for up to 2 000 hens (Big Dutchman, Liberty Livestock Systems, McGregor) to smaller home-made sheds. The commercially available mobile systems are equipped with one or two floors of slatted areas with multi-tier or single-tier equipment and perches mounted over the slats (Figure 5a) or on the sides in the form of aerial perches (Figure 5b). In all situations, perch availability will be the same. However, in general, there is a wide variety of materials, heights, shapes and locations of the perches in mobile systems, ranging from metal perches protected by rubber to wooden perches of different dimensions.

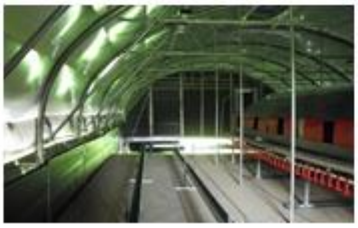


Figure 5a

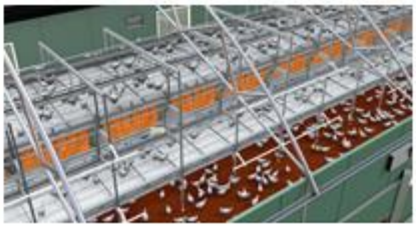


Figure 5b

Figure 5: Commercially available mobile system with perches mounted (a) over the slatted floor (photo: McGregor) and (b) aerial perches in white (photo: Big Dutchman)

1.3.4. Management aspects that affect perch use

In addition to perch characteristics, the management of pullets and laying hens will have an impact on perching ability and motivation. The main management aspects known to have an impact are hen rearing, laying hen stocking density and lighting programmes.

1.3.4.1. Impact of rearing management

The effect of rearing with and without perches on the perch use of laying hens has been investigated by different authors. Hens reared without perches have difficulty using perches owing to low muscle strength, a lack of motor skills and the inability to keep balance, or they have impaired spatial skills, which are necessary for moving around in three-dimensional space. These background factors are not mutually exclusive. Gunnarsson et al. (2000) showed that absence of early access to perches (1–8 weeks of age) does not impair the ability of adult hens to reach food 40 cm above the ground, but such hens have increasing difficulty as the height increases (up to 160 cm above ground), and in some cases could not even reach the food. Giving access to perches during rearing can enhance the capacities of hens to use perches during the laying period. Some authors concluded that there seems to be an association between an early start to perch use and later use of perches by laying hens for real night-time roosting (Heikkilä et al., 2006). Roll et al. (2008) showed that floor-reared hens spend more time perching in laying furnished cages than cage-reared hens (7.5 % versus 13.4 %). In this case, rearing condition has an impact on perch use, even if no perch has been provided during rearing.

Providing perches to pullets compared with providing no perches had long-term benefits, as gross and relative thigh and total leg muscle deposition of laying hens were increased. Muscle growth during development is probably stimulated by physical activity, such as jumping on and off perches during light hours (Hester et al., 2013). The increase of keel bone mineralisation resulting from perch access during rearing and laying was not sufficient to prevent a higher incidence of keel bone fractures, caused by perch usage, at the end of lay (Hester et al., 2013).

1.3.4.2. Stocking density and group size

Stocking density can have an influence on perch use in broiler chickens (Hongchao et al., 2014: 1-day- to 5-week-old chickens) and laying hens (Chen and Bao, 2012). Guo et al. (2012) showed that bigger group size (48 versus 21 hens, with small differences in stocking density, i.e. 543 versus 586 cm^2/hen) can stimulate perching. In some papers, stocking density and group size effect are confounded (Chen et al., 2012, 2014; Hongchao et al., 2014), and thus no conclusions can be drawn on the main influencing factor. This is the case in the work of Chen et al. (2012), who showed that, in the same pen, groups of four hens were perching more than groups of one or eight hens. In the same way, Hongchao et al. (2014) demonstrated that there was more perching among chickens in groups of 64 chickens (16 hens/m^2) than for smaller (48 chickens, 12 chickens/m^2) and higher (80 chickens, 20 chickens/m^2) groups/stocking densities.

Some social - group size or stocking density- dependent factors, such as stimulation, social facilitation (Pettit-Rilez and Estevez, 2001) and competition (Newberry et al., 2001), may also have an effect on perch use.

Pettit-Riley and Estevez (2001) suggested that social facilitation, related to the larger number of hens, was probably the explanation; this is similar to the findings that bigger groups size can stimulate perching (Guo et al., 2012). On the other hand, in a study in which density was controlled for, Newberry et al. (2001) found lower perching in larger groups (120 hens) than in groups smaller (15 hens) during the daytime. These results were explained as an anti-predator response.

1.3.4.3. Lighting

Commercial housing systems for laying hens are often kept at low light intensity to reduce the incidence of feather pecking. This low light intensity may restrict the ability of hens to visually perceive environmental features such as perches. By affecting the visibility of perches, lighting management can have an impact on perch use and can impair take-off and landing from perches and increase the risk of injury to hens. On one hand, the results of Taylor et al. (2003) (who compared light intensity from 0.8 to 40 lx) suggest that very low light intensity conditions could restrict the movement of hens and their access to perches in non-cage systems. As an example, the latency to jump and the number of vocalisations were significantly higher at lower light intensity when hens have to jump from one perch to another. On the other hand, Moinard et al. (2004) did not show any effect of lighting conditions (5, 10 or 20 lx; incandescent or high- or low-frequency fluorescence) on hens' ability to jump to and from perches in different light environments. These differences can be explained by the fact that lower light intensity in the Moinard et al. study (5 lx) was higher than the low light intensity of Taylor et al. (2003) (0.8 lx).

Gunnarsson (2013) investigated if environmental enrichment (e.g. CDs, plastic bottles) and light characteristics enhanced perching behaviour at an early age and consequently protected against behavioural problems. No significant effect of enrichment was found on the latency to start perching, but pullets given access to enrichment on the floor had a tendency to roost earlier. Exposure to daylight has a tendency to promote perching early in life.

As roosting is triggered by a reduction in light and because hens need some time to find a resting place, a period of dim light before lights are turned off at night is recommended. A phase of gradually dimmed light will allow the hens to orientate while searching for a resting place and will reduce the risk of failed landings while entering perches during dusk in particular in non-cage systems.

1.3.4.4. Relationships between breed and perch use

Hens of all breeds that have been studied so far will perch at night and, to a lesser extent, will also perch during the daytime. However, there are some indications of differences in perch usage between breeds. For example, in an experimental study, White Leghorn hens showed higher perch usage than Rhode Island Red × Light Sussex hens, and Brown Leghorn hens showed the least perch usage (Faure and Jones, 1982b). In get-away cages, Shaver hens used a low perch more often than Lohmann Selected Leghorn hens, although usage of a higher perch did not differ between breeds (Tauson and Abrahamsson, 1994). In furnished cages, Lohmann Selected Leghorn hens used perches more than Lohmann Brown hens at night, and Hy-Line Brown hens showed a tendency for a higher usage of perches than Hy-Line White hens (Wall and Tauson, 2007). However, Cook et al. (2011) did not find any differences in perch usage when they compared Lohmann Brown hens with White Leghorn hens kept in enriched cages.

One possible explanation for differences in the usage of perches may be differences in body weight and, consequently, differences in wing load. These factors seem to affect the control of jumps and flights from perches and hens of heavier breeds showed more difficulties controlling jumps and/or flights from perches (Moinard et al., 2004) or landings on perches (Scholz et al., 2014). These differences may also result in different perch usages. However, different breeds may also have different motivations to perch.

In another study, the effect of domestication was investigated (Eklund and Jensen, 2011). Daytime perching of junglefowl and White Leghorn chickens has been compared, but not night time roosting. Junglefowl performed more frequent and more synchronous daytime perching. Single sex and single strain groups of three hens were provided with a 100-cm perch at a height of 45 cm within a test arena. Hens were allowed 24 hours to habituate and then their behaviour was recorded for a further 24 hours, but data from only the 12-hour light period was extracted. Synchrony was assessed by recording the average frequency within each time window when two or three of the hens were exhibiting the same behaviour. Red Junglefowl perched more than chickens during the day, and males perched more than females. Red Junglefowl also perched significantly closer together than chickens, again suggesting a possible relaxation of protective behaviour in domestic chickens. The need for daytime vigilance may have decreased during domestication but it certainly has not been eliminated.

2. Data and methodologies

The terms of reference (ToRs) were addressed on the basis of the outcomes of six main activities:

1. A literature review about the motivation of hens to perch and to stay at an elevated area (ToR1).

2. The development of an overview table linking the risk factors (i.e. the aspects of the perch) and the welfare consequences for the hens based on the Working Group (WG) expert opinion (ToR2 and ToR3).
3. A scoping review to investigate the available data on different aspects of perches in relation to the welfare consequences for the hens (ToR2).
4. A qualitative literature review addressed the different housing systems that hens are kept in, and the diversity of the aspects involved when addressing perch use (ToR2).
5. A systematic literature review on a limited number of aspects related to perches, followed by semi-quantitative analyses of these data (ToR2 and ToR3).
6. An expert knowledge elicitation process to determine appropriate levels of various aspects of perches (ToR2 and ToR3).

2.1. Identification of the degree to which a minimum and a maximum height and the position of the perch are important factors for hens' welfare (ToR1)

ToR1: Identify to what degree a minimum and maximum height and the position of the perch are important factors for the birds' welfare.

ToR 1 was primarily addressed through an extensive literature review (activity 1 of Section 2) conducted by the WG members to investigate the motivation and ability of hens to perch related to height and position.

In addition, ToR1 was addressed in the technical meeting with hearing experts (activity 6), in which one of the scenarios presented to the hearing experts (see 'Technical meeting with hearing experts' under Section 2.3) was about hens provided with perches of different heights (from 0 to 200 cm), investigating what experts believe about hens' motivation to perch.

2.2. Identification of perch design criteria that best satisfy hens' behavioural needs without impacting negatively on their health (ToR2)

ToR 2: Identify the design criteria of the perch, such as material, shape and length, which may influence the hens' welfare and assess which design is best suited to satisfy the hens' behavioural needs without impacting negatively on their health.

ToR 2 was addressed by the WG experts, first, by listing risk factors (perch design aspects) in relation to health and welfare consequences (activity 2 of Section 2). The factors and consequences identified by the WG experts provided key words for a subsequent scoping review (activity 3 of Section 2), which was followed by extensive literature searches (activity 4 of Section 2) and by a systematic literature review (activity 5 of Section 2). The scoping review consisted of an analysis of the scientific literature on perches in laying hens. Its aim was to identify relevant studies for each perch characteristic, as well as relevant outcomes that describe animal-based welfare outcomes in relation to perch presence and features.

The two most commonly mentioned animal-based welfare outcomes identified by the scoping review were: (1) the level of use of the perches (day and night) and (2) the level of keel bone damage (including fractures and deformities). These were then used in a systematic literature review – carried out by an external contractor (O'Connor et al., in press) – that focused on the height of the perch in relation to the two animal-based outcomes. The systematic literature review aimed at providing a quantitative description of this relationship.

Aspects related to the position and other features of the perches were addressed through extensive literature searches on relevant studies identified in the scoping review. Such literature searches (activity 4 of Section 2) were carried out by the WG members, and their outcomes were discussed in the WG. These literature sources were then used to describe (in a qualitative way) the outcomes of ToR 2.

2.3. Identification of minimum and maximum height and most suitable design of perches (ToR3a)

ToR 3a: Propose the minimum and maximum height and most suitable design of the perch according to the above data which may be considered appropriate or adequate.

ToR 3a was addressed through expert knowledge elicitation in a technical meeting with hearing experts (activity 6 of Section 2), as insufficient quantitative data exists. The table linking risk factors and welfare consequences, the outcomes of the systematic literature review on perch height and the analyses of the scientific papers resulting from the scoping review all provided input for the meeting with experts.

The technical meeting with hearing experts was held on 24 February 2015 in order to elicit expert knowledge following the methodology adopted by EFSA in its 'Guidance on expert knowledge elicitation in food and feed safety risk assessment' (EFSA, 2014). The objective of this meeting was to address questions regarding the 'appropriateness' of various perch characteristics in relation to their implications for animal welfare and health. Eight hearing experts were invited to participate in this meeting. They were selected on the basis of criteria set by the WG to cover practical experience with the different systems considered by the opinion (furnished cages, and single-tier and multi-tier aviary systems). Experts were also selected to cover experience of different EU countries and experience with more than one system.

The elicitation procedure required attendance at a one-day workshop—this allowed sufficient time for the experts to discuss the information provided. The experts received a briefing document, including the main findings from the literature, before the workshop. The aim of this was to bring all invited experts up to the same level of knowledge and to ask for any other scientific evidence available.

In the workshop, the elicitor introduced the participants to the process of expert knowledge elicitation. The experts of the WG gave an outline of the EFSA mandate, an outline of the literature findings and an explanation of the parameters they were asked to elicit. The experts were then given a series of cards explaining different 'perch scenarios' combining several perch heights with several perch features. Different scenarios were formulated for each of the two exercises that were carried out:

Exercise 1: scenarios focusing on the height of the perches (in single-tier non-cage systems)

Exercise 2: scenarios focusing on other perch features (in both cage and non-cage systems)

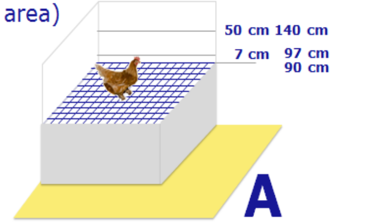
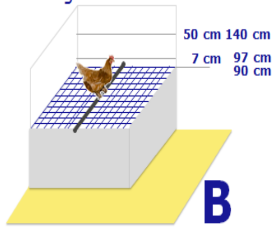
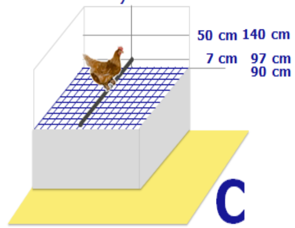
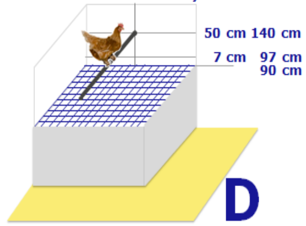
For both exercises, the experts were first asked to rank the scenarios individually. The ranking was based on the judgement of (1) the preference of the hens to use the perch at night and (2) the expected rate of keel bone deformities (including damage and fractures).

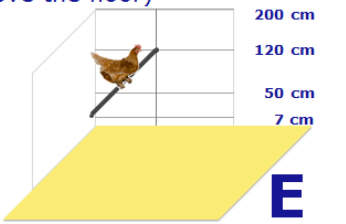
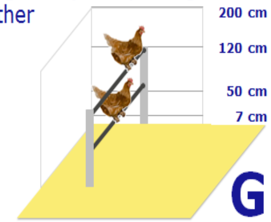
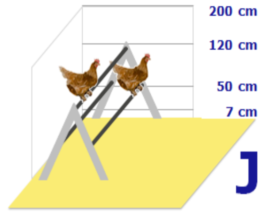
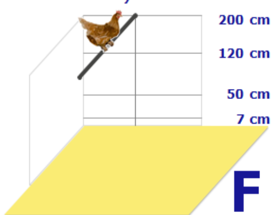
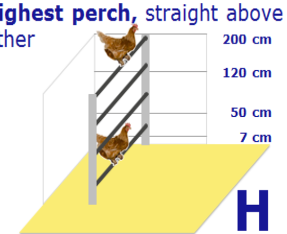
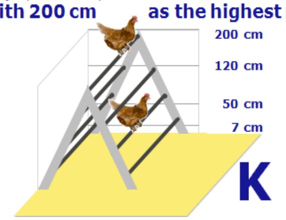
Finally, through a group discussion, consensus was sought to rank the scenarios, following the Sheffield method (EFSA, 2014).

2.3.1. Exercise 1: scenarios about perch height and position

The first 10 scenarios were all based on the presence of a part-slatted area (ca. 90 cm above ground) and a part-littered area (ground level). Perches were arranged above the slatted area (grid structure in Table 1) or above the littered area (yellow area in Table 1). Scenarios A–F in Table 1 represent single-tiered arrangements of (multiple) perches with different heights above the slatted area or littered area. Scenario A did not have a perch (B, C and D had perches at 0, 7.5 and 50 cm above the slats (equal to 90, 97.5 and 140 cm above ground level), respectively). Scenarios E and F had perches at 120 and 200 cm above ground level (i.e. above the littered area). Alternatively, an equal number of perches was arranged in a ladder (G and H: highest perch at 120 or 200 cm above ground level) or an A-shape design (J and K: with the highest perch at 120 or 200 cm above ground level). Table 1 summarises the 10 scenarios in a revised version that reflected the reasoning of the hearing experts. All scenarios allow the same perch space per hen.

Table 1: Scenarios to elicit perching preferences (figures were revised after the elicitation process, reflecting the reasoning of the hearing experts)

	Perches above the slatted floor			
	No additional perches	**Wider bars in the slatted floor**	**Low perch (7 cm)**	**Medium perch (50 cm)**
Low heights above slatted floor	**No additional perches** (perching during night on slatted area) 	**Wider bars integrated in the slatted floor** at regular intervals 	**Low perch** (single perches 7 cm above the slatted area) 	**Medium perch** (single perches 50 cm above the slatted area) 

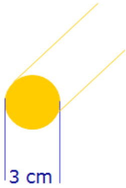
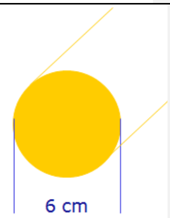
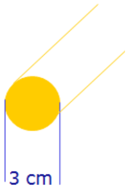
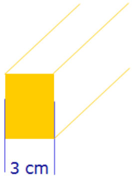
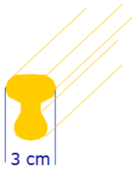
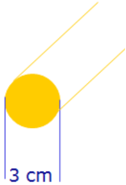
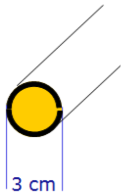
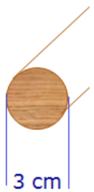
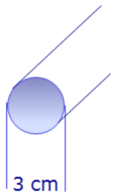
	Perches above the litter area			
	Single perch	**Ladder design**	**A-shape design**	
Maximum height 120 cm	**High perch** (single perches 120 above the floor) 	**Ladder frame with 120 cm as the highest perch,** straight above each other 	**A-frame or other structure** where birds can jump from one perch to another at a different height, **with 120 cm as the highest perch** 	
Maximum height 200 cm	**High perch** (single perches 200 cm above the floor) 	**Ladder frame with 200 cm as the highest perch,** straight above each other 	**A-frame or other structure** where birds can jump from one perch to another at a different height, **with 200 cm as the highest perch** 	

2.3.2. Exercise 2: scenarios about perch design features

The eight scenarios in this exercise (Table 2: A to H) combined three aspects of perch design: (1) thickness or diameter (1.5, 3 and 6 cm), (2) shape (flat—rectangular profile; round—circular profile; rounded edge—mushroom profile) and (3) material (metal, plastic, wood, rubber coated). Within these dimensions, the ratings were consistent (see Table 2 below). The additive combination across the dimensions was not supported because the experts were not unequivocal regarding the interaction of thickness and profile shape.

The scenarios were ordered by their dimension.

Table 2: Scenarios to elicit preferences to features of perches (figures were revised after the elicitation process, reflecting the reasoning of the hearing experts)

	Perch features			
Diameter	**3 cm**	**1.5 cm**	**6 cm**	
	A **Perch features** Diameter: **3 cm** Shape: **round** Material: **plastic** (without rubber layer) 	**B** **Perch features** Diameter: **1.5 cm** Shape: **round** Material: **plastic** (without rubber layer) 	**C** **Perch features** Diameter: **6 cm** Shape: **round** Material: **plastic** (without rubber layer) 	
Shape	**Round**	**Rectangular**	**Oval/mushroom**	
	A **Perch features** Diameter: **3 cm** Shape: **round** Material: **plastic** (without rubber layer) 	**D** **Perch features** Diameter: **3 cm** Shape: **rectangular** (with sharp edges) Material: **plastic** (without rubber layer) 	**E** **Perch features** Diameter: **3 cm** Shape: **oval/mushroom** Material: **plastic** (without rubber layer) 	
Material	**Plastic (without rubber layer)**	**Plastic with rubber layer**	**Soft wood**	**Metal**
	A **Perch features** Diameter: **3 cm** Shape: **round** Material: **plastic** (without rubber layer) 	**F** **Perch features** Diameter: **3 cm** Shape: **round** Material: **plastic** **(with rubber layer)** 	**G** **Perch features** Diameter: **3 cm** Shape: **round** Material: **soft wood** 	**H** **Perch features** Diameter: **3 cm** Shape: **round** Material: **metal** 

2.4. Identification of perch design criteria and animal-based welfare measures to be used to assess perch adequacy (ToR3b)

ToR 3b: If these data do not enable an assessment of the exact minimum and maximum height or range of heights which are appropriate from a welfare point of view, indicate a set of design criteria of the perch and animal-based welfare measures which may be used to assess if a perch is adequate.

ToR 3b was addressed by the WG through the design of two tables. In the first table, the WG listed all relevant perch design aspects and linked them to potential welfare outcomes.

In the second table, the welfare consequences were linked to animal-based measures to assess them. Details on how to apply the animal-based measures and supporting literature for their assessment (mainly the Welfare Quality® protocols for laying hens) were also provided in the table.

3. Assessment

3.1. Welfare consequences and animal-based measures related to the presence and adequacy of perches

The first step taken to evaluate if height and position of the perches are important factors for hen health and welfare (see ToR1) and to assess the adequacy of perch design and other features (see ToR2) was to investigate the welfare consequences linked to such aspects. The welfare consequences related to the ability (or inability) to perch and the adequacy of perches are numerous. Appendix A presents these potential welfare consequences. Among them are the occurrence of red mites, keel bone injuries including fractures, foot pad lesions and other foot problems (such as bumble foot), and toe and claw damage. Differences in perch availability also potentially affect injurious behaviours. If the relative position of perches allows easy access to the cloaca of other perching hens this can increase the risk of cloaca injuries and plumage damage. The level of perch use will also be affected by design features, as well by the actual type of behaviour hens perform on the perch (resting, balancing, comfort behaviour). Finally, it is likely that some physiological parameters, e.g. body temperature, can be affected by the design of the perch.

All welfare consequences listed in Appendix A were investigated in the literature scoping review. Figure 6 gives a summary of the results from the scoping review. From this figure, it can be seen that usage of the perches— daytime and night time usage—as well as health outcomes—predominantly referring to bones—are mostly referred to when assessing perch adequacy (yellow highlighted cells).

	Bone associated outcomes	Foot health and foot lesions-	Biochemical such as cortisol or noradrenaline	Thermal behavior e.g. panting and huddling	Comfort behavior- preening	Physiological indicators of stress	Balancing movements	Freedom of movement	Landing behaviour	Flightiness and fearfulness	Bird preference –	Nighttime usage	Daytime usage	Social behavioral outcomes	Health outcomes	Egg outcomes
Wet	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Color	0	0	0	0	0	0	0	0	3	0	1	1	1	0	0	0
Clean	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Temperature	4	3	1	5	0	4	1	0	0	0	0	2	1	2	4	3
Shape	5	4	0	0	2	0	0	0	2	0	3	5	4	1	5	3
Width	2	2	0	1	3	0	1	0	2	0	3	4	3	1	2	1
Position	7	4	0	0	1	2	0	1	6	0	4	6	7	3	10	6
Height	5	4	0	0	3	3	1	2	6	1	9	10	12	9	8	4
Material	5	4	0	1	2	0	1	0	2	0	2	3	2	0	5	1
Length per bird	2	3	1	0	1	1	0	0	0	1	3	5	5	2	3	3

Figure 6: Summary of results from the scoping review (O'Connor, in press).

3.2. Results about the degree to which a minimum and a maximum height and the position of the perch are important factors for hens' welfare (ToR1)

3.2.1. Perching behaviour and motivation related to grasping and seeking elevation

ToR 1: Identify to what degree a minimum and maximum height and the position of the perch are important factors for the hens' welfare.

To establish what an adequate perch is, it is necessary to investigate if a perch is needed at all by looking at the possible motivations for animals to use a perch. Therefore, it is necessary to identify the motivational basis for perching and the strength of the motivation, if possible. Under natural or semi-natural conditions, chickens make use of elevated structures in the environment (most often tree branches) to perch on during the day (Wood-Gush et al., 1978) and to roost on at night (Blokhuis, 1984). Often chickens grasp branches or other structures with their feet whilst perching. Thus, in considering the causation, function and need to perch or roost, it is important to consider both grasping and the seeking of elevation separately, where possible, although in most studies these two aspects are confounded.

The literature review conducted by the WG members to investigate the ability of hens to perch and their motivation to grasp and seek elevation led to the following results.

3.2.1.1. Grasping

Grasping is the act of wrapping the toes around a (rod or stick) perch, via active or passive flexion of the toes. Chickens can grasp branches with their feet, and originally it was proposed that grasping required considerable muscular effort. Early experimenters with domestic fowl (e.g. Watson, 1869) disproved this hypothesis and argued instead that grasping was a passive process, starting with the body weight of the sitting hen leading to flexion of the hip, knee and ankle joints and passive stretching of the particular avian arrangement of limb muscles and tendons. Finally 'as the tendons passing to the toes in front are closely connected with that one passing to the posterior toe, they are consequently put upon the stretch at the same moment, and thus compel the toes to grasp firmly the branch on which the hen is situated'. Most subsequent authors have taken the same view and proposed complementary mechanisms (e.g. ratchet-like microstructure of avian foot tendons, Quinn and Baumel, 1990) that might act together to maintain digital force without continuous muscular effort. However, actual tests of this hypothesis are rare. Recently, Galton and Shepherd (2012) examined anaesthetised starlings and found that passive leg flexion produced no toe flexion, and also found that hens subjected to surgery to disable toe flexion roosted in a similar way to control hens. They noted that starlings did not always grasp the structures or branches they were sitting on and suggested that, when a high degree of balance is necessary (e.g. during high winds), grasping could be maintained by an active contraction of flexor muscles acting on the toes only.

Chickens possess touch receptors (Herbst corpuscles) in the pads of their feet which assist in grasping and balancing movements.

Chickens have feet that are capable of grasping. However, in comparison with many other hen species, the feet of chickens are less specialised for grasping, as chickens make greater use of their feet for locomotion and for scratching for food (Sustaita et al., 2013).

The relative preference of roosting hens for an object that can be grasped versus an elevated structure was examined by Schrader and Muller (2009) who offered hens different combinations of high (60 cm) or low (15 cm) perches, or high or low flat plastic grids, for night-time roosting. Hens showed a very strong preference for high roosting structures over low, and a weaker preference for perches over grids when these were presented at the same height. When forced to make a choice between high grids or low perches, the height was by far the most important component in hens' preference. However, there is no work examining grasping motivation per se (e.g. examining if the need to grasp increases with time after grasping was last performed).

3.2.1.2. Seeking elevation

Birds subject to the threat (or perceived threat) of predation tend to seek locations which provide a good view of their surroundings so that subtle predatory cues can be detected. Individuals of many avian species invest less time in vigilance behaviour when they have an unobstructed view of their surroundings (Metcalf, 1984; Devereux et al., 2005). However, there is a potential trade-off between having a good view of predators and being more visible and exposed to this same threat and this aspect has not been studied in laying hens. Further research would be required to establish whether achieving a good view of their surroundings was an important component in hens' motivation to seek elevation.

Commercial laying hens provided with continuous access to elevated structures were less fearful than flocks with no aerial perches (Donaldson and O'Connell, 2012), again supporting the idea that perches enhance a sense of security. However, not all studies have found an effect of perches on fearfulness (Campo et al., 2005 (ornamental breed); Brake et al., 1994 (broiler breeder pullets)). The height of the perches used in these studies, and the effects on fearfulness for hens in edge versus central locations of elevated platforms or grids, requires further investigation.

There may be ways to provide hens with a sense of security other than through elevated structures or perches; for example, hens prefer pen areas with partial cover and preferentially perform resting and preening behaviours in these areas (Newberry et al., 2001). Hens that have experienced hostility from conspecifics use floor-level covered areas beneath tiers of perches as a refuge (Freire et al., 2003). It is not known if the provision of cover (i.e. a partially covered area by, for example, a canopy or awning) could substitute partially or fully for the provision of an elevated structure or perch.

3.2.1.3. Motivation to perch at night

The motivation to seek elevation is particularly strong at night when hens select a site for resting or sleeping (Blokhuis, 1984) and this instinct remains strong in domestic chickens. Feral domestic hens seek out branches for perching during the late afternoon or early evening (Wood-Gush et al., 1978). This ensures that the majority of hens are safely elevated when night falls. The proximate cue that triggers roosting appears to be a fall in light levels during afternoon periods when hens are more photosensitive (Kent et al., 1997). Thus, a drop in ambient light levels in the afternoon triggers roosting, whereas similar drops in light levels at other times of day do not. This mechanism applies both to broody hens caring for young chicks and to adult hens (Kent et al., 1997).

The high percentage of perch usage at night is, in itself, some indication that roosting is a highly motivated behaviour. Studies demonstrate a strong preference to seek and access elevated areas at night (Oden et al., 2002; Wichman et al., 2007), although Cordiner and Savory (2001) reported a tendency for greater utilisation of low perches than of high perches in small experimental pens. Good evidence that roosting is a highly motivated behaviour comes from studies showing that, when roosting is prevented, hens become agitated (Olsson and Keeling, 2000). The high motivation for night-time roosting is further demonstrated by studies showing that hens will use a push-door to access a perch at night. Olsson and Keeling (2002) increased the force required for a hen to open the push-door from 25 % of an individual's capacity to 100 %, the maximum possible for that individual hen (calculated from the force overcome to reach food after 24 hours of food deprivation). The median resistance overcome to access the perch was 75 % of capacity, compared with 0 % for a sham perch.

The motivation to seek an elevated area is reduced in caged hens by a competing motivation to avoid contact with the cage roof. Provided there is a minimum distance of approximately 20 cm between the top perch and the cage roof, hens prefer to roost at night on the highest perches available over a range of 6 to 36 cm (Struelens et al., 2008b). However, cage heights of less than 55 cm removed the preference for the highest perches, reduced perch use overall and reduced the amount of comfort behaviour performed on the perch.

3.2.1.4. Motivation to perch during the day

During the day, perching in elevated locations gives chickens a vantage point from which they can monitor their environment and reduce the risk of daytime predation. Elevation may also allow social monitoring, but this is a lesser influence as shown by group size effects on perching behaviour (Newberry et al., 2001) and as was discussed previously about stocking density. These authors found that daytime perch usage rates were slightly higher (just over 40 %) in small groups of young White Leghorn chickens than in larger groups, over group sizes ranging from 15 to 120 hens. In addition, the proportion of perching hens that were vigilant on the highest perches declined with increasing group size. If hens were using perches to monitor their social companions, the opposite result would be expected, with more perch use in larger groups where there are more individuals to observe. Instead, the authors suggested that individuals in smaller groups have to be more vigilant for potential predators (Newberry et al., 2001). Likewise, Cheng et al. (2014) reported a higher perch use in smaller groups of one to eight Hy-Line Brown laying hens, with perching frequencies varying from 86.7 % to 68.3 % in single-housed hens and groups of eight, respectively. In addition, hens in smaller groups preferred higher perches (20 cm), while hens in groups of eight showed a preference for lower height perches (10 cm). In support of the idea that seeking elevation during the day may increase chickens' perception of safety, Keeling (1997, conference abstract) reported that chickens perching on a low perch reacted sooner to the presence of a model predator than chickens on a higher perch. However, not all results are consistent with this idea, as Guo et al. (2012) found higher perch use in larger groups of 48 hens compared with groups of 21 hens, although perch use in both groups was rather low (below 10 %). In non-cage systems, greater utilisation rates have generally been reported for high perches than for low perches during the daytime (Newberry et al., 2001). However, for caged hens, the tendency to avoid contact with the cage roof has a greater effect on daytime perching than on night-time roosting (Struelens et al., 2008b). Indeed, in cage environments, non-elevated perches can be preferred for daytime use (e.g. Rönchen et al., 2010). Chen et al. (2014) found that hens in 65-cm high cages preferred perches at heights of 10 cm or 20 cm than perches at heights of 30 cm or 40 cm.

Large flock sizes of many thousands in both colony cage and non-cage houses may reduce hens' motivation to be vigilant for predators, and hence their motivation to perch, but this has not been studied.

Chickens may also use elevated structures to escape from other hens (Cordiner and Savory, 2001). These authors sequentially provided small groups of 20 adult hens with no perches or combinations of perches in low (17.5 cm above ground), medium (highest perch 35 cm above ground) or high (highest perch 70 cm above ground) configurations. The frequency of aggressive interactions was significantly lower when a high perch was provided than when no perch was provided, but no significant effects were detected for feather pecking. In two of the four groups, perches of all heights were used more by subordinate hens than by dominant hens, suggesting that the perches may have provided a refuge. Aggressive interactions were relatively frequent in this experiment, as newly mixed hens within these small groups attempted to form social hierarchies, so generalisation to larger or more stable groups requires caution.

Finally, hens may seek elevation to avoid poor or damp litter conditions that are known to have a direct impact on foot pad lesions (Wang et al., 1998), but the use of perches to avoid deteriorated litter conditions has not been directly investigated.

The proximate cues that influence daytime perching are not known. Demand experiments for daytime perching have not been conducted. However, two early experiments examined the relative preferences of hens for structures that could be grasped versus elevated platforms. Hens made little use of a wooden perch compared with a wire mesh cube when both of these were presented in pens either for 1 hour/day or continuously (Faure and Jones, 1982a, b). In the latter experiment, chickens were provided with continuous access to one of five perching options, namely covered or uncovered wire mesh cubes at a height of 45 cm or 5 cm, or a rectangular wooden perch (45 cm length, 5 cm breadth, 2 cm depth) at a height of 35 cm. Little or no daytime perching was observed on the wooden perch in comparison with the elevated cubes, suggesting no motivation for grasping a rectangular perch. The limitations of this work include the small number of hens, the lack of group-level replication and the lack of control over other experimental variables.

3.2.1.5. Motivation when perches are absent

Although there is evidence that laying hens are frustrated if they are unable to access perches that they have previously used, evidence of a deprivation effect is equivocal. The extent to which the actual presence of higher structures stimulates hens' preference for elevated perching (i.e. provides a cue that the hens would not miss in its absence) remains to be investigated. No one has examined if any type of chicken 'misses' absent perches. When pullets or laying hens are housed in conventional or furnished cages either with or without the provision of a perch, no differences in stress response have been observed in commercial breeds (Barnett et al., 1997, 2009; Yan et al., 2013), despite the fact that the perches are well-used when provided. An exception to this general result has been reported for a Spanish ornamental breed (Black Menorca) housed in small experimental pens, where hens with perches had lower heterophil to lymphocyte ratios after 15 weeks (Campo et al., 2005) and greater fluctuating asymmetry at 36 weeks (Campo and Prieto, 2009), which are indicators of lower stress.

3.3. Results about perch design criteria that best satisfy the hens' behavioural needs without impacting negatively on their health (ToR2)

ToR 2: Identify the design criteria of the perch, such as material, shape and length, which may influence the hens' welfare and assess which design is best suited to satisfy the hens' behavioural needs without impacting negatively on their health.

3.3.1. Perch temperature

The temperature of a perch is affected by the range of the ambient temperatures in the house and by the type of material used in their construction owing to differences in thermal conductivity. Thus, perches built with highly conductive materials, such as steel or stainless steel (thermal conductivity: 43 and 16 W/(mK), respectively), will be exposed to greater variations in temperature than perches made with materials of low conductivity, such as plastics, wood, rubber or PVC (thermal conductivity ranging from 0.03 to 0.19 W/(mK)). Therefore, the differences in the capacity for heat transfer (loss or gain of heat) of perches built of diverse materials may have implications for the comfort of the hens while perching.

3.3.1.1. Conductivity and the artificial provision of cooling

The effects of acute or chronic heat stress episodes in laying hens are well documented in the scientific literature (e.g. Mahmoud et al., 1996; Mashaly et al., 2004; Melesse et al., 2013). To avoid these situations, more or less sophisticated automatic environmental control systems usually regulate the range of ambient temperature. In addition, perch temperature is also susceptible to manipulation by artificially cooling or heating the perches, usually by running chilled or warm water through them. Previous studies on the effects of cool perches in broiler chickens (from the 3 weeks of age until the end of rearing at 6 weeks) have shown a higher used of the coolest perch sections and a positive effect on the body weight for females (Estévez et al., 2002), and research is currently ongoing to determine the potential benefits of cool perches for commercial application in layer hens (Gates et al., 2014). The use of cool perches therefore has the dual purpose of meeting behavioural hen demands for perching, and controlling, or moderating, the impact of heat stress episodes. Although warm perches have a similar potential to be used as heating devices, so far only one study has looked at its effect on resting and comfort behaviour (Pickel et al., 2011).

3.3.1.2. Cool perches (water inside the perches) versus ambient temperature perches

A series of experimental studies in White Leghorn pullets was designed to determine the potential benefits of providing cool perches (cooled by chilled water) when environmental temperature exceeded 25 °C, compared with the effects of non-cooled perches. Cool perches were built in galvanised pipes and were cooled by chilled water circulating in a closed water circuit. Both cooled perches and ambient perches were provided to the hens from 16 to 32 weeks of age. When hens were 27 weeks old, they were exposed to a four-hour acute heating episode in which temperature was increased to 32–34.6 °C.

Makagon et al. (2014) reported no effects of the cool perches on bone mineralisation or muscle deposition at 32 weeks of age (mineralisation of the keel of 0.091 ± 0.002 and 0.095 ± 0.004g/cm^2 for the cool and ambient perches, respectively). Liedtke et al. (2014) indicated that, following the acute heating episode, no differences were detected in comb or rectal temperatures in layer hens exposed to cool or ambient temperatures, although they were significantly lower than those with no access to perches. Daytime perch use was similar with cool perches (20 %) and ambient perches (18 %) three days prior to the acute heat stress episode. However, during the heat stress episode, cool perch use was significantly higher (58 %) than ambient perch use (45 %), with the onset of panting and wing spreading delayed in hens with access to cool perches (Makagon et al., 2014). These authors concluded that cool perches may assist layer hens in coping with heat stress.

3.3.1.3. The effects of perch surface temperature (15, 18 and 28 °C)

Pickel et al. (2011) analysed the effect of varying the perch surface temperature on resting behaviour and comfort by manipulating the temperature of the water passing through the perches, with temperatures of 15, 18 (room temperature) and 28 °C. Perches were galvanised steel pipes 34 mm in diameter. At night, an average of 93.3 % of the layer hens were found to be using the perches, regardless of their temperature, spending a similar amount of time no matter what test perch they were on. In total, 80 % of layer hens were resting in a sitting position, compared with 20 % resting standing, with more standing occurring in the 28 °C perch group than in the 15 and 18 °C perch groups. The results are summarised in Table 3.

Table 3: Summary of the results of the effect of perch temperature

Breed	Treatment	Welfare indicator	Results	Reference
Hy-Line	Cool versus ambient perches	Bone mineralisation and muscle deposition at 32 weeks	NS	Makagon et al. (2014a)
Hy-Line	Cool versus ambient perches	Daytime use of perches	20 % cool, 18 % ambient NS	Makagon et al. (2014a)
Hy-Line	Cool versus ambient perches	Daytime use of perches (acute heat stress episode)	58 % cool, > 45 % ambient	Makagon et al. (2014a)
Hy-Line	Cool versus ambient perches	Comb and rectal temperatures (acute heat stress episode) (differences in hens with perch versus no perch access)	NS	Liedtke et al. (2014)
Lohmann Selected Leghorn	Perch surface temperature: 15, 18, 28 °C	Night perch use	NS 93 % More resting standing at 28 °C	Pickel et al. (2011)

NS, no significant difference.

3.3.2. The effect of dry versus wet perches and dirty perches

3.3.2.1. Definition of dryness or wetness

There are detrimental effects of moisture on feet of the hens. There is little information about dryness and wetness related to perches per se but moisture in the litter is a well-known factor that affects the incidence of foot pad health in poultry (e.g. Martland, 1984; Ekstrand et al., 1997; Wang et al., 1998). Increases in moisture levels might occur as result of water spillage, condensation, wet faeces due to the diet, health problems or, in some cases, over drinking. Although the causal mechanism is still unknown, it is suggested that high water content may increase the production of irritants or bring them into closer and more persistent contact with the foot skin (Wang et al., 1998). In addition to the foot health problems triggered by increased moisture levels, manure may create slippery conditions, which when deposited in the perches may potentially increase the risk of accidents.

3.3.2.2. Available data from literature

Dry versus wet perches

Wang et al. (1998) investigated the effect of dry versus wet perches in combination with dry or wet litter on the incidence of foot pad lesions in 120 cage-reared Hisex layer hens. The prevalence of foot pad dermatitis in dry (17 %) and wet perches (13 %) when the litter was dry was similar (no statistical difference). In contrast, when the litter was wet, prevalence of foot pad dermatitis was 49 % for dry perches and 48 % for wet perches. The incidence of the lesions was not affected by the presence of wet perches.

Clean versus dirty perches

Scott and MacAngus (2004) investigated the effect of faecal contamination on the ability of medium hybrid brown hens to jump between paired perches of different materials. The type of perches used were 5 × 5 cm wooden perches with rounded edges, 4 cm semi-circular metal perches with half-rounded sections or 4 cm rounded PVC perches which where clean or dirty with 0.5- to 1-cm deep fresh poultry manure. Hens took longer to jump from PVC perches when clean than from wooden or metal perch types. However, no differences were observed when perches were dirty, as time to jump from both metal and wooden perches increased compared with clean perches of the same materials. In addition, the number of hens failing to jump from dirty wooden and metal perches increased, whereas, for PVC perches, the number of hens failing to jump reduced. The authors concluded that, once the perches become dirty, any welfare issues concerning the risk of injury from slippery perches cease to be as important as the potential slipperiness of the manure covering the perch itself. The results are summarised in Table 4.

Table 4: Summary of the results of the effects of wet and dirty perches

Genotype	Treatment	Welfare indicator	Results	Reference
Hisex	Combination of: wet litter, dry perch wet litter, wet perch dry litter, dry perch dry litter, wet perch	Foot pad lesions	For dry litter: NS between dry (17 %) and wet (13 %) For wet litter: NS between dry (49 %) and wet (48 %)	Wang et al. (1998)
Shaver medium hybrid brown	Paired perches of the same material: 5 cm wooden round, 4 cm metal half-rounded, 4 cm PVC Perches clean or dirty	Time to jump	Longer for PVC when clean NS when perches dirty	Scott and MacAngus (2004)
Shaver medium hybrid brown	Paired perches of the same material: 5 cm wooden round, 4 cm metal half-rounded, 4 cm PVC Perches clean or dirty	Number of hens failing to jump	Lower for wooden and metal than for PVC when clean NS when dirty	Scott and MacAngus (2004)

NS, no significant difference.

3.3.3. Material

3.3.3.1. Definition of material

The material of which perches are made (either on commercial farms or in experimental facilities) can be wood, plastic or metal, either covered with rubber or not. Wood can be hard or soft wood. Some prototype perches have been tested with materials to increase perch softness, e.g. with air cushioning on top of the perch (Pickel et al., 2011).

3.3.3.2. Available data

The available data from the literature can be summarised in Table 5.

Table 5: Summary of the results of perch materials

Genotype	Material	Welfare indicators	Results	References
White, LSL Brown, LB	Plastic, wood Plastic, rubber-coated metal	Keel bone deviations	NS	Kappeli et al. (2011a)
Different (field study)	Wood, plastic, metal	Keel bone deviations	NS	Kappeli et al. (2011b)
White and brown	Hardwood, plastic, hardwood covered with 4 mm of rubber	Keel bone deviations Bumble foot Toe pad hyperkeratosis	NS Bumble foot: plastic > hardwood NS	Tauson and Abrahamsson (1996)
White, LSL	Plastic, wood	Keel bone deviations Bumble foot	Keel bone deviation: NS Bumble foot: plastic > wood	Valkonen et al. (2005)
Brown, HB	Steel, wood, plastic	Preference for perching Perching behaviour	Wood: preferred NS	Chen et al. (2014)
LSL	Wood, steel, rubber cover	Day and night perching behaviour (resting, standing, preening, frequency of balance movement and comfort behaviour)	Balance movement: rubber < wood and steel Standing: steel < wood, rubber	Pickel et al. (2010)
ISA brown	Hardwood, softwood, textured metal, smooth plastic, padded vinyl	Daytime perching and roosting proportion, breaking strength, feather, sole and claw damage	More perching on softwood and vinyl padded Less sole damage and better plumage condition in softwood Less sole damage and more overgrown claw with increasing perching	Appleby et al. (1992)

HB, Hy-Line Brown; LB, Lohmann Brown; LSL, Lohmann Selected Leghorn; NS, no significant difference.

Various papers present studies about the role of perch material on different welfare outcomes for laying hens. Indeed, all perch design elements, including material, could have consequences for animal welfare either in a positive (increasing perching, decreasing balance movement, increasing resting on perch, etc.) or in a negative manner (increasing keel bone problems, bumble foot, toe pad hyperkeratosis, etc.) (Jendral and Linthorne, 2009). The choice of the material is of high concern regarding animal welfare, but cage cleanness and disinfection are also important (some materials are easier to clean than others). Studies have been undertaken at the field level (one paper) or in experimental facilities (eight papers). The effect of perch material has been studied mostly in furnished or test cages and, in a few cases, in non-cage systems.

Perch material could have an important influence on the prevalence or severity of keel bone problems. Hard materials, such as metal, are potentially responsible for keel deformities/fractures. In an aviary system, Kappeli et al. (2011a) studied the effect of different perch materials (plastic, rubber-coated metal or wood) on keel bone deformities from week 6 onwards. One experiment examined 4 000 White Lohmann Selected Leghorn pullets reared in an aviary system (two types of aviaries, two types of perches in each system with different materials (plastic and rubber-coated metal) and shapes) and then transferred to one of two laying aviaries. One laying aviary (Rihs Boleg 2, four pens) was equipped with mushroom-shaped plastic perches (the same as during rearing, 4.5 cm wide, 7 cm high) and the other (Globogal voletage, four pens) had wooden perches (3.5 cm wide, 3 cm high). In a second experiment, 2 000 Lohmann Brown chicks and 2 000 Lohmann Brown parent stock were reared in the same conditions as previously described (with birds of each strain submitted to each condition). During laying, hens were kept in 24 floor pens with elevated perches (12 with plastic perches and 12 with rubber-coated metal, the same as during rearing). There were practically no keel bone deformities during rearing, but deformities began to appear by week 22 and increased throughout the laying period in both experiments. In the first experiment, no significant difference was found between the two aviary systems (equipped with different perch materials), but this may have been the result of the high variation in the prevalence of deformities between pens in both systems. In the second experiment, hens from pens with rubber-coated metal perches had more moderate and severe keel bone deformities and fewer birds from these pens had normal keel bone structure than hens from pens with plastic perches. It was proposed that the deformities associated with metal perches were caused by trauma, probably because the rubber used was too thin to compensate for the hardness of the metal. Nevertheless, the complex interactions between perch material, width and height, together with high variation between pens, precludes a robust conclusion about the effects of the material.

Non-fractured keel bone deformities and foot pad lesions possibly result from high mechanical pressure loading during perching activities (Tauson and Abrahamsson, 1996). In this regard, Pickel et al. (2011) undertook a study to analyse peak pressure and contact area of the keel bone and foot pad in perching laying hens. Several shapes of perches of different materials were compared. Confounding of shape and material in this experiment did not allow a firm conclusion about material alone. However, it did appear that perches with a soft surface (experimental air cushion below a soft polyurethane surface) reduced peak force and increased contact areas compared with commercial perches. Soft materials of this kind could possibly decrease keel bone and foot pad welfare problems.

In field surveys, it is usually very difficult to isolate any effects of perch material because this is frequently confounded by housing system and other parameters (genotype, management, perch arrangement, frequency of perch use, etc.) For example, Kappeli et al. (2011b) conducted a survey on 39 non-cage flocks in Switzerland and showed an association between housing system and perch material, with single-tier systems being more likely to use wooden perches and aviary systems more likely to employ metal or plastic perches. Although the aviary systems were associated with a higher prevalence of keel problems, no conclusions could be drawn about the extent to which perch material was determining such problems.

When hens are given the choice between different perch materials, a wooden perch is often chosen (Chen et al., 2013). Tauson and Abrahamsson (1994, 1996) studied hardwood and hard plastic perches of the same shape in getaway cages. Although plastic perches are easier to keep clean than hardwood ones, the authors concluded that plastic perches result in more bumble foot than hardwood. Soft rubber perch covers do not reduce bumble foot or keel bone lesions compared with hardwood. Valkonen et al. (2005) also found more bumble foot in hens from furnished cages fitted with plastic perches compared with those furnished with wooden ones. Jendral and Linthorne (2009) studied an outbreak of bumble foot which had manifested in a furnished colony cage house equipped with mushroom plastic perches. They tried to resolve the problem by replacing plastic perches with semi-circular hardwood perches. Although hens showed a preference for the wooden perches, there was no improvement of the hens' foot condition. Chen et al. (2013) gave grouped hens in test cages a choice between perches of the same design but of three different materials (steel, wood and plastic). Wooden perches were chosen significantly more than steel and plastic perches, but this tendency decreased with increasing group size (from one to eight hens), probably because of competition for the preferred perch. Perch material had no effect on perching behaviour in this paper. Wood may be preferred because of its moderate hardness and lower thermal conductivity (Pickel et al., 2010) and because it is less slippery than other materials such as metal or PVC (Scott and MacAngus, 2004) In contrast, Pickel et al. (2010) found a rubber-coated surface to be less slippery than steel or wood. In this paper, hens were experimentally submitted to different materials and a broad range of welfare outcomes was studied, including balance movements. Standing was shown less often on steel than on wooden and rubber-covered perches. Balance movements were fewer on rubber perches than in wood and steel. Preening and comfort behaviours were not modified by perch material. These divergent results suggest that the 'characteristics' of the rubber cover (e.g. softness, non-slippery, thickness) influence hen preference and usage. The importance of the perch surface texture was underlined by Appleby et al. (1992) who said that hens generally perched most on softwood and vinyl-padded perches, which gave more grip for their feet, and least on plastic perches with the smoothest surface.

3.3.4. Colour

3.3.4.1. Definition of colour

Chickens have similar, although slightly broader, responses to light than humans. Chickens are slightly more sensitive to the blue (~ 480 nm) and red (~ 650 nm) parts of the spectrum (Prescott and Wathes, 1999). However, sensory biology suggests that, if perches appear to be of different colours to humans, they are likely to be perceived in a similar way by hens. Very few papers studied the colour of perches. The colour can vary from the natural colour of the material (brown for wood, grey for metal, white for plastic) to a specific colour (e.g. wooden perch painted in white or black).

3.3.4.2. Available data

Commercial housing systems for laying hens are usually kept at low light intensities with the primary intention of reducing feather pecking. This low light intensity can restrict the ability of hens to jump from slats to perches and to jump between perches, so jumps can be misjudged. In these conditions, altering perch colour is a potential way to make the perches more visible to hens, preventing or decreasing landing accidents.

Taylor et al. (2003) trained hens to jump from perch to perch with a distance of 75 cm. Results showed that perch colour has an effect on the number of hens jumping from perch to perch and the latency to jump at low light intensity only (0.6 lx compared with 1.8 and 32 lx). Indeed, 91 to 95 % of hens jumped successfully to all perch colours at 32 lx, whereas this proportion fell to 87, 80 and 62 % at 0.6 lx for white, natural wood and black perches, respectively. In the same way, latency to jump from perch to perch was significantly shorter for white perches than for natural brown and black ones (latency being even longer for black ones than for brown ones), at the very low light intensity of 0.6 lx. It is thought that these results are due to the higher visibility of the white perch at the low light intensity. At the higher light intensities, perch colour had no significant effect, indicating that there was no preference for perch colour by itself. Other authors, studying laying hens' preferences during the night in cages did not show any difference between white, black and brown perches (Chen and Bao, 2012). These results suggest that providing perches of a material that contrasts well with the dark background of poultry houses could help hens to move from perch to perch in very low light intensity conditions and could prevent landing accidents.

3.3.5. Shape

3.3.5.1. Definition of shape

Shape is defined as the cross-section of a perch. Different shapes are used in layer hen housing: round, oval, rectangular, square or mushroom-shaped perches can be found. The edges of rectangular and square perches often are chamfered. In aviary systems, curved profiles are used at the edges of tiers and the slatted floor or the wire mesh of the tiers are offered as perches.

3.3.5.2. Available data

There are only a few studies on the shape of perches and these have focused on different outcome measures. In some of these studies, the shapes of perches varied with other properties such as the diameter and the material. Moreover, all studies on perch shape have been conducted in cages (enriched or get away) or in certain experimental settings. Thus, the relevance of these results for non-cage systems is questionable, as perch use may differ in cage and non-cage systems.

In experimental cages equipped with two wooden perches of rectangular (3.5 × 3.5 cm) and round (3.5 cm) shape, Chen et al. (2014) observed the usage of perches. During the night, hens preferred the rectangular perch to the round perch. In the daytime, hens showed more comfort behaviours on the rectangular perches, but other observed behaviours and usage of perches did not differ between the two shapes.

In conventional cages equipped with either round (3.5 cm) or rectangular (5.0 × 2.2 cm) wooden perches, a trend for higher daytime use of rectangular perches than of round perches was found (Duncan et al., 1992). However, foot pad lesions were less frequent in cages with rectangular perches than in cages with round perches.

In the daytime, laying hens used a wooden rectangular perch (5 × 2 cm) with a height of 45 cm less often than platforms differing in height (5 or 46 cm) and surface (wire mesh or hardboard) (Faure and Jones, 1982b).

Tauson and Abrahamsson (1994) conducted two experiments in which they addressed the shape of perches. In one experiment, get-away cages were equipped with rectangular perches (5.3 × 3.3 cm) of hardwood, round perches (3.6 cm) of softwood and a perch made of welded wire mesh (10 cm wide). These perches were offered simultaneously in the following combinations: rectangular/rectangular, rectangular/wire, round/rectangular and round/wire. The incidence of bumble foot was highest in the rectangular/rectangular setting and lowest in the round/wire setting. Keel bone lesions were worst in the round/rectangular setting compared with the other combinations. Perching behaviour did not differ between combinations. In another experiment, the hens were offered perches of welded wire mesh (10 cm wide) and additionally either mushroom-shaped perches (4.8 × 6.8 cm), narrow perches of hardwood (3.5 × 5.0 cm), rectangular perches of hardwood (5.3 × 3.3 cm) or oval perches made of beech wood. Bumble foot scores were poorer in get-away cages with mushroom-shaped perches than in those with oval and narrow perches. When offered at a high position, the oval perch was used less, but, at a lower position, hens roosted more on the oval perch than on the narrow perch. The hygiene of the plastic mushroom perch was better than the other perches, and the oval perch had the poorest hygiene standards. In a further experiment, either the mushroom perches or the oval perches were installed at the top tier of aviary systems. Bumble foot scores was better with the oval perches than with the plastic mushroom perches, but the latter were cleaner. The perch usage at night was high but did not differ between mushroom and oval perches (94 and 88 %, respectively).

Pickel et al. (2011) measured the peak force and the contact area on the keel bone and foot pads of hens resting on round, square and oval perches. Each shape was tested in three perch widths. Peak force under the keel bone was lower on square perches than on oval and round perches. Contact area was highest on square perches, followed by oval perches, and was the lowest on round perches. In sitting hens, the peak force under the foot pads was lower on oval than on round and square perches. The contact area of foot pads was lowest on round perches, followed by oval and then square perches. In standing hens, peak force under the foot pads was lowest on oval perches, highest on square perches and intermediate on round perches. The contact area under the foot pads of standing hens was lowest on round perches, highest on square perches and intermediate on oval perches.

Finally, Cox et al. (2009) showed that perch profile in furnished cages had more impact on perch occupation than perch material (wood, plastic, iron).

3.3.6. Width

3.3.6.1. Definition of width

The width of a perch is the widest extent of its cross-section measured in parallel to the floor. For round perches, the width is equivalent to the diameter. In perches with a rectangular cross-section, the height is given in addition to the width.

3.3.6.2. Available data

There are two preference tests focusing on the width of perches. In an experimental study, hens were offered two rectangular perches (3 × 3 cm and 5 × 5 cm) at a height of 25 cm (Chen et al., 2014). At night, the smaller perch (3 cm) was preferred to the larger perch (5 cm) in small groups (one and four hens). In the daytime, hens showed more pecking on the 5 cm perch, but perch use did not differ. Struelens et al. (2009) tested preferences for perches differing in width during the night and daytime in enriched cages. Cages were equipped with either seven perches of different widths arranged parallel to each other or two perches for which the seven different widths were arranged stepwise. Tested perch widths were 1.5, 3.0, 4.5, 6.0, 7.5, 9.0 and 10.5 cm. During the daytime, hens spent less time on the smallest perch (1.5 cm) than on the wider perches (9.0 and 10.5 cm) when perch width was arranged stepwise. When perches were arranged in parallel, there was no clear trend for preferring the perches with increasing width. During the night, there was no effect of perch width in either of the two experiments.

The usage of perches and the behaviour while perching during the night was also tested by Pickel et al. (2010). Experimental pens were equipped with one round perch of 2.7, 3.4 or 4.5 cm width. Perch usage and resting and comfort behaviours did not differ between perch widths. However, balance movements were lowest on the perches with the largest width.

Appleby (1998) investigated if perch slope and width (and length) affected perch use. Individual cages were equipped with softwood perches of a rectangular cross-section fitted across the width of each cage. Perches either had a slope (8 °) or did not have a slope. The width of perches was 3.8, 5.0 or 6.0 cm. Hens spent about half of the daytime on the perches irrespective of perch width or angle.

In an experiment, contact area and peak force on foot pads and the keel bone were measured while laying hens were sitting and standing on perches differing in width (3.4, 4.4 or 6.0 cm) (Pickel et al., 2011). While sitting on the perches, the contact area under the keel bone was larger and the peak force on the foot pads was lowest on the widest perch compared with the smaller ones. Peak force on keel bones was not affected by perch width. While standing, the contact area under the foot pads was larger on the widest perch.

3.3.7. Length

3.3.7.1. Definition of length

The length of a perch describes the longitudinal extent of a perch. For usage of perches, the perch length for each hen is most important.

3.3.7.2. Available data

First, it should be noted that studies on the effects of the length of perches are scarce.

Appleby (1995) recorded usage of perches by medium-weight hens (about 2 kg) kept in cages with softwood rectangular (5.0 × 2.5 cm) perches. The perches offered different lengths per hen: 12, 13, 14 or 15 cm. During the daytime, perch length did not affect perch use. At night, perch use increased with increasing perch length, as uses of 81, 86, 94 and 95 % were recorded for perches offering 12, 13, 14 and 15 cm per hen, respectively. Moreover, perch use of the perches offering 14 and 15 cm per hen was significantly higher than of the perches offering 12 and 13 cm.

Perch usage in relation to perch length was also investigated by Duncan et al. (1992), with laying hens kept in conventional cages and a group size of four. Cages were equipped with one perch of 45 cm, one perch of 60 cm or two perches of 45 cm, resulting in 11.25, 15 or 22.5 cm perch length per hen, respectively. Daytime perch usage of the 2 × 45 cm and 1 × 60 cm perch lengths was higher than of the 1 × 45 cm perch. At night, perch usage was highest for the 2 × 45 cm perches (99–100 %) and lower for the 1 × 60 cm (71–78 %) and 1 × 45 cm perches (60–72 %).

In a study done with enriched cages, Cook et al. (2011) varied group sizes (5, 10, 20 and 40 hens) and lengths of round metal perches per hen (15.0, 17.0, 19.0 or 25.8 cm). Usage of perches at night was significantly lower in the cages with the smallest perch length (15 cm) than in all of the other cages.

3.4. Results about the minimum and maximum height and most suitable design of perches (ToR3a)

ToR 3a: Propose the minimum and maximum height and most suitable design of the perch according to the above data which may be considered appropriate or adequate.

3.4.1. Height

3.4.1.1. Definition of height

For the purpose of this opinion, perch height is taken to be the distance between the floor (of the cage or the barn) and the perch. In systems with single or multiple elevated platforms or tiers, the vertical distance between the tier and the perch is a second measure of height, and ideally both should be reported (see more details in Section 1.3.3).

3.4.1.2. Available data

The systematic review of the effect of perch height on keel bone fractures/deformities/injuries, bone strength, foot lesions and perching behaviour (O'Connor et al., in press) assessed 1518 abstracts. They identified nine studies related to height of perches which reported perch use and one study which reported keel injuries. These studies were the basis for a descriptive analysis of perch height against perch use. Only six of these studies actually contained data in sufficient detail for them to be plotted in graphs of night and daytime usage. Because of the rather low number of papers, this descriptive analysis was not able to account for lack of independence, differences in sample size and other important sources of heterogeneity. Three papers (Struelens et al., 2008b; Tuyttens et al., 2013; Chen et al., 2014) referred to cage systems and the three others (Cordiner and Savory, 2001; Newberry et al., 2001; Brendler et al., 2014) referred to non-cage systems.

On the basis of the data provided by the systematic review, the following Figures 7–10 can be generated which graphically describe the relationship between perch height and perch use during day and night for the cage and non-cages systems of the six papers.

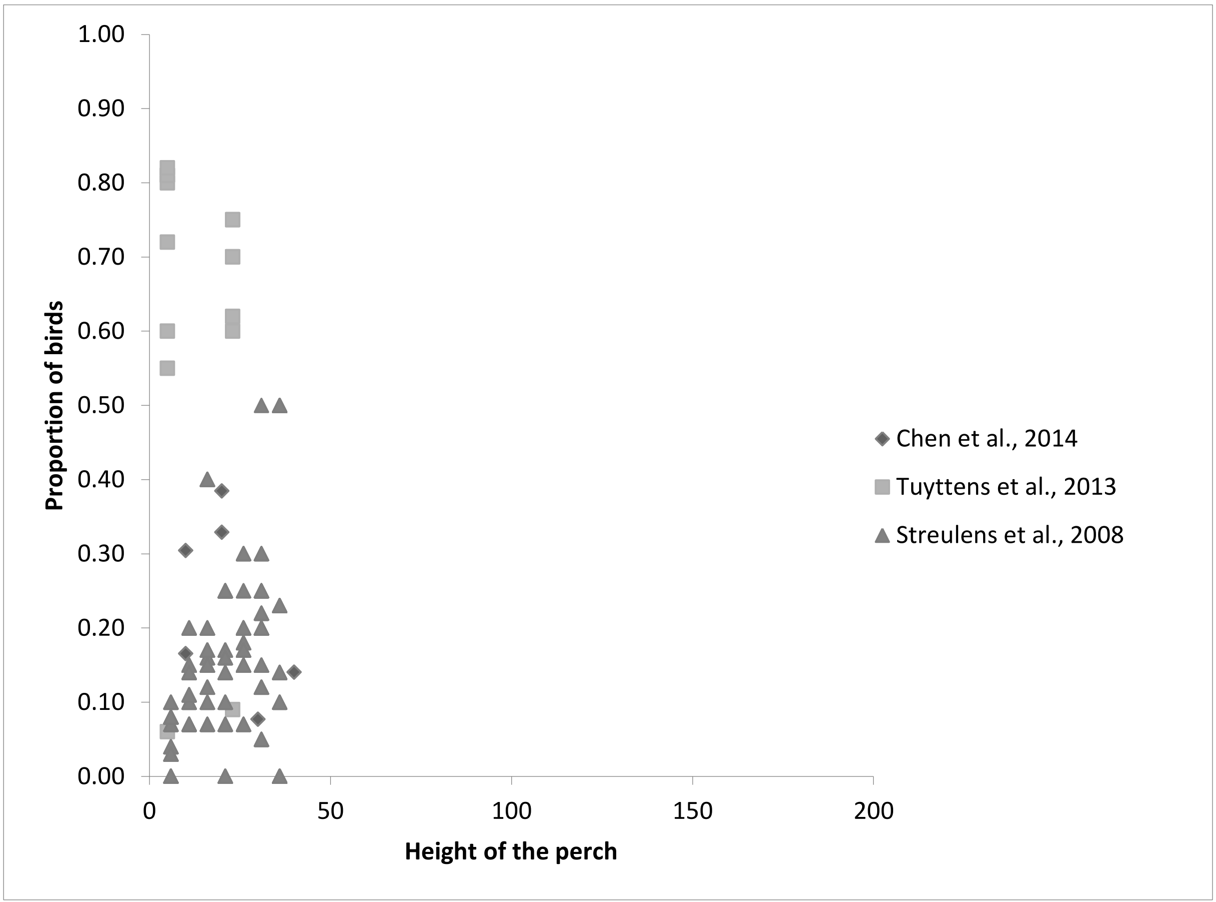


Figure 7: Scatterplot comparing raw data of the height of perches with metrics of usage of perches during the night in cage systems. Multiple data points arise from single studies, and multiple studies may occur at one point. Different symbols represent data points from different studies

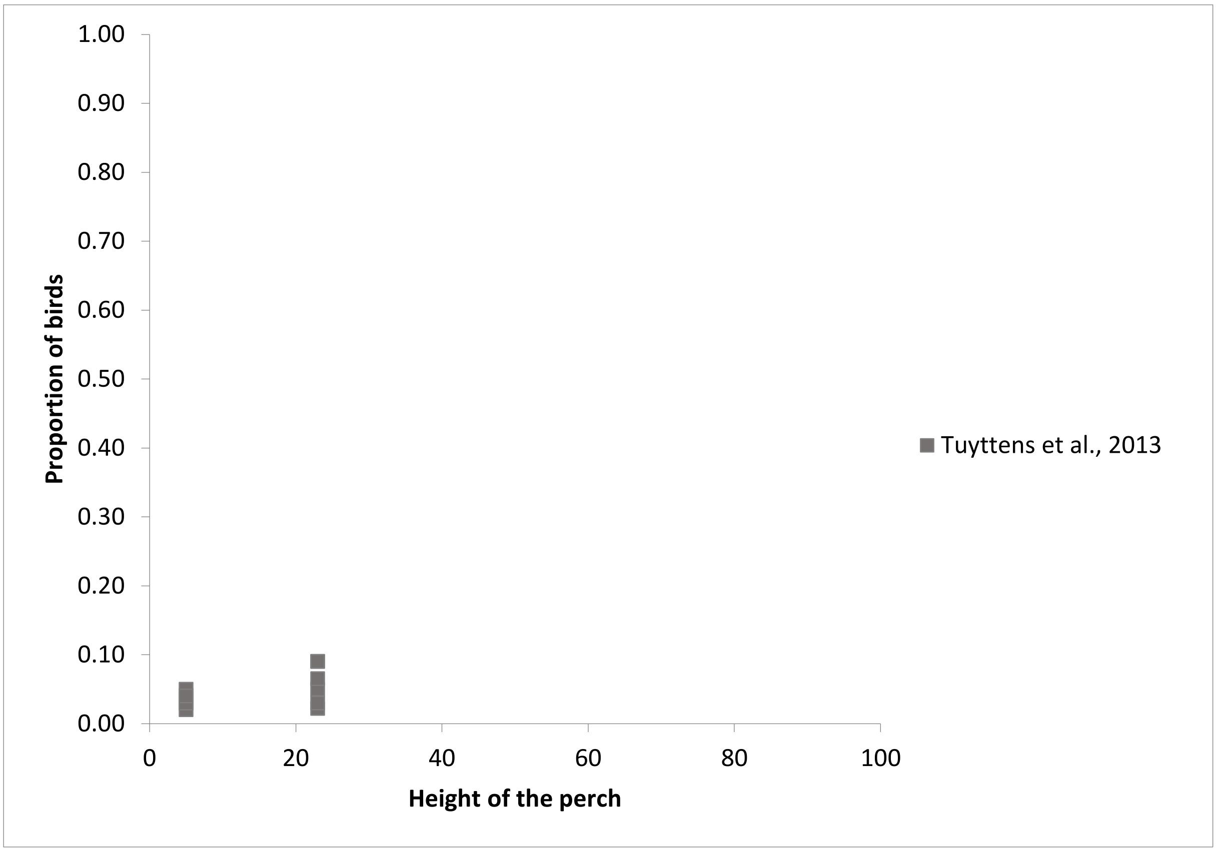


Figure 8: Scatterplot comparing raw data of the height of perches with metrics of usage of perches during the day in cage systems. Multiple data points arise from one study

The three studies on cage systems did not all reach the same conclusions regarding the effect of perch height on perch use. Chen et al. (2014) found no effect of heights from 10 to 40 cm on perch use, and neither did Tuyttens et al. (2013), who investigated a range from 5 to 23 cm. However, the latter study reported more sitting behaviour as a proportion of perch usage on higher perches than on lower perches. Struelens et al. (2008b) found that hens were more likely to roost on the highest perches (range 6–36 cm) at night. They also investigated the relationship between perch height and the height of the ceiling (range 150–45 cm) and suggested that use of the highest perches was hampered by ceiling distances of 24 cm or less.

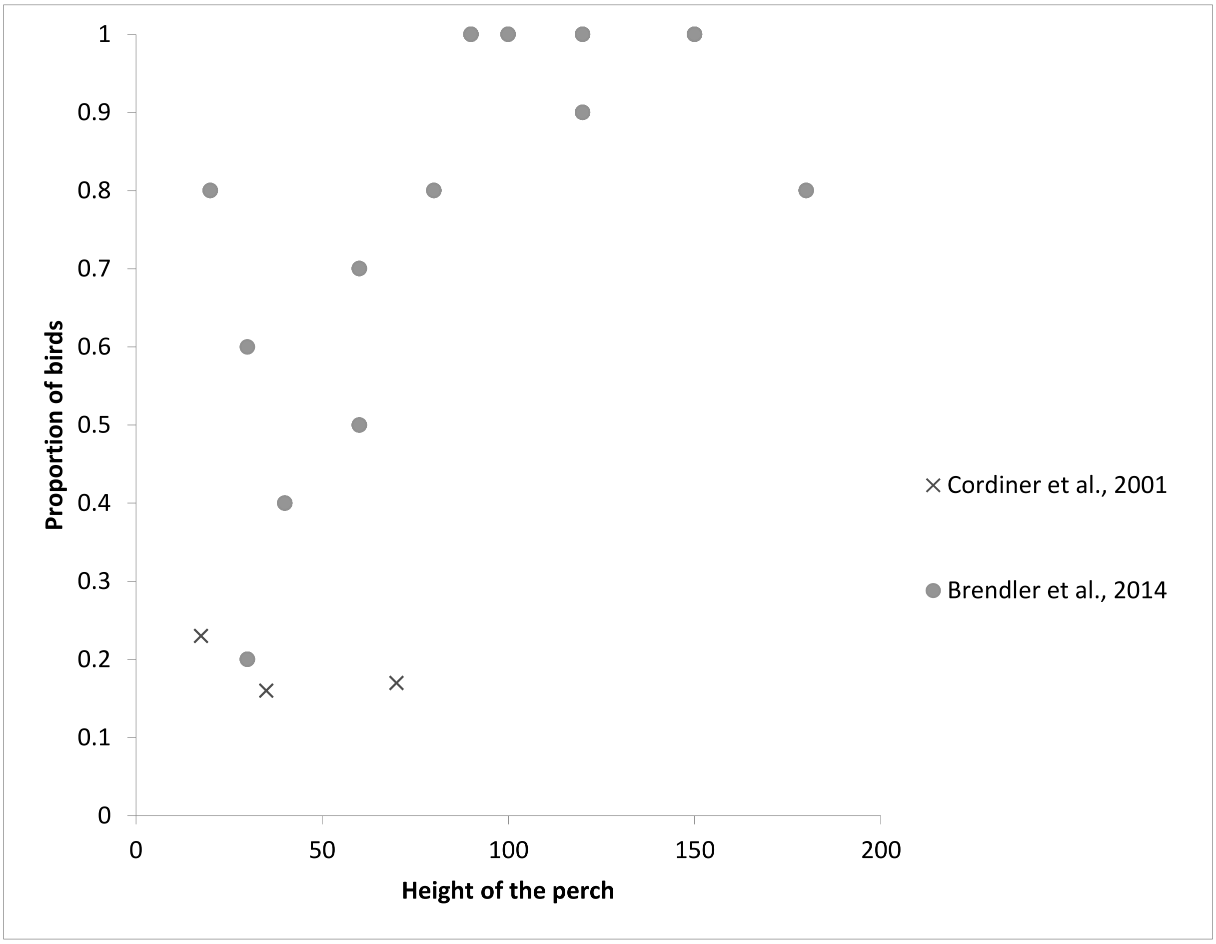


Figure 9: Scatterplot comparing raw data of the height of perches with metrics of usage of perches during the night in non-cage systems. Multiple data points arise from single studies, and multiple studies may occur at one point. Different symbols represent data points from different studies

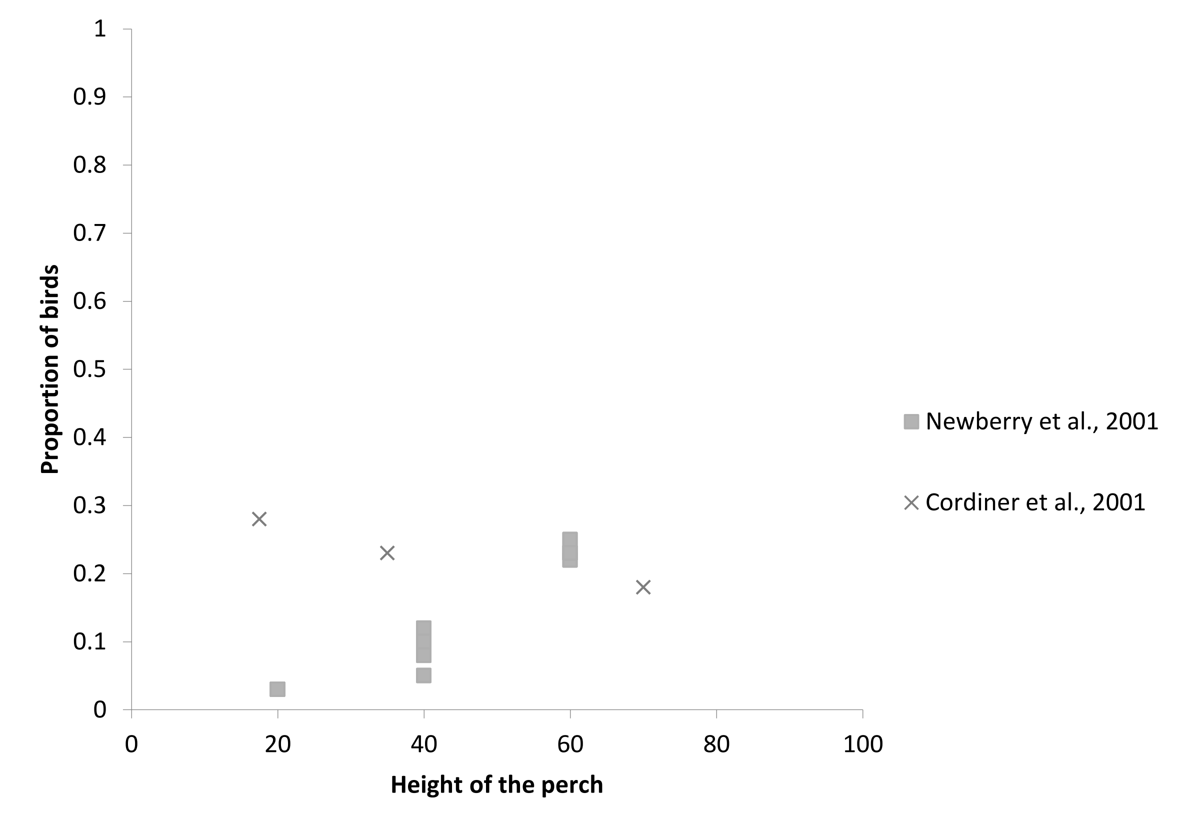


Figure 10: Scatterplot comparing raw data of the height of perches with metrics of usage of perches during the day in non-cage systems. Multiple data points arise from single studies, and multiple studies may occur at one point. Different symbols represent data points from different studies

In a descriptive analysis of non-cage systems, Cordiner and Savory (2001) investigated daytime and night time use of perches at heights ranging from 17.5 to 70 cm, and did not find a significant effect of height. Wichman et al. (2007) compared daytime usage of perches at heights of 20, 40, 50, 90 and 130 cm. When the birds had to jump to the perches from the floor, the lower heights were used most. When perch access was made easier, the most preferred heights were 50 and 90 cm, with very few birds using perches of 130 cm. The two other non-cage studies found a positive effect: Brendler et al. (2014), who investigated the effect of heights ranging from 20 to 180 cm on night time use, and Newberry et al. (2001), who investigated the effect of heights ranging from 20 to 60 cm on daytime use. Newberry et al. (2001) found the 60cm perches were used significantly more than perches at20cm or 40cm. Brendler et al. (2014) found that nearly all birds roosted on perches at heights of 90cm or above. When perches were lower than 80cm birds were as likely to use the floor as the perches for night-time roosting. Because virtually all birds roosted on perches at heights of 90cm no additional benefits of higher perches could be detected. Both of these studies support the suggestion that increased perch height up to at least 80 cm will positively affect perch use.

3.4.2. Position

3.4.2.1. Definition of position

For the purposes of this review, perch position is taken to mean the placement of perches relative to each other, or the placement of perches relative to cage or house structures (other than the floor, which is considered in Section 3.4.1.1).

3.4.2.2. Available data on the position of perches in relation to the front or back of the cage (furnished cages)

Furnished cages are generally arranged such that hens at the front of the cage look out over the egg-collection and inspection passageway. Cages are arranged back to back, with the rear of each cage in the centre of each row. Many layouts of perches now exist in commercially available furnished cages. Most of these provide parallel straight perches, situated near the front, middle or rear of the cage, and sometimes situated directly above an interior feed trough. Two or three rows of perches may be provided, e.g. at the front and rear, or at the front and in the middle. Perch height has been considered elsewhere, but if perches of different heights are provided within a furnished cage, the angle at which a hen must jump to move between perches is another aspect of perch position which must be considered.

There are few data available comparing the costs and benefits of different commercially available perch positions. However, one set of studies has examined frontal versus rear placement of perches, and the interaction of this with perch elevation. These results are described in Table 6 below.

Table 6: Summary of experimental results on perch position relative to furnished cage structure

Genotype	Treatment	Welfare indicator	Results	Reference
LB	NE vs. BE	Daytime perch use	19.1 % of hens on two low perches, 10.9 % on BE	Rönchen et al. (2010)
LSL1440	NE vs. BE	Daytime perch use	22.9 % of hens on two low perches, 10.4 % on BE	
LSL	BE vs. FE vs. ST	Daytime perch use	23.5 % on FE, 16.9 % on BE, 13.3 % on ST	
L silver	BE vs. ST	Daytime perch use	19.2 % on BE, 14.9 % on ST	
LSL	NE vs. FE vs. BE	Bone strength	No overall effect, but LSM tibia strength on NE > on FE	Scholz et al. (2009)
LSL	NE vs. FE vs. BE	Bone strength	No overall effect, but LSM tibia strength on FE > on NE	
LSL	FE vs. BE vs. ST	Bone strength	No overall effect, but LSM humerus strength on FE + BE > on ST	
L silver	BE vs. ST	H/L ratio (higher ratio = more stress)	H/L on ST > on BE	Scholz et al. (2008)
LB	NE vs. FE vs. BE	Foot condition (higher score = worse)	Overall effect of hyperkeratosis sole pad score: NE > FE; also LSM toe NE > FE; toe/claw BE > NE + FE	Rönchen et al. (2008)
LSL	NE vs. FE vs. BE	Foot condition	Overall effect of hyperkeratosis sole score: NE > FE; also LSM toe NE > FE; toe/claw NE > FE	
LSL	NE vs. FE vs. BE	Foot condition	Overall effect of sole lesion: NE > BE; also LSM hyperkeratosis toe/claw NE > FE	

BE, one low front (by feeder) and one back-elevated perch (back elevated); FE, one front-elevated perch (front elevated) LB, Lohmann Brown; LSL, Lohmann Selected Leghorn; NE, two low non-elevated perches (non-elevated); ST, stepped perches, arranged like for FE but all perches slightly higher than in FE (stepped).

Because not all designs were tested in all experiments, overall conclusions are difficult. However, it appears that perch use was greatest when both perches were non-elevated although this was accompanied by minor increases in foot damage. Elevation of one perch decreased perch usage, and further elevation decreased perch usage further, increased stress and decreased bone strength.

3.4.2.3. Available data on horizontal orientation of perches in furnished cages

Although the majority of cages provide parallel perches, a minority of commercial designs have included perches that are perpendicular to the cage front. To meet the requirements of 15 cm perching length per hen, sometimes perches can be placed at an angle to each other. The implications of using such cross perches are described in Table 7.

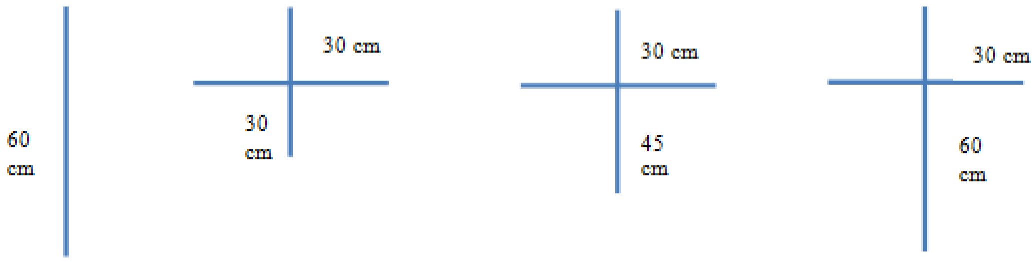
In one set of experiments, a number of different experimental arrangements of perches (termed models by the authors) were examined:

Design 1: single straight perch (in one set of studies, e.g. 60 cm for six hens (10 cm/hen))

Design 2: cross perches providing same total length of a single perch for six hens (e.g. 30 cm + 30 cm)

Design 3: cross perches providing greater total length of a single perch for six hens (e.g. 30 cm + 45 cm)

Design 4: cross perches providing much greater total length of a single perch for six hens (e.g. 30 cm + 60 cm)



Design A: single straight perch for eight hens allowing 12 cm/hen

Design B: cross perches for eight hens providing 15 cm/hen

Design C: cross perches for eight hens providing 15 cm/hen

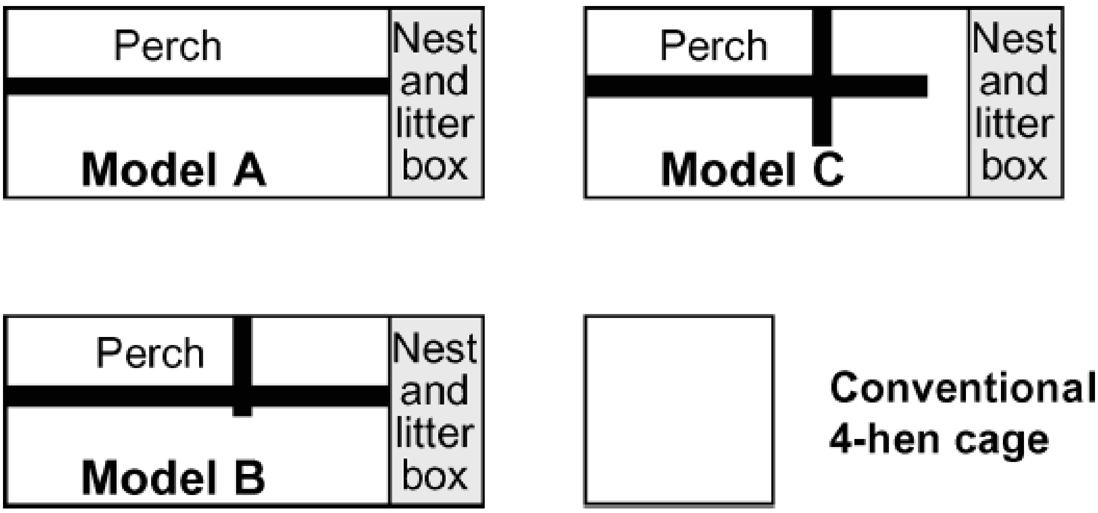


Table 7: Summary of experimental results on relative horizontal perch position in furnished cages

Genotype	Position	Welfare Indicator	Results	Reference
Bovans Goldline	Straight 60 cm vs. 30 + 30 cm	Daytime perch use	Straight > cross perch	Struelens et al. (2008a)
Bovans Goldline	Straight 60 cm vs. 30 + 45 cm	Daytime perch use	Straight > cross perch	
Bovans Goldline	Straight 60 cm vs. 30 + 60 cm	Daytime perch use	Straight > cross perch	
Bovans Goldline	Straight 60 cm vs. 30 + 30 cm	Evening perch use	Straight > cross perch	
Bovans Goldline	Straight 60 cm vs. 30 + 45 cm	Evening perch use	Straight > cross perch	
LSL + LB	Straight model (A) vs. cross models B and C	Night-time perch use	85 % hens on A and B, 81 % on C	Wall and Tauson, (2007)
Hy-Line White	Straight A vs. cross B and C	Night-time perch use	89 % on A, 86 % on B, 82 % on C	
LSL + LB	Straight A vs. cross B and C	Feather condition (1 bad to 4 good)	3.9 on A, 3.71 on C. B is intermediate	
Bovans Goldline	Straight 60 cm vs. 30 + 60 cm	Evening perch use	Straight > cross perch	

LB, Lohmann Brown; LSL, Lohmann Selected Leghorn.

In summary, straight perches permit greater daytime, evening and night-time usage and improved feather condition.

3.4.2.4. Available data on horizontal distance and angle between two perches

In non-cage systems, hens may attempt to jump between perches or from a perch to other elevated structures. The physical ability of hens to negotiate horizontal distances and angles between perches or perches and other elevated structures is relevant, as it will affect the risk of making poor jumps and bad landings that can be significant risk factors for keel bone fracture. Studies that have examined this aspect are summarised in Table 8. These studies have examined two aspects:

1. Horizontal distance varying between 0.5 and 1.15 m between stepped perches
2. Angle varying between 30 and 60 ° between stepped perches

Table 8: Summary of experimental results on the ability of hens to jump between perches at different relative positions

Genotype	Position	Welfare indicator	Results	Reference
LB	0.6, 0.8 or 1.15 m gap between two stepped perches	Movement	All hens move at 0.6 or 0.8 m, one failed at 1.15 m	Moinard et al. (2005)
LB	0.6, 0.8 or 1.15 m gap between two stepped perches	Movement	Hens visually fixate at all distances	
LB	0.6, 0.8 or 1.15m gap between two stepped perches	Movement	All hens move at 0.6 m, one failed at 0.8 m (down), one failed at 1.15 m (up), six failed at 1.15 m (down)	
Hy-Line Plus	Horizontal distance between perches	Movement	Hens move more easily at 0.5 than at 1.0 m	Taylor et al. (2003)
LB	Horizontal distance between perches	Movement	0.73 probability of movement at 0.5 m, 0.16 probability at 1.50 m	
ISA brown	Angle of 0, 30, 45 or 60 ° between two stepped perches	Movement	Up easier at 0, 30 and 45 ° than at 60 °; down progressively more difficult as angle increases	Scott et al. (1999)
LB	Angles and horizontal and diagonal distances varied	Movement	Angles of 30 ° easier than of 60 ° (up and down); diagonal separation of 0.5 m easier than of 1.0 m	Scott et al. (1997)
ISA brown	Horizontal distance between perches	Movement	Hens move more easily at 0.5 m than at 0.75 m. Significantly slower movement at 1.0, 1.25 and 1.5 m	Scott and Parker (1994)
ISA brown	Horizontal distance between perches	Movement	Increased failure to move between perches at spacing of 1.0 m or above	

LB, Lohmann Brown; LSL, Lohmann Selected Leghorn.

In summary, as distances between perches increase beyond approximately 75cm-80cm vertically, horizontally or diagonally, or as angles increase beyond 45 ° (measured at the horizontal plane), the risk of bad landing is increased.

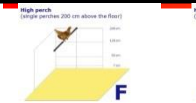
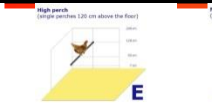
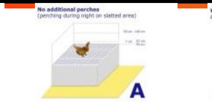
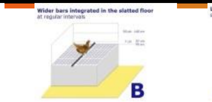
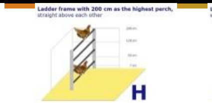
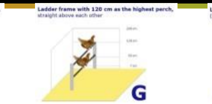
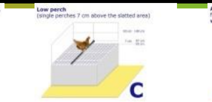
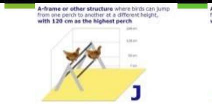
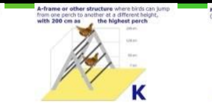
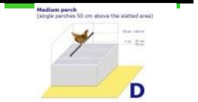
3.4.3. Outcomes from the expert knowledge elicitation process

The first expert knowledge elicitation (EKE) exercise was related to perch configuration (height and design of perches) and two aspects were ranked: (1) the percentage of hens using the perch at night and (2) the level of keel bone damage. The second EKE exercise was related to the size, material and shape of the perches. The full report and analysis from the EKE exercise are published in a separate report (EFSA, in press).

3.4.3.1. Exercise 1: adequate perch configuration

Results are presented in Table 9 as the average rank of the individual experts' rankings and resulted in the following order of scenarios (lowest rank on the left to highest rank on the right).

Table 9: Question 1A: Please rank the 10 scenarios by the preference of the hens to use the perch at night

Ranking	Low preference F	E	A	B	H	G	C	J	K	High preference D
Result										
Average rank	1.6	2.6	3.6	4.3	4.5	5.6	6.6	8.5	8.8	8.9
Inter expert variation (SD)	±0.9	±0.9	±2.7	±1.6	±1.5	±1.5	±1.3	±1.2	±1.9	±0.8

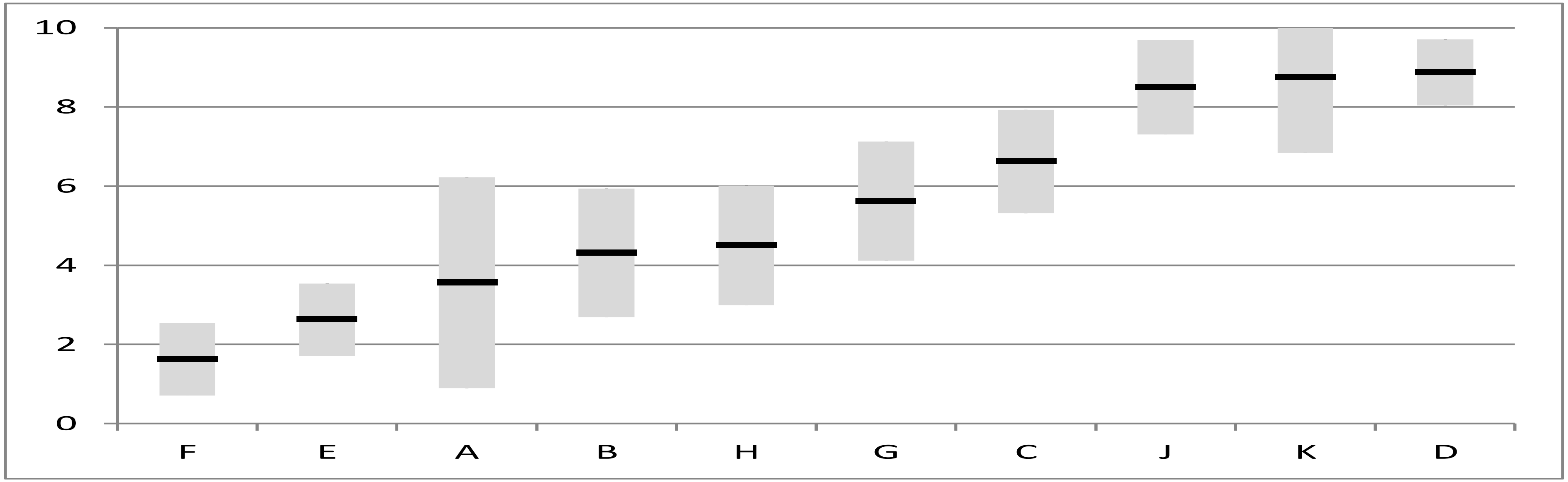


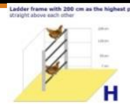
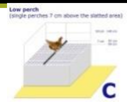
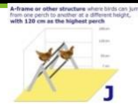
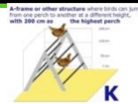
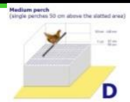
Figure 11: Average rank (and standard deviation) given by the hearing experts to scenarios on preferences of the hens to use the perch at night

The outcome of the ranking exercise appears to include two considerations by the experts that were confirmed in the subsequent discussion between them. First, scenarios with increasing height provided above the litter level are ranked higher (K, J, D, C) than scenarios in which climbing to the higher perches appears more difficult or in which higher perches were less accessible (G, H lower to middle perches) or scenarios in which the perch is not elevated (in relation to the slatted area) or present anymore (B, A). Second, the use of perches that are difficult to reach is expected to be lower (H top perches, E, F). During the discussions, it was considered that hens have difficulties coping with height increases beyond 90 cm, and that hens are unlikely to climb a ladder design but have to jump onto each perch directly. In contrast, hens can climb from one level of an A-frame perch to another level.

A theoretically determined ranking system based on perch height and accessibility agreed very well with the expert ranking (Table 10 and Figure 12). In conclusion, the experts assumed that hens like to have the opportunity to get as high as possible above ground level, and stated that this level should be accessible by a series of small sized steps (e.g. 40 cm). Accessibility through other means (such as ramps or other structures) was not investigated in this EKE study.

Relevant deviations from these two principles were recognised for the 200 cm above litter scenario and the 200 cm ladder scenario, which were given too low a rank (compared with the theoretical considerations) by the expert panel. This demonstrates concerns related to the physical reachability of, for example, a 200 cm perch by direct jumps. In contrast, the experts rated the 120 cm ladder more positively than expected from the average distance to the perch. The reason for this might be that the experts did not recognise that the jumping height to the perches is less than 90 cm for only the lower perches in the ladder, thus making the upper perch theoretically unreachable, which is not the case for the 120 and 200 cm A-shape perch.

Table 10: Comparison of the ranking by hearing experts with theoretical ranking based on two aspects: 'maximum height' and 'average accessibility'

Ranking	**Low preference**									**High preference**
	F	**E**	**A**	**B**	**H**	**G**	**C**	**J**	**K**	**D**
Result										
Average rank	1.6	2.6	3.6	4.3	4.5	5.6	6.6	8.5	8.8	8.9
EKE rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Highest perch above ground level (cm)	200	120	90	90	200	120	97	120	200	140
Average distance to climb to next-level perch (cm)	200	120	n.a.	0	120	80	7	40	40	50
Height-based rank	9	5	1.5	1.5	9	5	3	5	9	7
Accessibility-based rank	2	3.5	1	10	3.5	5	9	7.5	7.5	6
Mean rank height and access	2	4.75	5.25	9.75	2.75	5.5	8.5	6.75	4.75	5
Combined rank	**4**	**2**	**1**	**5**	**7.5**	**3**	**6**	**7.5**	**10**	**9**
Deviation (combined – EKE rank)	**3**	0	–2	1	**2.5**	**–3**	–1	–0.5	1	–1

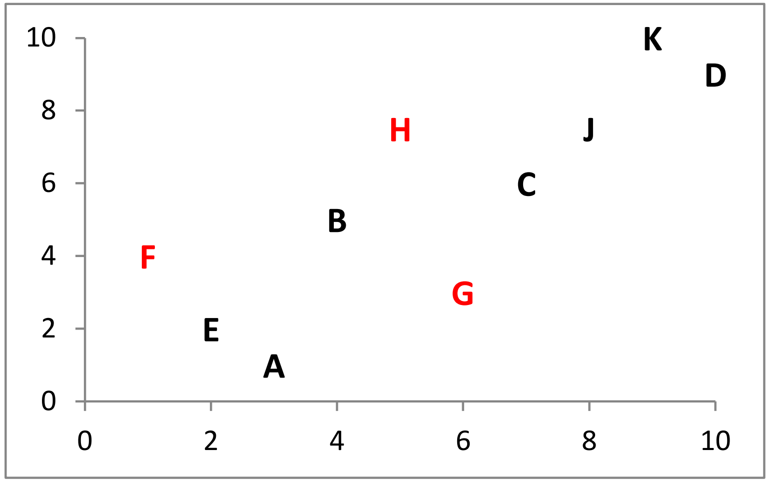


Figure 12: Comparison of expert ranking (horizontal axis) with ranking using two aspects: ‘maximum height’ and ‘average accessibility’ (vertical axis). The letters indicate the scenario and large differences are highlighted in red

Table 11: Question 2A: Please rank the 10 scenarios by the expected rate of keel bone deformities (including damage and fractures)

Ranking	Low rate									High rate
	A	B	C	D	J	G	K	E	H	F
										
Average rank	1.4	2.0	2.8	3.8	5.6	6.8	7.0	8.1	8.4	9.1
Inter expert variation (SD)	0.6	0.3	0.4	0.5	0.7	1.4	1.4	1.4	1.3	1.4

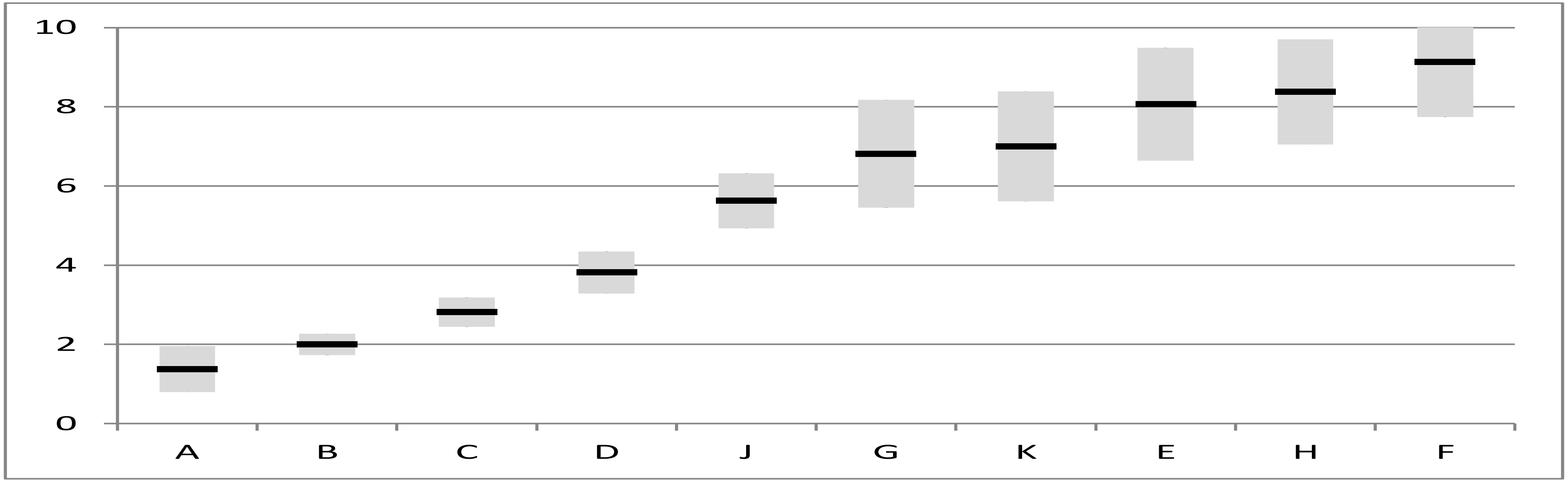
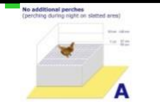
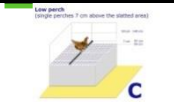
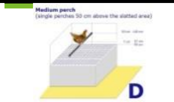
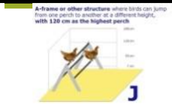
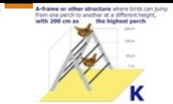
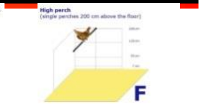


Figure 13: Average rank (and standard deviation) given by the hearing experts to scenarios on keel bone damage

The rank order appears to be dominated by the rule that the higher the perch is above the ground, the higher the chance is of bone damage. The A-shape perches (J and K) are slightly better rated then the ladders (G and H), as the steps are expected to facilitate accession to the highest tiers.

Table 12: Comparison of the ranking by hearing experts with theoretical ranking based on the aspect 'average height'

Ranking	Low rate									High rate
	A	**B**	**C**	**D**	**J**	**G**	**K**	**E**	**H**	**F**
										
Average rank	1.4	2.0	2.8	3.8	5.6	6.8	7.0	8.1	8.4	9.1
EKE rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Average perch height for all hens above litter or slatted area (cm)	0	0	7	50	72	80	111	120	120	200
Height-based rank	**1.5**	**1.5**	**3**	**4**	**5**	**6**	**7**	**8.5**	**8.5**	**10**
Deviation (height-based – EKE rank)	0.5	–0.5	0	0	0	0	0	0.5	–0.5	0

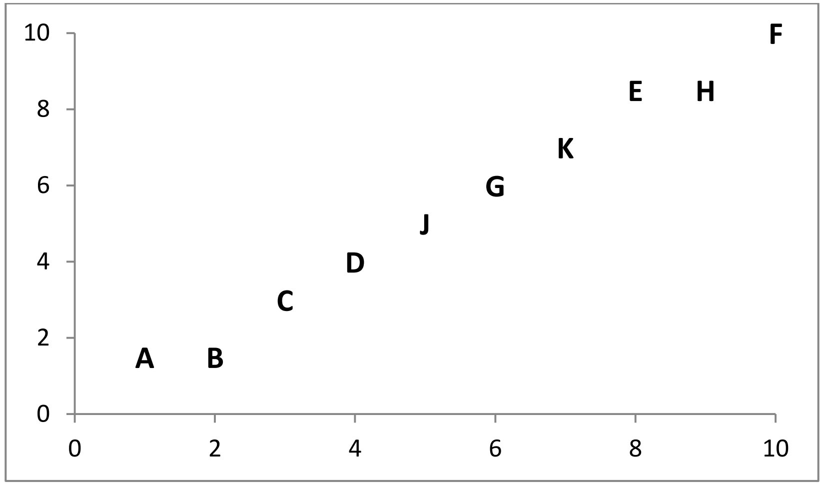


Figure 14: Comparison of expert ranking (horizontal axis) with ranking using the aspect 'average height' (vertical axis). The letters indicate the scenario

3.4.3.2. Exercise 2: adequate size, material and shape of perch

Table 13: Question 4A: Please rank the eight scenarios by the preference of the hens to use the perch at night

Ranking	Low preference							High preference
	B	D	H	A	E	C	G	F
Result								
Average rank	1.3	**2.8**	**3.4**	**4.3**	**5.3**	**5.7**	**6.7**	**6.7**
Inter expert variation (SD)	±0.7	±1.4	±1.8	±0.9	±1.8	±2.1	±1.2	±1.4

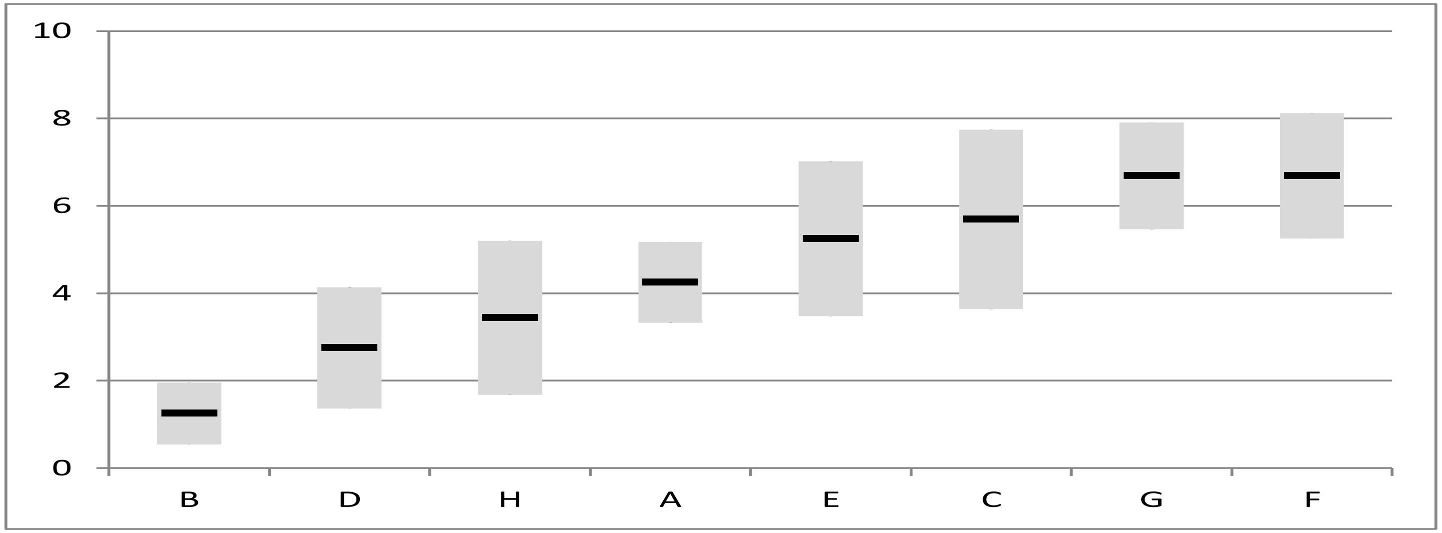


Figure 15: Average rank (and standard deviation) of preferences given by the hearing experts to different features of perches

Table 14: Question 5A: Please rank the eight scenarios by the expected rate of keel bone deformities (including damage and fractures)

Ranking	**Low rate** F	C	G	E	A	H	D	**High rate** B
								
Average rank	**2.4**	**2.8**	**3.3**	**3.9**	**4.5**	**5.6**	**6.4**	**7.1**
Inter expert variation (SD)	**1.2**	**2.3**	**1.3**	**1.8**	**1.4**	**1.2**	**1.6**	**2.5**

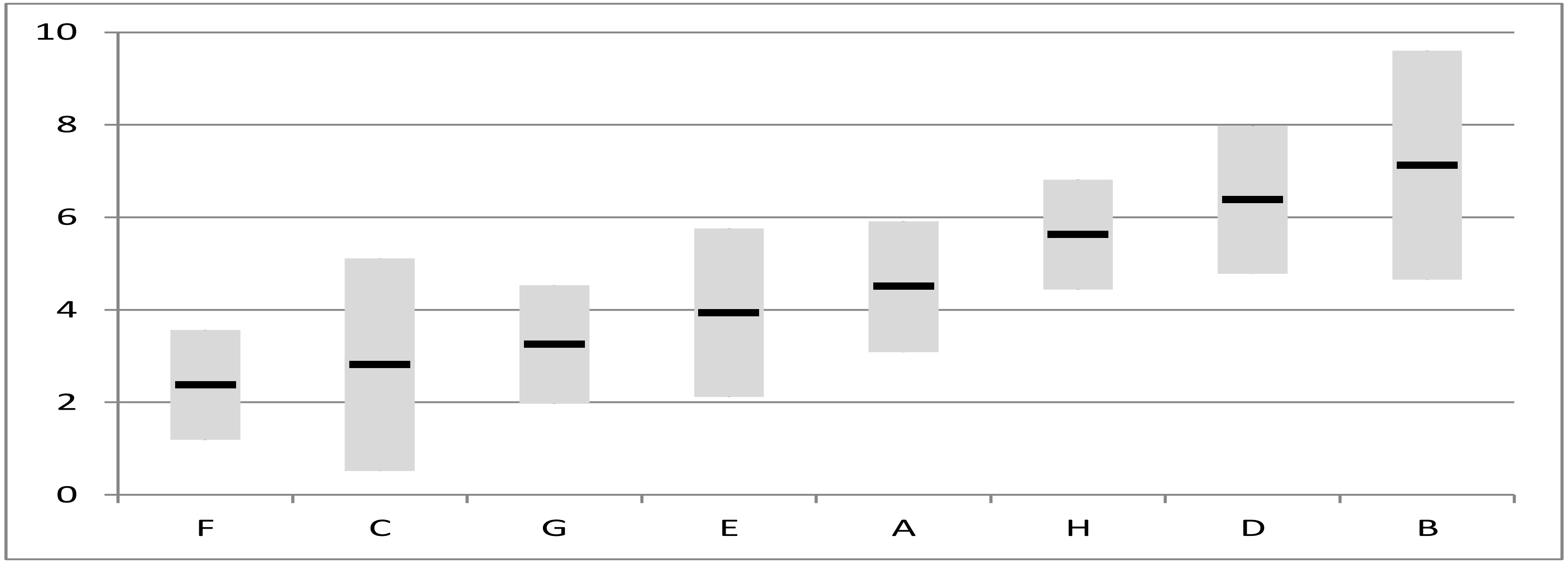


Figure 16: Average rank (and standard deviation) of keel bone damage given by the hearing experts to different features of perches

The resulting expert ranking based on expected preferences during the night and the expected level of keel bone damage is similar.

Material: rubber-coated, wood, plastic, metal

The results on the ranking of 'material' suggest that preference was given to increasing 'pliability'. The reason might be that a pliable deformable surface material may stabilise the grasping of the hen while roosting and may reduce peak pressure on keel bones.

Thickness: 6, 3, 1.5 cm

The discussions between experts suggested a ranking of 'thickness' reflecting ease of standing, rather than the need to grasp the perch. This could not be confirmed by the data, as the necessary scenarios to show this (e.g. mushroom profile with 6 cm thickness, etc.) were missing.

Profile shape: mushroom, circle, rectangle

The outcome reflected the tendency towards a more horizontal but rounded top line (mushroom preferred over circle), and a maximised top surface but still with rounded edges supporting clinging (mushroom preferred over rectangle).

3.5. Results about perch design criteria and animal-based welfare measures to be used to assess perch adequacy (ToR3b)

ToR 3b: If these data do not enable an assessment of the exact minimum and maximum height or range of heights which are appropriate from a welfare point of view, indicate a set of design criteria of the perch and animal-based welfare measures which may be used to assess if a perch is adequate.

Overall, as an additional outcome from the EKE and from the literature reviews, it became clear that an adequate design of perches is influenced by three overall aspects of perches: (1) elevation above ground level (**height**), (2) proximity and orientation to other perches or structures (**accessibility**) and (3) functioning of the design as an elevation point to view the scene (**functionality**).

As mentioned at the beginning of this section, the most common welfare consequences found in the literature were (1) usage at night, (2) usage in the day, (3) keel bone deformities and (4) keel bone fractures. Subsequently, for the EKE process, it was decided that the exercise should be restricted to focus on (1) night time usage and (2) keel bone damage (including deformities and fractures). The working group therefore suggests that the animal-based measures that could be used to verify the adequacy of perches are those that measure these two welfare consequences. They are reported here below in Table 15, together with the method reported in the literature for their measurement. More animal-based measures—and related welfare consequences—are reported in Appendix B. The method for their measurement and sample size are those suggested by the Welfare Quality protocols for laying hens.

Table 15: Animal-based welfare measures to assess if a perch is adequate

Welfare consequences	ABM	Method for measuring	Reference
Keel bone deformities/injuries	Evidence of deformities/injuries *Classification* 0—No deviations, deformities or thickened sections, keel bone completely straight 1—Deviations (flattening, s-shape, bending) present in very slight form 2—Deviation or deformation of keel bone (including thickened sections)	Palpation: examine the breast of the hen by looking at it (in the case of a featherless breast) or by running fingers alongside and over the keel bone. Collection of hens for assessment can be made either by penning (corralling) hens or by picking up individual hens in several areas of the hen house. The number of places to collect hens is dependent on the housing system and the number of compartments. Pick up a hen from within the penned group or from the litter or slatted floor, inspect the keel area visually and palpate the area. In cage systems, take the hens from different areas of the house and from different tier levels	WQ 6.1.3.1
		Post mortem	
Keel bone fractures	Evidence of fractures *Classification* See previous for deformities	Palpation: see previous for deformations	WQ 6.1.3.1
Night-time usage of hens	(Number or percentage of hens sleeping, roosting or resting on the perch)	Counting hens on the perch or off the perch. Lighting needs to be considered to enable inspection	
Daytime usage of hens	(Number or percentage of hens using the perch)	Counting hens on the perch or off the perch	

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

- Overall, the body of literature on the use of perches in cage and non-cage systems is limited. There are very few studies addressing the question of perch position. Even where studies are available, relevant features of perch height and position are often confounded with other factors. This limits the conclusions that can be drawn.
- The conclusions drawn below are based on convincing evidence in the literature referred to in this opinion, or based on the expert opinion consultation. In the latter case, this is indicated explicitly.

<u>ToR1: Identify to what degree a minimum and maximum height and the position of the perch are important factors for the hens' welfare.</u>

- Laying hens seek elevation during the day as well as at night. The motivation to seek elevation is particularly strong at night when hens select a site for resting or sleeping.
- Elevated perches allow hens to monitor the environment, to escape from other hens or (the perceived risk of) predators, to avoid disturbances and to improve thermoregulation.
- Perches provide laying hens with a perception of elevation. When raised platforms, grids or slats are used, birds at the edges will perceive this elevation. Birds in central or rear areas of platforms, grids or slats may not perceive that they are on a raised structure.

- The presence of elevated structures for perching can have negative consequences for animal health and welfare with increased prevalence of keel deformities and keel fractures. There is also an increased risk of vent pecking, if perch height allows the vent of a perching hen to be reached easily by another hen.
- Therefore, this opinion concludes that perch height has major but opposing effects on different aspects of laying hen health and welfare.

<u>ToR2: Identify the design criteria of the perch, such as material, shape and length, which may influence the hens' welfare and assess which design is best suited to satisfy the hens' behavioural needs without impacting negatively on their health.</u>

- Material, shape, length and width of the perch all influence perch preference and acceptability, and affect hen welfare and health. Perch colour has no impact on perching behaviour, except when the light intensity is very low, when white perches can more easily be seen by the birds.
- Adequate perching requires that hens are stable when sitting. Stability can be achieved through flat non-slippery platforms or grids, or perches that allow good grip (e.g. not slippery, wide enough and with an adequate shape for grasping).
- The risk of keel bone injuries and foot pad lesions can be decreased by perches of soft materials (softwood, rubber-covered perches). Wider perches increase contact area under the keel bone and reduce peak force on bones and foot pads, thus potentially reducing injuries.
- There is no consistent evidence from the literature on perch shape preference (e.g. round, oval, square, rectangular, mushroom) of laying hens. However, the experts' opinion was that perches with rounded edges were preferable.
- There is no consistent evidence from the literature of a preference for perch width within the range of 1.5 to 10.5 cm. However, the experts' opinion was that a perch width of 6 cm is better for bird welfare than a perch width of 3 cm (less good) or 1.5 cm (poor).

<u>ToR3a: Propose the minimum and maximum height and most suitable design of the perch according to the above data which may be considered appropriate or adequate.</u>

- In non-cage systems, the minimum and maximum height of perches is considered relative to the house floor and relative to the height of any platforms or tiers. In cage systems, the minimum and maximum height of perches is considered relative to the cage floor and to the cage roof.
- During the day, rates of perch usage are much lower than at night. In addition, hens do not show a clear preference for any specific height.
- According to scientific evidence in experimental floor pens, for night-time roosting, hens show a significant preference for accessing perches higher than 60 cm compared with lower perches. The experts' opinion was that a perch height of approximately (as not all height options were considered) 50 cm would best meet the hens' night-time preference.
- Making perches more accessible increases perch use and the experts considered that more accessible perches would reduce the risk of injuries.
- Although there is no evidence for a maximum height, when hens jump a distance of more than 80 cm vertically, horizontally or diagonally to reach or leave a perch, or jump an angle between 45 and 90 ° (measured at the horizontal plane), the risk of bad landing is increased. This is likely to increase the risk of injuries.
- In cage systems, perch use is reduced when the minimum distance between the highest perch and the roof is 20 cm or less. Possibly for the same reason, daytime usage of low perches is

generally greater than of elevated perches. It is likely (although not studied) that this constraint will also apply in non-cage systems.

ToR3b: If these data do not enable an assessment of the exact minimum and maximum height or range of heights which are appropriate from a welfare point of view, indicate a set of design criteria of the perch and animal-based welfare measures which may be used to assess if a perch is adequate.

- The most commonly used animal-based measures in the literature to assess perch adequacy are keel bone damage (including fractures and deformities), foot deformities and the usage of the perch by the hens. However, these ABMs are not solely related to perch design. More animal-based measures can be used to reinforce the assessment of perch adequacy. Suggested animal-based measures are provided in Appendix B.
- To assess if a perch is adequate, the design criteria that can be used are height, accessibility, shape, width and surface allowing a good grip, material (soft and not slippery) and length (allowing all birds to perch).

RECOMMENDATIONS

ToR1: Identify to what degree a minimum and maximum height and the position of the perch are important factors for the hens' welfare.

- Elevated structures for perching should be provided and should be accessible to all laying hens in a system to meet their behavioural needs. Elevation must be considered both relative to the floor and relative to any platforms or tiers that are provided in the house.

ToR2: Identify the design criteria of the perch, such as material, shape and length, which may influence the hens' welfare and assess which design is best suited to satisfy the hens' behavioural needs without impacting negatively on their health.

- Perches which are covered by pliable materials at points of body contact should be provided.
- Perches which consist of a bar or stick should be of an appropriate width to enable hens to grasp to minimise balance movements and reduce peak force under the keel bone and the foot pads.
- Within the constrained environment of a cage, a perch length of at least 15 cm per hen should be offered to enable all birds to perch.
- Non-cage systems should provide perching opportunities that take account of variation in the hens' ability to reach the perch. Therefore, stepped perches, ramps or other solutions should be provided to allow easy access to high perches, platforms and grids.

ToR3a: Propose the minimum and maximum height and most suitable design of the perch according to the above data which may be considered appropriate or adequate.

- The design of a perch should be such that injuries to the hens are minimised and perch use is maximised.
- Perches should provide laying hens with a perception of elevation.
- In non-cage systems, the minimum and maximum height of perches should be specified relative to the house floor and relative to the height of any platforms or tiers. In cage systems, the minimum and maximum height of perches should be specified relative to the cage floor and to the cage roof.
- In non-cages systems, the minimum perch height to adequately meet the hens' preference should be 60 cm from ground level.

- Although there is no evidence for a maximum height, hens should not have to jump more than 80 cm vertically, horizontally or diagonally to reach or leave a perch, and they should not jump an angle of more than 45 ° (measured from the horizontal plane).
- Perch design should ensure stable perching, e.g. by being graspable or solid and flat (and non-slippery).
- A perch width of between 3 and 6 cm is recommended to minimise balance movements and reduce peak force under the keel bone and the foot pads.
- Graspable edges of slatted or grid platforms or tiers that are at least 60 cm from the ground should be considered as part of the perching allowance of 15 cm per hen. Such edges are likely to provide hens with a perception of elevation.
- As the central and rear areas of slatted or grid platforms or tiers may not provide hens with a perception of elevation, it cannot be recommended that these areas are considered as part of the perching allowance, unless perches are provided in these areas.
- The distance between the perch and the cage roof, tier roof or building ceiling should be more than 20 cm.
- The area where two perches cross should not be considered as available perch length.
- In cages, a minimum perch length of 15 cm per hen is recommended.

<u>ToR3b: If these data do not enable an assessment of the exact minimum and maximum height or range of heights which are appropriate from a welfare point of view, indicate a set of design criteria of the perch and animal-based welfare measures which may be used to assess if a perch is adequate.</u>

- The animal-based measures that should be used to assess perch adequacy are keel bone damage (including fractures and deformities), foot deformities and the usage of the perch by the hens. It is opinion of the Panel that more animal-based measures should be used to reinforce the assessment of perch adequacy. Suggested animal-based measures are provided in Annex B.
- An adequate perch should have a height that attracts the maximum number of laying hens to perch (this involves a combination of the need to seek elevation and the accessibility of the perch) while minimising the risk of keel bone damage (not too high).

RECOMMENDATIONS FOR FURTHER RESEARCH

- The influence on perching behaviour of the hen rearing period needs to be further evaluated.
- The different features of the perches need to be investigated in an integrated manner so that conclusions can be drawn about the most adequate perch.
- Research is needed to establish if hens 'miss' perches or elevated structures if they have never experienced them.
- The WG has identified the following areas that need further investigation in order to define specific characteristics of perches or perching areas: (1) motivation of hens to survey their surroundings when perching and (2) motivation of hens to grasp. This research will be essential for maximising perch use from the hens with minimal impact on their health.
- More research is needed on strategies to reduce keel bone damage and vent pecking (e.g. genetic selection, nutrition, management) so that perches can be used safely by all hens. Methods for improving the accessibility of perches, e.g. optimum position and design of ramps, should be investigated.
- Minimum perch length requirements need to be investigated in non-cage systems.

- To facilitate the assessment of perch adequacy it is recommended that additional animal based measures are identified, and that a protocol is developed to standardise their application.

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APPENDICES

Appendix A. Links between features of the perches and welfare consequences.

Links are represented by an "x".

		Presence /absence of perches	Height of perches	Material	Shape	Diameter	Length of the perches (per animal)	Angle and distance between perches	Colour (contrast to background)	Fixture of perches	Spatial arrangement of perches related to house features (e.g. related to walls, drinkers)
Welfare consequences	**Red mite occurrence**	x		x (wood)	x					x	
	Keel bone deformation/injuries	x		x	x	x					
	Keel bone fractures	x	x	x	x	x	x	x	x	x	x
	Foot pad dermatitis (especially bumble foot)	x	x	x	x	x				x	
	Toe and claw damage	x	x	x	x	x				x	x
	Aggressive/agonistic behaviour (resulting in comb pecking wounds)	x	x				x	x			x
	Synchrony of behaviour						x				
	Plumage damage	x	x	x						x	x
	Fracture of bones other than keel bone	x	x (if difficult to reach)	x	x	x		x			x
	Bone strength	x	x								x
	Muscle strength-development	x	x								x
	Cloaca wounds		x					x			x

Welfare consequences	Presence /absence of perches	Height of perches	Material	Shape	Diameter	Length of the perches (per animal)	Angle and distance between perches	Colour (contrast to background)	Fixture of perches	Spatial arrangement of perches related to house features (e.g. related to walls, drinkers)
Night-time usage (number or % of birds sleeping, roosting or resting on the perch)	x	x	x	x	x	x	x			x
Daytime usage (number or % of birds using the perch)	x	x	x	x	x	x	x			x
Physiological indicators of stress (corticosterone, HL ratio, catecholamines, and other…,)	x									
Physiological indicators of stress (organ weights: e.g. liver weight, adrenal weight....)	x									
Abdominal fat	x									
Thermal-comfort behaviour (e.g. panting and huddling)	x	x	x			x				x
comfort behaviour (e.g. preening)	x	x	x	x	x	x	x			x
Balancing movements	x		x	x	x				x	
Egg quality	x	x								x
Flightiness and fearfulness	x	x								

Welfare consequences	**Presence /absence of perches**	**Height of perches**	**Material**	**Shape**	**Diameter**	**Length of the perches (per animal)**	**Angle and distance between perches**	**Colour (contrast to background)**	**Fixture of perches**	**Spatial arrangement of perches related to house features (e.g. related to walls, drinkers)**
Cleanliness and disinfection possibilities	x		x	x					x	x
Freedom of movement	x	x					x			x
Bird preference	x	x	x	x	x	x				x
Landing behaviour		x	x	x	x		x	x	x	x

Appendix B. Animal-based measures (ABM) that can be used to verify the adequacy of perches

Welfare consequences	ABM	Method for measuring	Reference
Red mite occurrence	Evidence of red mites *Classification* 0 – No red mites detectable on birds and in the house 1 – Red mites found on birds or in the house, but not in large numbers and not clearly visible (e.g. no or few mites found on hens, and mites found in the house are hidden in cracks and crevices but not in many places and not in large quantities) 2 – Large quantities of red mites found on birds and/or in the house (e.g. large numbers of mites are evident)	Examine both the equipment in the house and actual birds for red mites (Dermanyssus gallinae). Common mite infestation sites are under perches and in cracks and crevices. Red mites can often be found by scraping in cracks and crevices with a sharp implement. Another way to find mites is to hold a piece of white paper underneath the wire floor or perch and to knock on it, any red mites will then fall onto the paper and can be seen. Severe infestations can be seen clearly as 'clumps' of mites bunched together. Severe infestations can also be seen as blood spotting on eggs. Furthermore inspect the birds for presence of red mites by checking the comb, legs and breast skin- and check dead birds if they are present.	WQ 6.1.2.1.
		Put red mite traps under the perch and check	
Keel bone deformation/injuries	Evidence of deformations/injuries *Classification* 0 – No deviations, deformations or thickened sections, keel bone completely straight 1 – Deviations (flattening, s-shape, bending) present in very slight form 2 – Deviation or deformation of keel bone (including thickened sections)	Palpation: examine the breast of the hen by looking at it (in case of featherless breast) or by running fingers alongside and over the keel bone. Collection of birds for assessment can be made by either penning (corralling) birds or by picking up individual birds in several areas of the henhouse. The number of places to collect hens is dependent on the housing system and the number of compartments. Pick up a bird from within the penned group or from the litter or slatted floor, inspect the keel area visually and palpate the area. In cage systems take the birds from different areas of the house and from different tier levels	WQ 6.1.3.1.
		Post mortem	
Keel bone fractures	Evidence of fractures *Classification* See previous for deformations	Palpation: see previous for deformations	WQ 6.1.3.1.

Welfare consequences	ABM	Method for measuring	Reference
		Palpation	Validation in paper from Canada (Widowski, 2013)
		Palpation	Validation in paper from Scholz 2008
Foot pad dermatitis (especially bumble foot)	Evidence of foot pad dermatitis *Classification* 0 – Feet intact, no or minimal proliferation of epithelium 1 – Necrosis or proliferation of epithelium or chronic bumble foot with no or moderate swelling 2 – Swollen (dorsally visible)	Visual inspection: pick up a bird from within the penned group or from the litter or slatted floor. In cage systems take birds from different areas of the house and from different tier levels: Examine both feet of the hen and choose the foot with the worst condition to score.	WQ 6.1.3.1.
		Post mortem	
Toe and claw damage	Number of birds with toe damage *Classification* 0 – No evidence of damaged toes 1 – Fewer than 3 birds with damaged toes 2 – Three or more birds with damaged toes	Visual inspection: wounds on one or more toes and/or missing (parts of) one or more toes. As missing toes can origin from accidents during rearing, only fresh wounds should be taken into consideration. 100 birds are examined and information from these birds will be included in the final score.	WQ 6.1.3.1.
		Post mortem	
Aggressive/agonistic behaviour (resulting in comb pecking wounds)	*Classification* 0 – No evidence of aggressive behaviour 2 – Evidence of aggressive behaviour	Behavioural Observation: fighting, severe pecking at other birds or chasing other birds (when observed more than twice). Aggressive behaviours often signalled by a loud squawk or vocalisation.	WQ 6.1.4.1.

Welfare consequences	ABM	Method for measuring	Reference
	Classification Individual level: 0 – No evidence of pecking wounds 1 – Less than 3 pecking wounds 2 – Starting from 3 pecking wounds and more Herd level : Percentage of birds with scoring categories 0,1,2.	Counting Comb wounds: Pick up a bird from within the fenced or field area or from the litter or slatted floor. In cage systems take the birds from different areas of the house and from different tier levels: Examine the comb on both sides and look for pecking wounds and score using the photographic reference. Do not score healed lesions (scars).	WQ 6.1.4.1.
Synchrony of behaviour		Behavioural Observation	
Plumage damage	_Classification_ 0 – no or slight wear, (nearly) complete feathering (only single feathers lacking); 1 – moderate wear, i.e. damaged feathers (worn, deformed) or one or more featherless areas < 5 cm in diameter at the largest extent; 2 – at least one featherless area ≥ 5 cm in diameter at the largest extent	Visual inspection: individually. Score each animal according to three individual body parts (see photographic reference). For each bird 3 scores are given (i.e. 1 for each body part): being the back and rump together, around the cloacae (belly) and head and neck together. The 3 body parts are chosen to give information regarding the cause of feather damage: damage to feathers of the back and rump usually indicate feather pecking, damage to the feathers of head and neck can be caused by abrasion, and feather damage to the belly can be seen in highly productive animals. (However, the latter can also be caused by vent pecking.). For each body part a score is given on a 3-point scale, taking into consideration the 3 indicated body part	WQ 6.1.4.1.
Fracture of bones other than keel bone		Palpation not feasible – post mortem only possibility	
		Visual observation of newly fractured broken wings	
Bone strength		Lab techniques	
Muscle strength-development		Lab techniques	
Cloaca wounds		Visual inspections by picking the birds up	

Welfare consequences	ABM	Method for measuring	Reference
Night-time usage (number or % of birds sleeping, roosting or resting on the perch)		Counting birds on the perch, or off the perch. Lighting needs to be considered to enable inspection.	
Daytime usage (number or % of birds using the perch)		Counting birds on the perch, or off the perch.	
Physiological indicators of stress (corticosterone, HL ratio, catecholamines, and other…,)		Lab	
Physiological indicators of stress (organ weights: e.g. liver weight, adrenal weight....)		Lab	
Abdominal fat		Lab	
Thermal-comfort behaviour (e.g. panting and huddling)		Visual observations	
comfort behaviour (e.g. preening)		Visual observation	
Balancing movements		Visual observation	
Egg quality		Farm records	
Flightiness and fearfulness		Tests of fearfulness	

Welfare consequences	**ABM**	**Method for measuring**	**Reference**
		Noise level, flock activity	
Cleanliness and disinfection possibilities			
Freedom of movement			
Bird preference		Preference tests / literature	
Landing behaviour		Visual (video)	