

EXTERNAL SCIENTIFIC REPORT

Systematic review of the effect of perch height on keel bone fractures, deformation and injuries, bone strength, foot lesions and perching behavior

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ABSTRACT

This report provides a summary of four systematic reviews on the impact of perch height on laying hen keel bone fractures, deformation and injuries, bone strength, foot lesions and perching behavior. After conducting a scoping review and identifying outcomes of interest, the review protocols were developed. An extensive literature search was conducted in information sources such as CABI, PUBMED and relevant conference proceedings. 1518 abstracts were assessed for relevance and 9 studies reported perch use and 1 reported keel injuries. No studies reported summary effect sizes; therefore it was not possible to conduct a meta-analysis. In lieu of a formal meta-analysis, a descriptive analysis was conducted, which plotted reported perch height against metrics of perch use. This descriptive analysis was not able to account for lack of independence, differences in sample size and other importance sources of heterogeneity such as cage height. The descriptive analysis suggested a positive association with metrics that measured perch use and height, i.e., increased usage was associated with increased height.

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KEY WORDS

Systematic review, poultry, cages, aviaries, perches, keel bone, welfare

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BACKGROUND AS PROVIDED BY EFSA

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 5cm 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.

TERMS OF REFERENCE AS PROVIDED BY EFSA

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.

This contract was awarded by EFSA to: Annette O'Connor at the Iowa State University, Julie Glanville at the York Health Economics Consortium, University of York and Jan Sargeant at the University of Guelph.

Contract/grant title: "SYSTEMATIC REVIEW OF STUDIES ON THE USE OF PERCHES FOR POULTRY"

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INTRODUCTION AND OBJECTIVES

1. Background and Rationale (PRIMSA ITEM 3)

The housing requirements of laying hens have been modified over many years to enhance the welfare of laying hens. The addition of features such as perches to cages has been one of many changes made in recent years. However, while much research has been devoted to documenting the improvements of laying hen welfare with the addition of perches, the characteristics those perches should have is less clear and only more recently the subject of scrutiny. Characteristics of perches that can vary include the height of the perch, the material used for the perch, the shape of the cross-section of perch and the position of the perch.

2. Objective of Review (PRIMSA ITEM 4)

The specific objective of this project was to evaluate the effect of perch height on keel bone fractures, keel bone deformation, keel bone injuries, bone strength, foot lesions and perching behavior. Although many characteristics could be reviewed, the rationale for the focus on perch height was based on the preference for this characteristic by the EFSA working group commissioning the review.

To achieve this goal, the review questions were specified using the PICO format which stands for Population (P), Intervention (I), Comparator (C.) and Outcome (O) based on the EFSA guidance for systematic reviews (EFSA, 2010). As the EFSA working group was interested in multiple outcomes, several reviews were conducted and the specific review questions were as follows:

- Review question 1. What is the change in the prevalence or incidence of keel bone fractures, keel bone deformation, and keel bone injuries associated (O) with different categories of perch height (I/C) for layer hens housed in alternative, furnished or aviary systems (P)?
- Review question 2. What is the change in bone strength (O) associated with different categories of perch height (I/C) for layer hens housed in alternative, furnished or aviary systems (P)?
- Review question 3. What is the change in the prevalence or incidence of foot lesions (including foot pad dermatitis, bumble foot, toe damage and claw damage) (O) associated with different categories of perch height (I/C) for layer hens housed in alternative, furnished or aviary systems (P)?
- Review question 4. What is the change in the absolute or percentage of time spent perching at night and during the day (O) associated with different categories of perch height (P/I) for layer hens housed in alternative, furnished or aviary systems (P)?

MATERIALS AND METHODS

3. Protocol and registration (PRIMSA ITEM 5)

The protocol was designed after a scoping review to assess available data about perch characteristics and in consultation with EFSA. The results of that scoping review and consultation process are available from EFSA. The protocol is provided in Appendix A. Several changes occurred to the protocol during the review and these are described here. EFSA specified laying hens as the study animal, however during data extraction the EFSA working group requested the inclusion of one study that related to chicks. The search and screening was not repeated to find studies that included chicks. Also modifications were made to the outcome extraction forms to enable extraction of all possible pairwise comparisons of perch heights within one study.

4. Eligibility criteria (PRISMA ITEM 6)

4.1. Relevant participants

The population of interest was white and brown breeds of commercial layer hens used for egg production, housed in furnished cages, pens, small group housing systems and aviary systems. We excluded studies that directly related to home production of eggs that would not be sold. Dual-purpose breeds that are used in home egg production and small-scale pasture egg production were also excluded. The rationale for excluding other breeds is that the dimensions of perch needed are likely different for the weight and height of the bird. The birds had to be housed in furnished cages or aviary systems, not conventional cages.

4.2. Interventions

The interventions and comparators of interest were different heights of perches. The results needed to be stratified by housing system as differences in heights are important within systems. When not stated we assumed that perch height was measured as the perpendicular distance between the floor (or grid) and the perch. If we could not determine the perch height e.g. authors described perch as “higher perch” or “top perch” without reporting actual height of the perch above the floor or authors reported height of perch above some other structure in the housing system other than the floor, we excluded those papers as height would be inaccurate. We only included studies that controlled for other factors in the design or analysis. For example, if a study evaluated both perch material and perch height in a 2 by 2 factorial design but did not report either the effect size for perch height differences for each type of perch material or an effect size that adjusted for perch shape, we excluded this data as the effect size could not be extracted.

For purposes of combining data in the meta-analysis we originally intended to use the following groupings for perch heights:

- Heights for furnished/ enriched cages:

< 5 cm, < 10 cm, < 15 cm, 15 to <25 cm, 25 cm to < 35cm, 35 to <45 cm, ≥45cm

- Height for alternative (aviary / aerial) systems:

45-100 cm, 100-150 cm, 150-200 cm, > 200 cm

4.3. Types of outcome measures

The reviews differed by the outcome of interest. For review question 1, any measure of keel bone lesions was considered relevant i.e., prevalence, incidence, severity, etc. Further, any lesions associated with keel bones, i.e., fractures, deformities, etc. were included as relevant to the review. For review question 2, we used any measure of bone strength reported by the authors. As these data would likely be continuous measures we expected to compare the means of measures of bone strength. In the unlikely event that the measure of bone strength was a categorical variable, such as “passed a threshold” such data would still be collected. For review question 3, any foot lesions (including but not limited to foot pad dermatitis, bumble foot, toe damage and claw damage) were included. For review question 4, the time spent on perches, we collected data on the percentage of time spent perching (daytime or night time) at different perch heights, perch height preference of birds, the absolute number of birds perching on perches at different heights, the proportion of birds perching on perches of different heights, and the use of a perch (ever) at a given height.

4.4. Relevant study designs

Study designs of interest were observational or experimental studies that enabled a valid comparison of perch heights with respect to the outcomes of interest. Study designs where perch height was

confounded by other factors were excluded. Although randomization to group is designed to prevent selection bias/ confounding, the EFSA working group requested that we not use “randomization to group” as an exclusion criteria.

5. Information Sources (PRIMSA ITEM 7)

The searches for this review were designed and conducted as part of the previous scoping review. For the scoping review a range of information sources indexing published research were searched for studies reporting on perches and laying hens

Information on on-going or recently completed trials, unpublished research, and research reported in the grey literature was identified by searching trial registers, databases indexing conference proceedings, and specialised search engines as follows: TEKTRAN;CRIS;Conference Proceedings Citation Index – Science; Science.gov; ScienceResearch.com; Open Grey.

The following key conference proceedings from the last three years (where freely available) were also searched via conference webpages to identify additional conference abstracts: International Workshop on Assessment of Animal Welfare at Farm and Group Level, OIE Global Conference on Animal Welfare, European Symposium on Poultry Welfare, Congress of the International Society for Applied Ethology, International Society for Applied Ethology Regional Conferences, Congress of the International Society for Animal Hygiene, European Poultry Congress, World Poultry Congress, Annual Meeting of the Poultry Science Association.

Where possible, search results were downloaded from the information sources and imported into EndNote bibliographic management software. Deduplication was undertaken using a number of algorithms.

In addition to the information sources described, the references of seven reviews identified during the scoping review were checked for additional studies that might had not been identified by electronic searches and hand searching of conferences.

These searches were not updated as the time frame for execution of the review was limited and the time between the scoping review and the start of conduct of the systematic review was less than 2 months.

6. Search strategy (PRIMSA ITEM 8)

The strategy was composed of two key elements:

- The population: laying hens (search line 1);
- The exposure: perches (search lines 2 and 3). The search terms for the exposure key element included terms to denote furnished, modified or enhanced cages as this type of housing often includes perches. It was not feasible to search for poultry housing more broadly, as this returned a large volume of irrelevant records, which could not be processed within the constraints of this project. It should be noted that this approach has the potential to miss studies which describe the welfare implications of housing options for hens, where perches are only discussed in the full text rather than at title and abstract level.

A wide range of welfare outcomes were eligible for inclusion in the review, and there is a great deal of variability in the language used to describe them in the title and abstracts of relevant studies. Moreover, studies do not routinely report outcomes in the title or abstract; outcomes are often only identifiable from the full text publication. For these reasons, the outcomes key element was not included in the search and was instead identified by the reviewers at record selection stage.

The search strategy used to identify studies indexed in CAB Abstracts (Web of Knowledge) is presented in Figure 1: The searches were not limited by language, date, or study design.

The search strategy developed for CAB Abstracts was adapted appropriately to perform efficiently in other information sources. This included consideration of database interface differences as well as adaption to different indexing languages and syntax. The strategies used to search each information source are presented in Appendix B.

7. Study Selection (PRIMSA ITEM 9)

The search results were uploaded into the online systematic review management software (DistillerSR®, Ottawa, ON, Canada). Abstracts and titles were screened for inclusion. Two reviewers, both veterinarians with post-graduate training in epidemiology and with systematic review methodology experience. The review had three levels of screening; each conducted independently. The 1st two levels were conducted using only the title and when available the abstract. The 1st rapid screening question was as follows:

Level 1 Screening Question 1: Does the title and/or abstract describe primary research related to perch characteristics in laying hens?

Citations were excluded if both reviewers responded “No” to this question. Studies that appeared to be potential review articles about perch characteristics were selected for evaluation of their reference lists. Non-English-language papers with English titles and abstracts were included in relevance screening. When conflicts about relevance arose the two reviewers discussed the abstract, and consulted with a third reviewer if necessary, to clarify the relevance decision.

A second level of screening was conducted on papers that passed the 1st level to identify papers that appeared to evaluate height as a perch characteristic. Again reviewers independently performed the relevance screening exercise on these citations. Conflicts were resolved by consensus or by seeking the opinion of a third reviewer (A.O). Studies that responded “Height” to the following question were obtained and further evaluated at level 3.

Level 2 Screening Question 1: Which aspects of perch design are assessed? (include all that are discussed)

- Perch length per bird
- Material (wood, steel, plastic)
- Height
- Perch cross-section
- Position
- Width
- Shape
- Temperature
- Clean vs dirty
- Perch color
- Wet vs dry
- Not specified in title or abstract
- None of the above

The third level of screening was conducted based on the full text, which evaluated if the paper provided a valid comparison of perch height and if the outcomes of interest were assessed. For full text screening the following questions were used to determine whether a study was included in the review

based on the full text. The reviewers independently performed the relevance screening exercise on these full texts.

Level 3 Screening Question 1: Is the paper available in English?

- Yes (proceed to next question)
- No (exclude from review)

Level 3 Screening Question 2: Does the study describe a valid comparison (not confounded by other perch characteristics) of keel bone lesions/ factors/deformities across perch heights?

- Yes (retain for keel bone Review #1)
- No (exclude from keel bone Review #1)

Level 3 Screening Question 3: Does the study describe a valid comparison (not confounded by other perch characteristics) of bone strength across perch heights?

- Yes (retain from bone strength Review #2)
- No (exclude from bone strength Review #2)

Level 3 Screening Question 4: Does the study describe a valid comparison (not confounded by other perch characteristics) of foot lesions across perch heights?

- Yes (retain from foot lesions Review #3)
- No (exclude from foot lesions Review #3)

Level 3 Screening Question 5: Does the study describe a valid comparison (not confounded by other perch characteristics) of night-time or day-time perch use across perch heights?

- Yes (retain from perch use Review #4)
- No (exclude from perch use Review #4)

8. Data collection process (PRISMA ITEM 10)

Data extraction forms were designed in Microsoft Excel as DistillerSR® is only suited to extraction of a single pairwise comparison at a single point in time and we anticipated that more than two perch heights would be assessed and possibly at multiple times. Initial forms were designed and piloted on two papers and modified as required for use. The first and second reviewers were randomly allocated to each paper determined to be relevant to the review. Each reviewer extracted data from his/her assigned papers. The second reviewer then verified the extracted data. When questions arose, the second reviewer noted and reported this to the first reviewer. Conflicts were resolved by consensus and, if consensus could not be reached, by a third reviewer (A.O.).

Also note that from PRISMA Item 11 onwards each of these steps was conducted separately for each review, i.e. the extraction of outcome data, assessment of eligibility for meta-analysis, conduct of meta-analysis, risk of bias assessment, report and summary were different for each review.

9. Data Items (PRISMA ITEM 11)

9.1. Study level information

For each study, we extracted (when reported):

- study year reported by authors, if not reported we did not use the year of publication,
- year and months the study was conducted,
- location of the study population (country),
- setting of the study (see Appendix A for list)

For the laying hen population, we extracted (when reported):

- plumage colour (see Appendix A for list)
- genotype

- size of the population in the production systems (if reported)
- size of the population under study
- age of birds in weeks
- housing system (see Appendix A for list)
- stocking density (if reported in units of floor space)
- stocking density (perch width available per bird)
- number of birds per cage if applicable
- cage height (if relevant)
- study design (see Appendix A for list)
- the experimental unit (see Appendix A for list)
- Does the design appear to have pseudo replication?

9.2. For each outcome at each time point for each intervention arm

We extracted the aggregated results reported by the authors. These data were often available only as aggregates or summaries i.e., the effect of height when multiple heights were included or p values only were reported. Such approaches to reporting precluded any opportunity to conduct a meta-analysis therefore we also extracted outcome data that related to all possible comparisons of perch heights, when the data were presented. For example, if a paper presented the proportion of hens perching at 6 heights, we extracted if possible all possible comparisons. This allowed us to collect data from multi-arm trials and calculate summary effect sizes not explicitly compared not reported by the authors. Where relevant outcome data were not available in the text or the tables of the paper, the reviewers extracted data directly from figures or graphs in the paper. Note that very frequently the studies did not report measures of variation for descriptions of perch use, however the estimate without variation was extracted. Because the appropriate samples sizes were so frequently unclear we did not extract measures of variation unless reported directly by authors, nor did we extract the sample sizes unless explicitly reported by the authors for the correct experimental unit. The rationale for this was that often studies used pseudo-replication and the loss to follow-up was poorly reported therefore the samples sizes for calculation could not be determined with confidence.

10. Assessment of risk of bias in included studies (PRISMA ITEM 12)

As most of the studies were experimental we used the Cochrane risk of bias form. This form was filled in by the reviewers in DistillerSR® (Ottawa, ON, Canada). The only modification to the tool we made was to add for the “Other Biases” a question about analyses that did not take into account pseudo-replication. For example, if a study has 2 perch heights, 4 cages for each perch height, and 10 birds per cage and treats the analysis as if there are 40 independent observations per treatment, this will be considered a high risk of bias. We acknowledge that this bias in truth affects precision, rather than a systematic direction bias. Additionally under “Other Biases” we added the question: Are there concerns about multiplicity? (e.g. If the authors did an ANOVA then did an F-test and it was significant and then the authors subsequently looked at all of the comparisons within that ANOVA and did a Bonferroni correction within the test, but did not correct for multiple comparisons across the study (just within the ANOVA), there would still be problems with multiplicity.

11. Summary measures (PRISMA ITEM 13)

We had anticipated that the summary measures were mean differences for continuous outcomes, and summary risk ratio or summary odds ratio for categorical outcomes.

12. Synthesis of results (PRISMA ITEM 14)

1.1. Screening for eligibility for meta-analysis

The above questions identified studies that reported the outcomes of interest. Ideally, authors comparing heights would report the effect sizes from valid comparisons of outcomes. Although the exact form of the effect size would depend greatly on the approach to data analysis used, examples 1

and 2 below give simplistic illustrations of an effect size based on ratios, where the null value would be one.

Example 1

- Proportion of birds on 80 cm perch ÷ proportion of birds of 20 cm perch= effect size
- $0.8 \div 0.2 = 4$, so use of 80 cm perches is 4 times the use of 20 cm perches

Example 2

- Proportion of birds with fractures of 80 cm perch ÷ proportion of birds with fractures on 20 cm perch= effect size
- $0.8 \div 0.2 = 4$, so the proportions of fractures associated with 80 cm perches is 4 time higher than that associated with 20 cm perches

These effect sizes would also have an estimate of variation, which would describe how certain the authors were about the effect size. As mentioned the exact effect size scale would depend upon the analysis and the experiment. For example, the effect size might be the difference in mean proportions; the ratio of proportions of perch use, the difference in log-transformed percentages of use etc. Regardless, the effect size is a metric that measures the comparison, rather than the result of the statistical test that measures the probability that the observed effect size or larger would occur due to random chance in a population with no effect i.e. the p value for the observed effect in the null population.

We initially proposed in the protocol to use the following questions, to determine if the studies reported an effect size for the association of perch height with the outcomes of interest. Those studies that reported an effect size could then be included in a meta-analysis to calculate a summary effect size.

Question 1: Does the study report data consistent with extraction of an effect size and variability of the effect size for inclusion in meta-analysis?

- Yes, the study is a two armed study and reported least squares means (or similar) for each group and SEM and N for each group
- Yes, the study is a multi-armed study of which at least two arms are relevant to the review and reported least squares means (or similar) for each group of interest and SEM and N for each group therefore the contrast of interest can be obtained after calculation of the point estimate of the contrast and the variance of the contrast.
- Yes, the study is a multi-armed study of which at least two are relevant to the review and reported an adjusted effect size and variance measure.
- No, the study did not report data in a manner that enables extraction of a comparative effect size.

12.1. Dealing with missing data

We did not contact authors to obtain missing data, as the time frame allowed for the review was too short < 3 months.

12.2. Assessment of heterogeneity

Our aim was to assess sources of heterogeneity, the sources of heterogeneity of interest where genotype and cage type. We proposed if possible to conduct meta-regression of the effect size with these sources of clinical heterogeneity as covariates.

12.3. Data Synthesis

In the protocol, we proposed that the feasibility of evidence synthesis would depend upon the frequency of the outcomes of interest within the relevant studies and the authors reporting effect sizes that compared outcomes across perch sizes. Meta-analysis is usually conducted to compare the outcome in two groups i.e. the proportion of fractures at height A compared to height B, however the EFSA working group were interested in any perch height, so such a pairwise comparison was not defined. Therefore we propose to group heights together (see section above) and if time allowed and sufficient data were available to conduct a mixed treatment comparison meta-analysis which would enable assessment of multiple perch heights.

13. Risk of bias across studies (PRISMA ITEM 15)

Studies with at least one high risk of bias domain were considered to have a high risk of bias. We had proposed in the protocol that we would if feasible conduct an analysis for small study effects.

14. Additional analyses (PRISMA ITEM 16)

For the outcome related to perch use a descriptive analysis aimed at illustrating the association was conducted. This analysis plotted the perch height in cm against the outcome reported by the author. Due to approaches to reporting, this descriptive analysis was used because a meta-analysis that would account differences in sample size or differences in units of concern was not possible, and therefore is purely descriptive and should only be interpreted as such.

RESULTS

15. Study selection (PRISMA ITEM 17)

A flow chart describes the flow of studies through the review process is provided (Figure 2:). The flow chart documents the number of studies identified by the search, the number Data were available from 10 studies to assess the outcomes of interest. The majority of studies (9) assessed perch use (Cordiner and Savory, 2001; Newberry et al., 2001; Riber et al., 2007; Struelens et al., 2008; Brugesch et al., 2012; Eusebio-Balcazar et al., 2013; Tuytens et al., 2013; Brendler et al., 2014; Chen et al., 2014). Only 1 assessed keel bone issues (Wilkins et al., 2011). No studies provided relevant data on bone strength or foot lesions. One study did evaluate bone strength, however these data were not reported with respect to perch heights and so were not extracted. The list of excluded studies that evaluated perch characteristics other than perch height is included in Appendix C. The reasons for excluding studies that appeared to evaluate perch height but were excluded after full text assessment are provided in Appendix D.

16. Study characteristics (PRISMA item 18)

Study characteristics related to the population, the interventions (perch heights) and housing conditions are provided in Table 2: Table 3: Table 4: The majority of studies used experimental designs; however often the perch use data was observational within such studies. For example, one study was designed to assess the impact of cage height on perch height preferences (Struelens et al., 2008). This study did describe usage of perches but as it was not the primary focus of the study, therefore the data were not analyzed to assess perch use differences by height. The results were reported for perch height but the study was designed to make inference about cage height.

17. Risk of bias (PRISMA item 19)

The risk of bias information is provided in Table 7: Frequently the risk of bias was unclear for two reasons. Often reporting was very incomplete, therefore it was difficult to determine if the potential for bias existed (Brugesch et al., 2012; Eusebio-Balcazar et al., 2013). Also, although some studies were conducted as randomized controlled trials designed to the effect of perch heights (Brendler et al., 2014), other experiments were designed to assess factors on the use of different height perches. An example of such a study is one by Riber et al. (2007). This study was designed to assess the impact of the addition of a broody hen to a group of chicks as compared to a group with no broody hen. The authors reported the location of chick perching, and after consultation with EFSA working group members it was decided this paper was relevant. However the differences in perch height were not allocated to chick and in fact the results are influenced by the treatment group. Technically such data would be suited to a review that asked “what is the impact of broody hens on perch use”, rather than a review that asks “what is the impact of perch height on perch use” as occurs in this review. Another example is a study that apparently randomized the shape of the stepwise perch to the group i.e. V or inverted V shaped stepwise perches. The explanatory variable based on the authors description of the experiment appeared to be the orientation of the V, however in the results these data were not reported at all, only the usage of certain heights, so again these are observational data, as heights were not randomized (Chen et al., 2014).

For such experiments, the authors often made no attempt to make inferential statistics about perch height, so it was unclear if it was valid to assess bias. Usually in systematic reviews, we only include experiments where the intervention assessed in the one randomly allocated to group i.e., laying hens randomly allocated to perch heights. However for this review we have included studies that assess the impact of other exposures on perch use when hens have various heights to choose from, however the impact of that inclusive decision is to make the risk of bias frequently unclear.

18. Results of individual studies (PRISMA item 20)

No studies are available for foot lesions or bone strength so no data were available for these outcomes. For the perch use data, no studies reported effect sizes that compared perch use of keel bone fractures across groups. For example the study by Riber et al. (2007), reported that “most chicks were first observed on the low perch” however no actual comparison of the percentage of chicks on the perches was conducted. Another example, is the study by Newberry et al. (2001). This study did evaluate perch use in different groups sizes and ages, and assess differences but reported the F statistic and the p value rather than the magnitude of difference in perch use “*This group size effect was consistent over all ages ($F=1.77$, $p 0.081$) and resulted in lower use of middle perches ($F=12.00$, $p=0.001$)*” (Newberry et al., 2001). The results reported by authors such as the F statistics, chi-square test statistics and p values results extracted but are not presented in this report but attached in a spreadsheet. As none report effect sizes these data are of little value.

One experiment that did directly report assessment of perch use was by Brendler et al. (2014). Brendler et al. (2014) conducted two analyses of the effect of height of perch use in Experiment 2. The first is a regression model, and the reported result is a Q test statistic, which suggests that we can reject the null hypothesis that the effect of height on perch use is zero. Regrettably Brendler et al. (2014) does not report either the beta for height variable (for transformed or untransformed data) from the model or contrasts of interest, so the direction of the association is truly clear. We might surmise the direction from the data presented in Figure 4, which suggest a U shaped relationship for median percentage use i.e., high median use at 20cm, decreasing at 30 cm, increasing at 40 cm, but only reaching the levels of 20 cm again at 80 cm then plateauing i.e., a curve. However, the authors do not report any assessment of the fit of the model or assessment of whether a linear relationship is a better fit than a quadratic or other form. The authors then appear to test the hypothesis that the amount of time spent on the perch is 50%, this assessment is not statistically significant until the perch height is 90 cm. The authors then appear to conclude that this suggests the hens prefer higher heights than lower, but regrettably this is not what is tested by this hypothesis test. Rather this test assesses if the

percentage of time is meaningfully different from 50%. A statistically significant finding could mean that the proportion is greater than or lesser than 50%. It appears that the authors are interpreting the decreasing p values as indicative of a measure of preference for perches of higher height, but as can be seen, the median perch use of birds on 20 cm perches is similar to that on 80cm perches. Therefore we would conclude that the interpretation of the results in Table 3 is a pragmatic interpretation rather than a true comparison of preferences of perch heights. Based on the wide inter-quantile range at 20 cm, it is likely sensible to conclude that although the median use at 20 and 80cm is similar, the consistency of the preference is higher at 80cm and above, as indicated by the narrow interquartile range.

For the keel bone data, only one study was relevant and the measure of association use was a correlation coefficient. These data are reported in Table 6: . The data suggest that as perch height increases the measures of keel bone injury also increase. No beta was reported for the fitted lines, which would have provided a summary of effect, i.e., the change in prevalence or incidence for each unit increase in perch height. Also it is unclear if the fitted lines were assessed for goodness of fit, or if curvilinear lines were assessed.

19. Synthesis of results (PRISMA item 21)

As discussed no studies are available for foot lesions, no studies are available for bone strength and only one study reported keel lesions, so no summary of those bodies of work are available. Also as no studies reported an effect size for perch use no meta-analysis was conducted, nor was it possible to assess sources of heterogeneity.

20. Risk of bias across studies (PRISMA item 22)

The ability to assess the risk of bias across studies is limited because the studies generally did not report effect sizes so no funnel plot could be calculated.

21. Additional analyses (PRISMA item 23)

As discussed no studies reported an exact effect size for the impact of perch height. Therefore in an attempt to extract some data from studies that might illustrate the findings, we extracted all possible pairwise comparisons reported by the authors. For example, if authors reported perch use for heights 20 cm, 30 and 60 cm we extracted data for all the pairs 20-30, 20-60, 30-60 and calculated the observed difference in metric. Often there was no data on variation for the outcomes as the data were reported in figures.

For the usage of perches, we provide four descriptive scatter plots of perch height in centimeters against the proportion of birds reported by the authors as used the bird at the height. The graphs are provided for nighttime and day time use and in cage and non cage systems. This is an overly simplistic representation of the data, as it ignores many aspects that should be considered in a more thorough meta-analysis i.e., the group sizes to weight the analysis, the inclusion of covariates (including cage height, housing system), differences in metrics (some studies have average proportions of birds with groups of birds as the unit of concern and others have the bird as the unit of concern), differences in central tendency measure (some use median others mean), clustering by study (i.e., some studies contribute multiple data points) and differences in day and night time usage. Data from the only some studies could be extracted and included in the figures (Cordiner and Savory, 2001; Newberry et al., 2001; Struelens et al., 2008; Tuytens et al., 2013; Brendler et al., 2014; Chen et al., 2014). These data of course have issues associated with lack of independence between observations, for example, the study by (Tuytens et al., 2013) includes observations on the same animals over time. This means these observations are not independent. A similar issue occurred with the data provided by Newberry (Newberry et al., 2001), which provided data for perch use by height by group size and height by age. Including both sets of data would have been duplicative so we included only the data for perch use by different group sizes. This descriptive analysis is provided for combined for day and night time

perching activity (Figure 3: , by night (Figure 4: and by day usage metrics (Figure 5: separately. As only one study explicitly reported using an aviary setting we did not separate the data into aviary and non-aviary settings,

DISCUSSION

22. Summary of evidence (PRISMA item 24)

For keel bone fractures, the data available suggested that there was a correlation between perch height and the prevalence of keel bone injuries. This data were from an observational study and important confounders were not adjusted for in the correlation analysis. Further, the magnitude of the association was not reported, only correlation. Therefore, the review team would conclude that while the work available suggests an association, the body of work is small and potential for bias is high and therefore there remains some uncertainty about the strength of the association between perches and keel bone injuries.

For the outcome, perch use, more studies were available, however few studies directly assessed the question of interest to the review. This means some data is observational and others experimental. The descriptive figures suggest that at night and at the day, birds are likely to use higher perches more than lower perches. However, the review teams is weakly certain that there is an association however the strength of that association is unknown. This conclusion is reached because of the numerous issues associated with the data. No studies provided effect sizes, and so in lieu of such information the review team extracted and plotted non-comparative data. So the conclusion is weakened because factors normally considered in meta-analysis such as impact of non-independence, different samples sizes, and different metrics cannot be taken into account. Also, although the figures appear to indicate numerous data points, many of these come from 2 or 3 studies which tested multiple heights in multiple groups, so there is a very strong influence of a small number of a studies on the conclusion.

23. Limitations (PRISMA item 25)

The review has many limitations, not least of which is the absence of studies with the direct purpose of assessing height. In this review we have included studies that reported perch use as an observational finding, such studies can no be expected to comprehensively report the comparisons of interest to this review if there were not the original purpose of the researcher. As such, it should not be seen as a criticism of the authors of this body of work that some results are not reported in a manner that would enable effect size estimation. Instead this is a function of the decision to include such studies, rather than limiting the review to experiments that explicitly set out to assess perch heights rather than other cage characteristics. However, if end users or experts consider that inclusion of such data does not create a systematic bias, then this pragmatic approach to increasing the number of data points available may be reasonable. Given this pragmatic approach to extracting available data that was intended for another purpose, the ability to conduct anything other than descriptive analyses is limited and it is unclear if exploration of approaches to conduct meta-analysis would result in hugely different conclusions.

24. Conclusions (PRISMA item 26)

Once the data was subset into four subgroups (day and night for cages and non cage systems system) any clear association between perch height and perch use and keel bone injuries is hard to find as for each subgroup as there are too few studies and sometime only one study informing the analysis. Due to the approach to reporting, the magnitude of the association cannot be determined. There is an absence of data about foot lesions bone strength and keel lesions, and perch height.

25. Funding (PRISMA item 26)

This project was funded by EFSA and the review team has no conflicts of interest that relate to poultry housing to declare.

Table 1: Information sources searched to identify relevant studies

Database	Interface
Science Citation Index (SCI)	Web of Knowledge, Thompson Reuters
Conference Proceedings Citation Index – Science (CPCI-S)	Web of Knowledge, Thompson Reuters
CAB Abstracts	Web of Knowledge, Thompson Reuters
BIOSIS Citation Index	Web of Knowledge, Thompson Reuters
MEDLINE and MEDLINE In-Process	OvidSP
AGRIS	http://agris.fao.org/
AGRICOLA	http://agricola.nal.usda.gov/
TEKTRAN	www.ars.usda.gov/services/tektran.htm
CRIS	http://cris.nifa.usda.gov/
Science.gov	www.science.gov/
ScienceResearch.com	http://scienceresearch.com/
Open Grey	www.opengrey.eu/

Table 2: Study level information of papers included in the review

Author	Country	Study setting	n	Study Design*	Breed	Plumage Color	Age (weeks)
(Brendler et al., 2014)	NR	Research		Block randomized design	Lohmann Selected Leghorn	White	31-42
(Chen et al., 2014)	NR	ND	390	Block randomized design	Hyline Brown	Brown	18
(Struelens et al., 2008)	NR	Research	192	Complete not-randomized experimental design (assumes balance)	Hysex Brown	Brown	18
(Eusebio-Balcazar et al., 2013)	NR	ND	432	Complete randomized experimental design	Lohmann Brown and Bovan White	Brown, White	15-35
(Brugesch et al., 2012)	NR	ND	108	NR	Lohmann Selected Leghorn	White	at beginning, middle and end of laying period
(Riber et al., 2007)	NR	Research	120	Block randomized design	Lohmann Tradition	Brown	0-27
(Tuytens et al., 2013)	Belgium	Research	256	Block randomized design	Lohmann Brown	Brown	41-53
(Cordiner and Savory, 2001)	NR	Research	80	Non-randomized Latin square design or other row column	ISA Brown	Brown	50
(Wilkins et al., 2011)	United Kingdom	Commercial farm	67 flocks	Non-randomized split plot design	HyLine B, Lohmann tradition, Lohmann brown, bovan goldline, other (not specified)	Brown (and possibly white ("Other" breed not specified))	NR or ND
(Newberry et al., 2001)	NR	Research	900	Block randomized design	White Leghorn	White	1 day (reared to 18 weeks of age)

Study year, study time frame, genotype and size of population in the production system were not reported by any study. All birds were females. This refers to the design used to assess the exposure of interest to the authors. Sometimes authors reported perch use when it was not the factor of interest in the experiment, in such situations the perch use data is observational and not subject to randomization.

Table 3: Summary of perch height and other design characteristics of studies included in the review

Author	Housing system	Experimental unit	Perch heights	Number of perches in each group
(Brendler et al., 2014)	Experimental	The cage	30, 90, 150, 20, 40, 60, 80, 90, 100, 120, 150, 180	1
(Chen et al., 2014)	Enhanced/furnished	The bird OR the perch	10, 20, 30 and 40 in each cage	4
(Struelens et al., 2008)	Enhanced/furnished	The cage	6, 11, 16, 21, 26, 31, 36	2
(Eusebio-Balcazar et al., 2013)	Aviary	The cage	"lower tier", "middle tier", "top tier" and lower perch above the litter (actual heights not reported)	10
(Brugesch et al., 2012)	Cages	The cage	"lower", "higher" (actual perch heights not reported)	3
(Riber et al., 2007)	Pens	The cage	20, 40	2
(Tuytens et al., 2013)	Enhanced/furnished	The cage	5, 23	1
(Cordiner and Savory, 2001)	Pens	The pen	17.5 35 cm and 17.5cm 70cm and 35cm	3
(Wilkins et al., 2011)	Free range; indoor house; organic mobile; House with a single tier of slats raised above the litter area; barn; Enhanced/furnished	Flock	Means and SE	NR for some 0 for some 6 for some 1 for some 0 for some
(Newberry et al., 2001)	Pens	The group size	Stair step design perches: 20, 40 and 60 cm	1 perch unit comprised 3 horizontal 3cm x 3cm softwood rails

Table 4: Summary of housing and a density characteristics of studies included in the review

Author	Cage height cm	Stocking Density	Stocking Density (# birds/cm of perch)	Stocking Density (# birds/cm of perch)
(Brendler et al., 2014)	250	1 hen per 1.4m ²	5	1 bird/40cm of perch
(Chen et al., 2014)	65	12800 cm ² per hen 3200cm ² per hen 1600cm ² per hen	1, 4 or 8	1 bird/160cm of perch 1 bird/40cm of perch 1 bird/20cm of perch
(Struelens et al., 2008)	45, 50, 55 and 150	1.32m ² per hen 0.19m ² per hen	"Two-hen test": 2 hens per cage "Fourteen-hen test": 14 hens per cage	1 bird/210cm of perch 1 bird/30cm of perch
(Eusebio-Balcazar et al., 2013)	NR	NR	54 birds per aviary unit	NR
(Brugesch et al., 2012)	NR	870 cm ² per hen	36 birds per cage	NR
(Riber et al., 2007)	NR	3.9 chickens/m ²	10 chicks per pen	1 bird per 34cm
(Tuyttens et al., 2013)	57	0.08775m ² per hen.	8 birds per cage. Some died	NR but 14.6cm per bird (assuming 8 birds per cage)
(Cordiner and Savory, 2001)	200	6.2 birds/m ²	0	1 bird/15cm perch space
(Wilkins et al., 2011)	NR	NR	NR	NR
(Newberry et al., 2001)	NR	5 birds/m ²	15, 30, 60 and 120 birds	10cm per bird (age 3 to 12 weeks) then 20cm per bird (age 12 weeks onward)

Table 5: Frequency of assessing birds for perch behavior studies

Author	How often were birds assessed (perch usage)?
(Brendler et al., 2014)	Expt. 2: the number of hens on the perch was counted once for each perch height, in the middle of the night
(Chen et al., 2014)	Recorded on the fifth and seventh day of the treatment; proportion of hens' positions during mid-night was calculated
(Struelens et al., 2008)	Behavior was videotaped 7:30 to 8:30, 11:30 to 12:30, 15:30 to 16:30, 23:30 to 00:30, 03:30 to 3:50. Location of hens (and for groups of 14 hens, the number of hens in the defined locations was counted) was scored every 5 minutes during these times.
(Eusebio-Balcazar et al., 2013)	Every 4 hours during a day at 15, 25 and 35 weeks of age
(Brugesch et al., 2012)	Once per hour during the light phase (14h) and twice by night.
(Riber et al., 2007)	12 times daily, 6 times during the photophase (7:30, 7:45, 12:00, 12:15, 18:00, 18:15) and from days 5 to 22 and at least every second night from days 22 to 40
(Tuytens et al., 2013)	When the hens were 41 to 53 wk of age, they were observed every 2 wk for 2 consecutive days from 1500 h until 1900 h during the light period; One hour after the lights had been switched off, an identical round of observation was repeated once (using a dimmed flashlight to avoid disturbing the birds) for recording the night positions. Stocking density calculated from cage dimension.
(Cordiner and Savory, 2001)	Daytime: observed on 4 days, for 30 min in the morning and 30 min in the afternoon. In the second 15 min, the identities of all birds using perches and all birds using nestboxes were recorded every 30 s. Nighttime: Each group was video recorded continuously from lights off (21.00 h) to lights on (05.00 h) on one night per week. From the recordings, in which all perches and nestboxes were visible, the identities of birds using perches or nestboxes were noted once every 15 min (i.e. 32 such scans during the 8-h dark period).
(Wilkins et al., 2011)	NA
(Newberry et al., 2001)	2 rounds of behavioral observations of the birds in each pen by direct observation from the aisle in from t of each pen during each of 5, 3 week age periods between 3 and 18 week. Half the pens were observed in the morning and the other half in the afternoon. Order of observing pens and the time of day was balance din a Latin square design.

Table 6: Summary of the associations reported between perch height and measures of keel bone injury (Wilkins et al., 2011)

Range of perch heights	Outcome	Type of Analysis	Summary measure	Effect Size	Upper 95% CI	Lower 95% CI	P-value	Additional Comments
40 to 180 (maximum accessible perch height above the slats, in cm)	% birds with keel bone fractures	Correlation coefficient	r^2	0.41	NR	NR	<0.001	Fig. 7a
55 to 275 (maximum accessible perch height above the litter in cm)	% birds with keel bone fractures	Correlation coefficient	r^2	0.59	NR	NR	<0.001	Fig. 7b
40 to 180 (maximum accessible perch height above slats, in cm)	Severity of keel damage	Correlation coefficient	r^2	0.39	NR	NR	<0.001	Fig. 8a
55 to 275 (maximum accessible perch height above the litter in cm)	Severity of keel damage	Correlation coefficient	r^2	0.30	NR	NR	<0.01	Fig. 8b
200 to 2100 (combined available perch heights in each house, in cm)	% birds with keel bone fractures	Correlation coefficient	r^2	0.62	NR	NR	<0.001	Fig. 9..

Table 7: Risk of bias for individual studies relevant to the review questions

Study ID	Random sequence generation	ROB: random sequence generation	Allocation concealment	ROB: Allocation concealment	Blinding caregivers	ROB: Blinding caregivers	Blinding outcome assessors	ROB: Blinding outcome assessors	Incomplete outcome data	ROB: Incomplete outcome data
(Chen et al., 2014)	Random allocation	Unclear	No	Low	No	Low	No	Unclear	Unable to assess/numbers not reported comprehensively	Unclear
(Tuytens et al., 2013)	Random allocation	Unclear	No	Low	No	Low	No	High	Loss to follow-up not explained	High
(Wilkins et al., 2011)	Non-random allocation	High	No	Unclear	No	Unclear	No	High	Unable to assess/numbers not reported comprehensively	Unclear
(Struelens et al., 2008)	Non-random allocation	High	No	High	No	Low	No	Low	Loss to follow-up not explained	High
(Riber et al., 2007)	Random allocation	Unclear	No	Low	No	Unclear	No	Low	No loss to follow-up	Low
(Newberry et al., 2001)	Random allocation	Unclear	No	Low	No	Low	No	Low	No loss to follow-up	Low
(Cordiner and Savory, 2001)	Not reported/Not discernible	Unclear	No	Low	No	Low	No	Low	Unable to assess/numbers not reported comprehensively	Low
(Brugesch et al., 2012)	Not reported/Not discernible	Unclear	No	Unclear	No	Unclear	No	Unclear	Unable to assess/numbers not reported comprehensively	Unclear

(Eusebio-Balcazar et al., 2013)	Random allocation	Unclear	No	Unclear	No	Unclear	No	Unclear	Unable to assess/numbers not reported comprehensively	Unclear
(Brendler et al., 2014)	Random allocation	Unclear	No	Low	No	Low	No	Low	No loss to follow-up	Low

Figure 1: Search strategy to identify studies reporting on perches for laying hens in CAB Abstracts (Web of Knowledge, Thompson Reuters)

# 5	#4 AND #1	866
# 4	#3 OR #2	6,175
# 3	TS=(("modified" OR modify* OR modification* OR enrich* OR furnish*) NEAR/4 ("cage" OR "cages" OR house* OR "housing" OR "aviary" OR "aviaries" OR "barn" OR "barns" OR "pen" OR "pens"))	1,525
# 2	TS=("perch" OR "perches" OR "perching" OR "perchery" OR "percheries")	4,797
# 1	TS=("hen" OR "hens" OR "layer" OR "layers" OR chicken* OR "gallus domesticus" OR "g domesticus")	338,913

Figure 2: PRIMSA flow chart

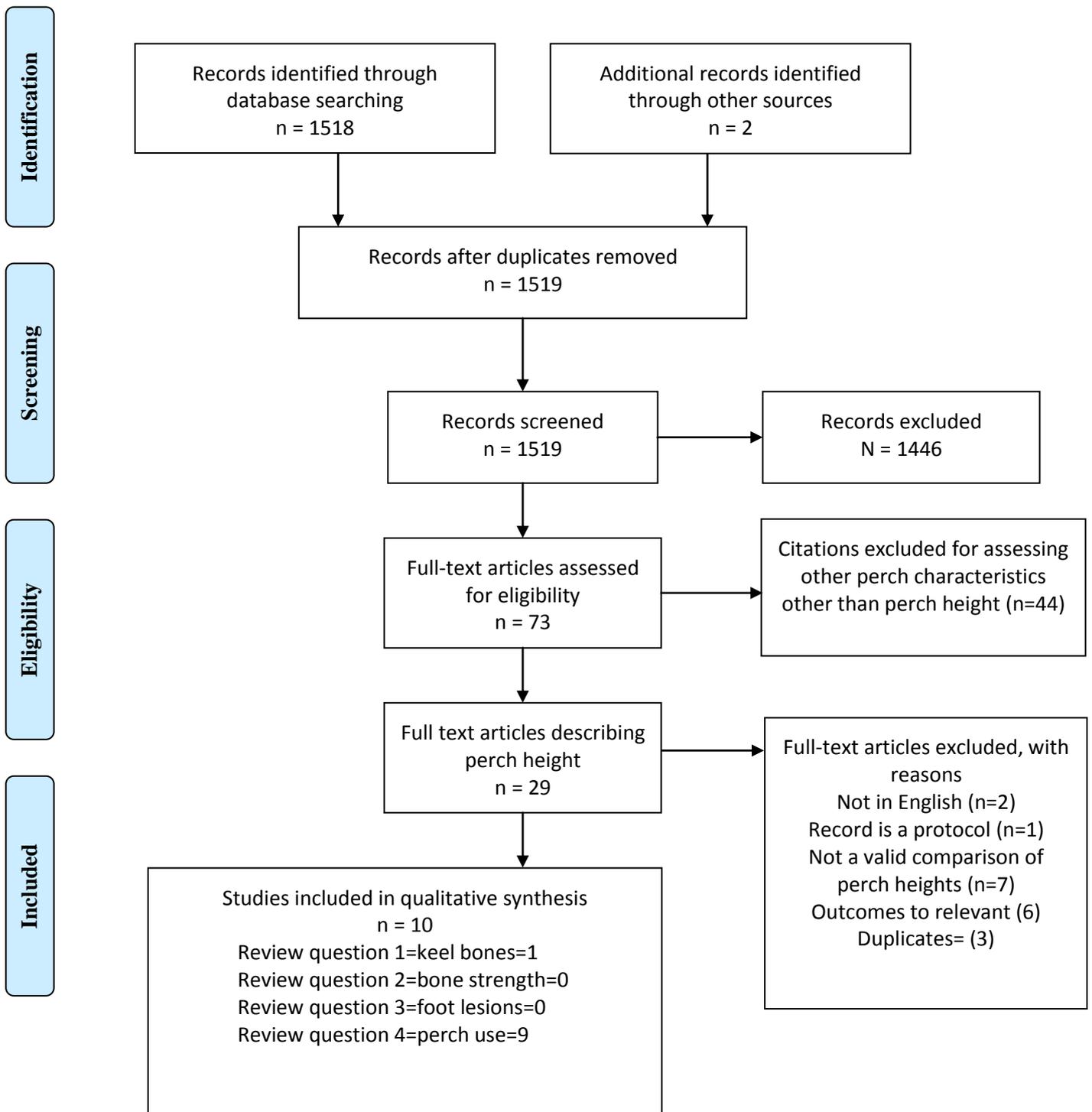


Figure 3: Scatterplot comparing raw data of height of perches and metrics of usage of perches in cage systems at night. Each diamond represents an estimate from a study. Multiple data points arise from single studies, and multiple studies may occur at one point. The points are not weighted by size or adjusted for covariates. Permission to reproduce this figure outside this document is not granted. Contains data from the following papers

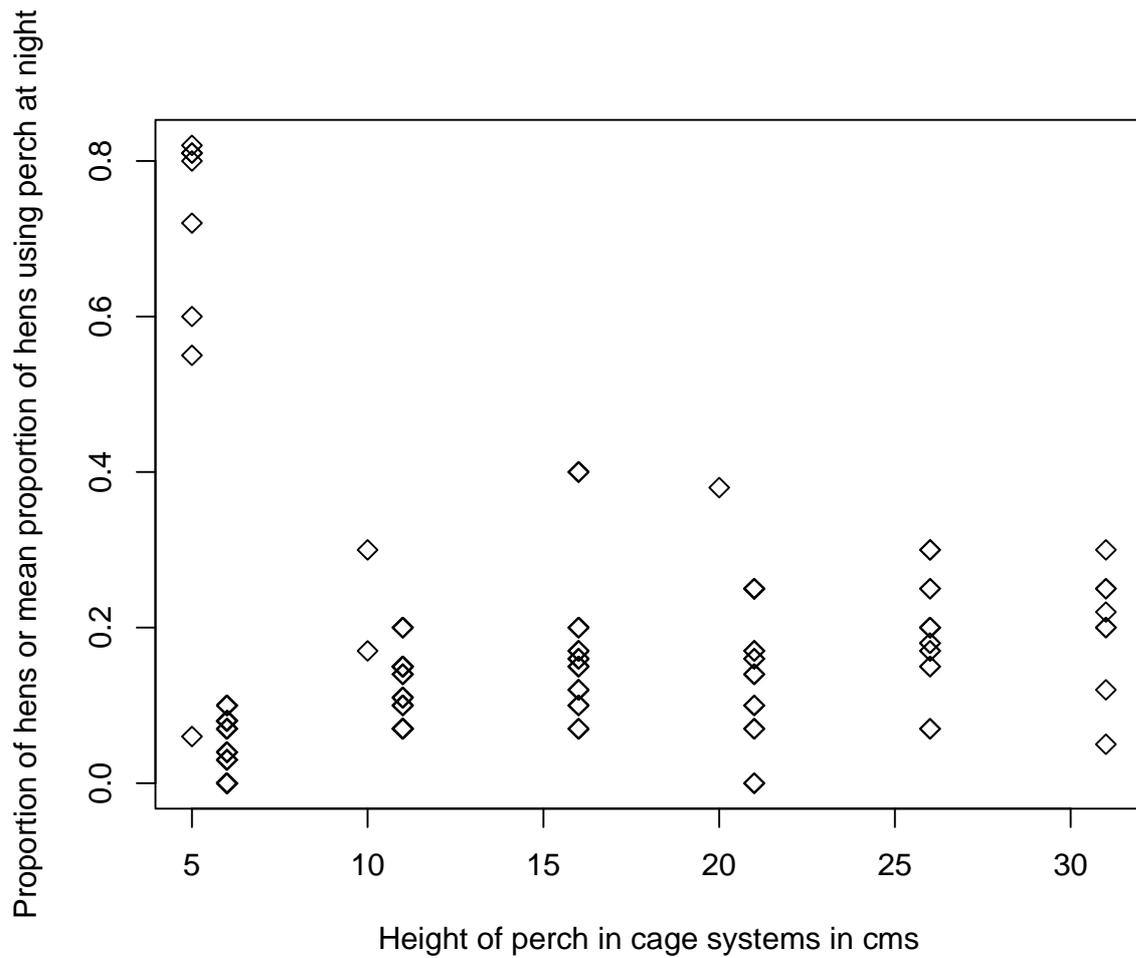


Figure 4: Scatterplot comparing raw data of height of perches and metrics of usage of perches during the day in cage systems. Each diamond represents an estimate from a study. Multiple data points arise from single studies, and multiple studies may occur at one point. The points are not weighted by size or adjusted for covariates. Permission to reproduce this figure outside this document is not granted.

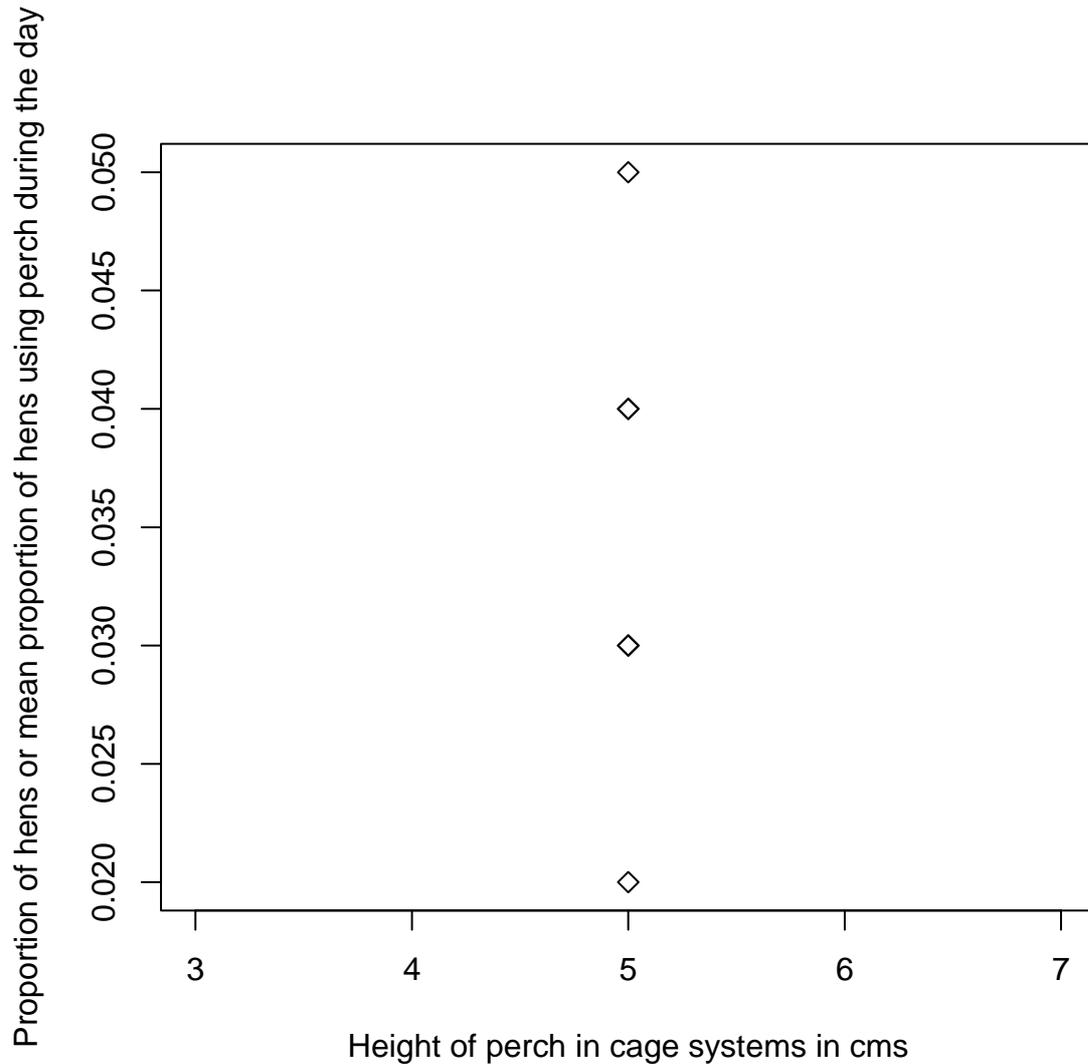


Figure 5: Scatterplot comparing raw data of height of perches and metrics of usage of perches at night in non-cage systems. Each diamond represents an estimate from a study. Multiple data points arise from single studies, and multiple studies may occur at one point. The points are not weighted by size or adjusted for covariates. Permission to reproduce this figure outside this document is not granted.

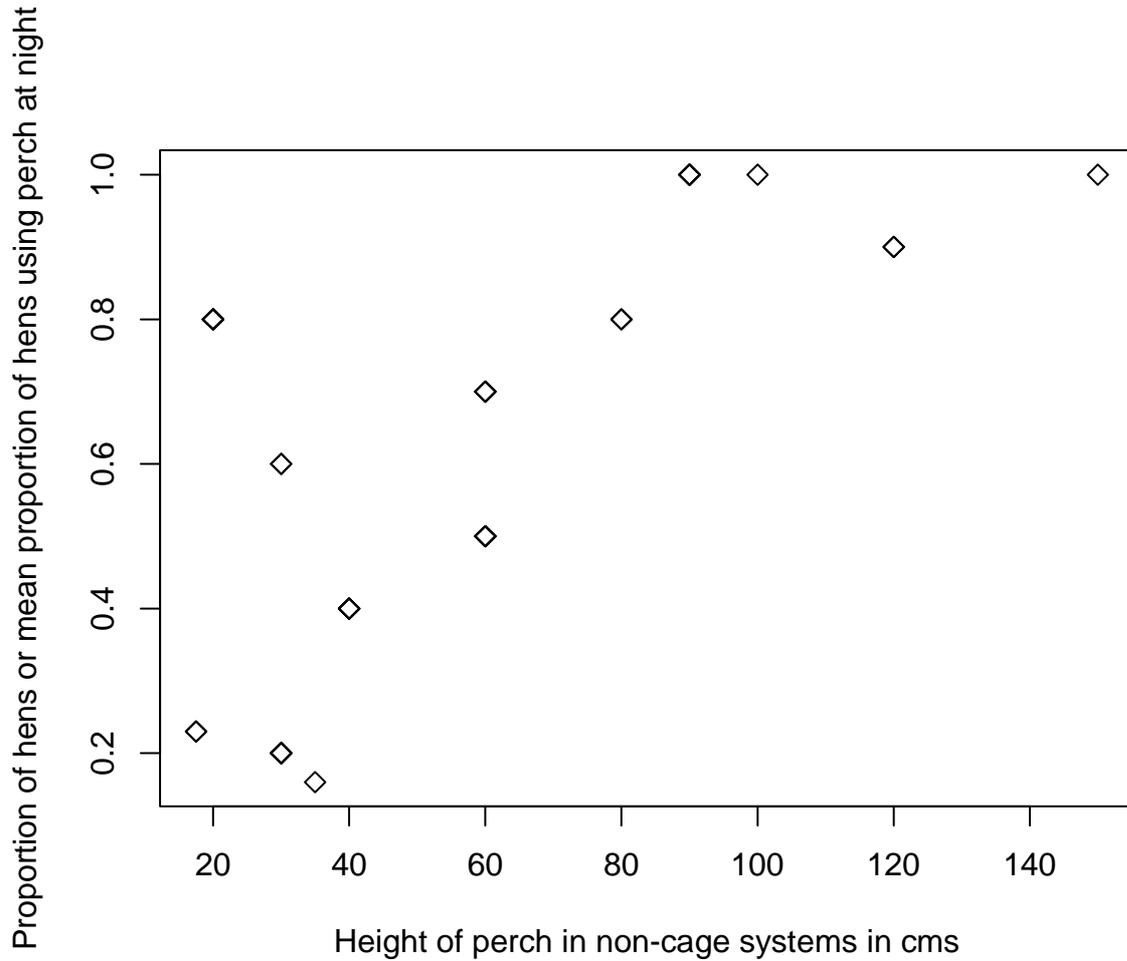
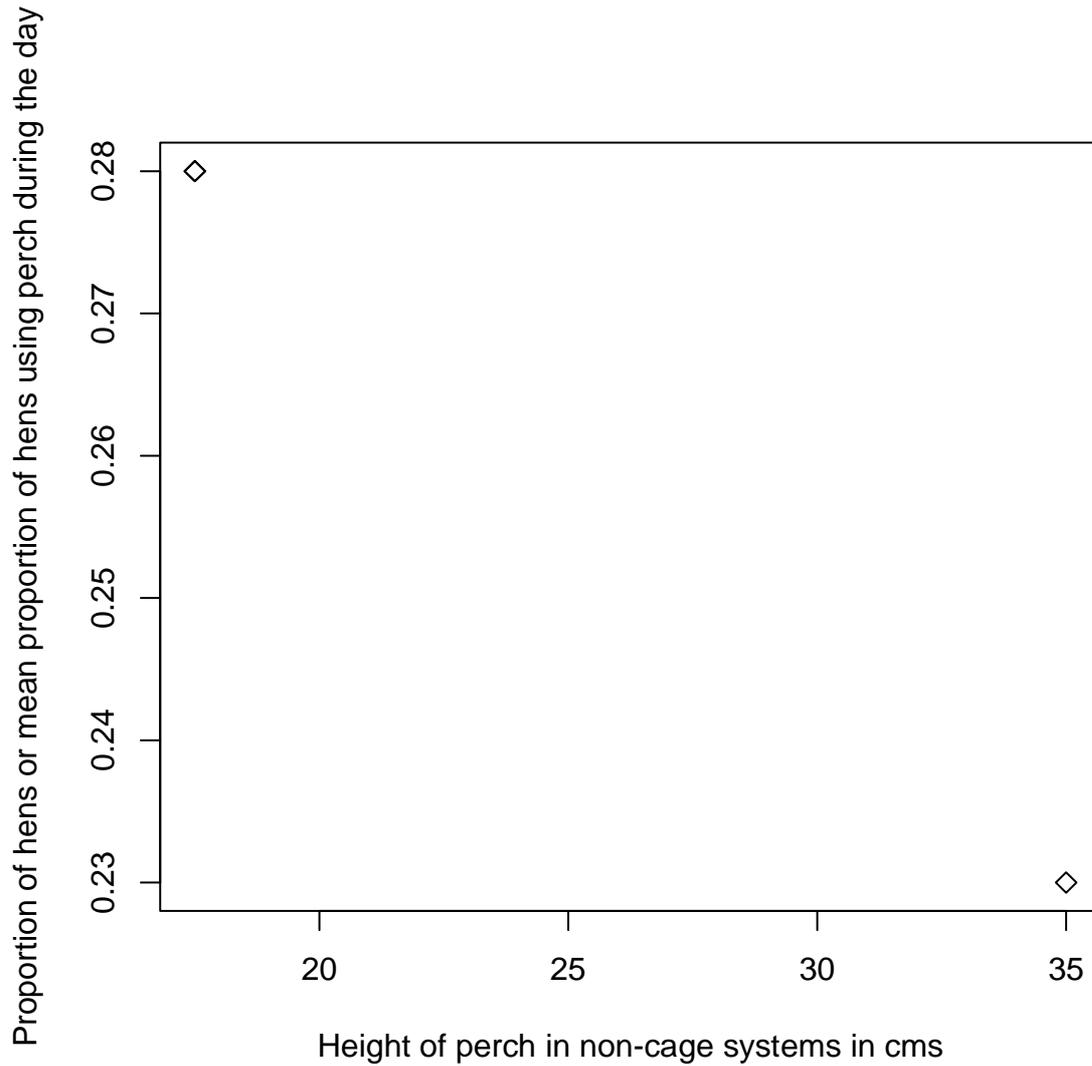


Figure 6: Scatterplot comparing raw data of height of perches and metrics of usage of perches during the day in non-cage systems. Each diamond represents an estimate from a study. Multiple data points arise from single studies, and multiple studies may occur at one point. The points are not weighted by size or adjusted for covariates. Permission to reproduce this figure outside this document is not granted.



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APPENDIX/APPENDICES

Appendix A Protocol for review

Here we provide a detailed protocol for specific outcomes included in the title. If EFSA wishes to modify the perch characteristics of interest, this can simply be done

TITLE (PRIMSA ITEM 1)

Based on EFSA contract

Structured summary (PRIMSA ITEM 2)

Based on EFSA contract

Rationale (PRIMSA ITEM 3)

Based on EFSA contract

Objectives and PICO (S) review question(s) (PRIMSA ITEM 4)

Four systematic reviews are proposed as follows

- What is the change in the prevalence or incidence of keel bone fractures/ deformation/injuries associated with different categories of perch height for layer hens housed in alternative, furnished or aviary systems.
- What is the change in bone strength associated with different categories of perch height for layer hens housed in alternative, furnished or aviary systems
- What is the change in the prevalence or incidence of foot lesions (including foot pad dermatitis, bumble foot, toe damage and claw damage) associated with different categories of perch height for layer hens housed in alternative, furnished or aviary systems
- What is the change in the absolute or percentage of time spent perching at night and during the day associated with different categories of perch height for layer hens housed in alternative, furnished or aviary systems

Protocol and registration (PRIMSA ITEM 5)

The protocol was designed after a scoping review to assess available data and outcomes. The protocol is available from EFSA.

Eligibility criteria (PRIMSA ITEM 6)

Relevant participants

The population of interest is white and brown commercial layers used for egg production housed in furnished cages and aviary systems. This would exclude studies that directly relate to home production of eggs that will not be sold. Dual-purpose breeds that are used in home egg production and small-scale pasture egg production would be excluded. The rationale for excluding other breeds is that the dimensions needed are likely different for weight and height of bird. The birds must be housed in furnished cages or aviary systems, no conventional cages.

Interventions

The interventions and comparators of interest are different heights of perches. The results will need to be stratified by housing system as differences in heights are important within systems. When not stated we will assume that height is measured as the perpendicular distance between the floor (or grid) and the perch. If we cannot determine the perch height- i.e., the authors give a metric that does not enable determination of height from floor we will exclude those papers as the height will be

inaccurate. We will only include studies that control for other factors in the design or analysis. For example, if a study evaluates both perch shape and perch height in a 2 by 2 factorial design but does not report either the effect size for perch height differences for each perch shape OR an effect size that adjusts for perch shape, we will exclude these data as the effect size can not be extracted.

For purposes of combining data we propose to use the following groupings for perch heights.

- Height for furnished/ enriched cages

< 5 cm, < 10 cm, < 15 cm, 15 to <25 cm, 25 cm to < 35cm, 35 to <45 cm.

- Height for alternative (aviary / aerial systems)

45-100 cm, 100-150 cm, 150-200 cm, > 200 cm

Types of outcome measures

For review number 1, any measure of keel bone lesions will be included i.e., prevalence or incidence etc. Further, any lesions associated with keel bones, i.e., fractures, deformities will be included.

For review number2, bone strength we will use any measure of bone strength reported by the authors. As these data are likely to be continuous measures we expect that to compare the means of measures of bone strength. In the unlikely event that the measure of bone strength is a categorical variable, such as passed a threshold” such data will still be collected. However, they will not be able to incorporated into a single meta-analysis.

For review number 3, any foot lesions (including but not limited to foot pad dermatitis, bumble foot, toe damage and claw damage) will be included. We anticipate that these will be measured as prevalence or incidence.

For review number 4, the time spent on perches, we propose to use absolute or percentage of time spent perching at night and during the day associated with different categories of perch heights. The data form of such an outcome is unclear and will depend upon the decisions made by the authors of the primary research. We expect that often comparisons of these data will be made using non-parametric methods as these are bounded data (i.e., the proportion of time spent on an activity can not be < 0 and > 1) or beta distributions. In these circumstances it may be difficult to extract effect sizes as some authors only report the p value for such data.

Relevant study designs

Study designs of interest are either observational or experimental provided they enable a valid comparison of perch heights. Designs where perch height is confounded by other factors will be excluded. Although randomization to group is designed to prevent selection bias / confounding the EFSA working group has requested we do not use “randomization to group” as a exclusion criteria.

Information Sources (PRIMSA ITEM 7)

The searches for this review have already been designed and conducted as part of the scoping review. This approach has been used to make maximum use of the time available for the project. The following data bases were searched: Science Citation Index (SCI), Conference Proceedings Citation Index – Science (CPCI-S), CAB Abstracts, BIOSIS Citation Index , MEDLINE and MEDLINE In-Process, and Open Grey. These searches will not be updated as the time frame for execution of the review is limited and the time between the scoping review and the conduct of the review is < 2 months.

Search strategy (PRIMSA ITEM 8)

The search strategy is reported in Appendix A. During the scoping review we identified 30 studies that reported aspects of perch height as the characteristics of interest. After the scoping review was conducted, a member of the working group nominated papers recently published by their group for inclusion in the review. We will include these papers, however we note that researchers outside the working group were not able to nominate relevant papers so there is a potential for bias. In the review teams opinion this risk of bias is likely minimal compared to the advantage of a more comprehensive review.

Study Selection (PRIMSA ITEM 9)

A 2nd level of screening will be conducted on the 30 papers identified by the scoping review and two nominated papers. The full texts of these papers will be obtained provided they are available in English. Two reviewers will independently perform the relevance screening exercise on these full texts.

Screening for eligibility for the review

The following questions will be used to determine whether a study will be included in the review based on the full text.

Question 1: Is the paper available in English

- Yes (proceed to next question)
- No (exclude)

Question 2: Does the study describe a valid comparison (not confounded by other perch characteristics) of keel bone lesions/ factors/deformities across perch heights?

- Yes (retain from keel bone review #1)
- No (exclude from keel bone review #1)

Question 3: Does the study describe a valid comparison (not confounded by other perch characteristics) of bone strength across perch heights?

- Yes (retain from bone strength review #2)
- No (exclude from bone strength review #2)

Question 4: Does the study describe a valid comparison (not confounded by other perch characteristics) of foot lesions across perch heights?

- Yes (retain from foot lesions review #3)
- No (exclude from foot lesions review #3)

Question 4: Does the study describe a valid comparison (not confounded by other perch characteristics) of night-time perch or day-time use across perch heights?

- Yes (retain from perch use review #4)
- No (exclude from perch use review #4)

Data collection process (PRISMA ITEM 10)

One reviewer will extract data independently from studies deemed to be relevant to the review and the 2nd reviewer will verify the data. The 1st and 2nd reviewer will be randomly allocated to each paper. When questions arise the 2nd reviewer will note the query and report to the 1st reviewer and discussion will occur. Data extraction forms will be designed in Excel as DistillersSR⁷ is only suited to extraction of a single pairwise comparison at a single point in time. In these designs we anticipate more than two perch heights will be assessed and possibly at multiple times. Initial forms will be designed and piloted on several papers and modified as required for use. Also note that from PRISMA Item 12 onwards each of these steps is conducted separately for each review i.e. the extraction of outcome data, assessment of eligibility for meta-analysis, conduct of meta-analysis, risk of bias assessment, report and summary are different for each review.

Data Items (PRISMA ITEM 11)

Study level information

For each study, we will extract when reported

- study year reported by authors, if not reported we will not use the year of publication,
- time frame the study was conducted, year and months
- location of the study population (country),
- the study location area (commercial farm, research farm, laboratory, not discernable). If not reported this will be inferred from the study design, and if truly not discernable we will report not discernable.

For the population, we will extract when reported

- the plumage colour (brown or white)
- The genotype
- The size of the population in the production systems (if reported)
- The housing system
 - Enriched/furnished
 - Aviary
 - Provide text from paper
- The stocking density (if reported in units of space)
- Number of birds per cage if applicable
- Cage height (if relevant)
- What design is used?
 - Complete randomised experimental design

-
- Block randomised design (blocked to reduced variation)
 - Incomplete block randomised design (blocked to reduced variation but block size is < treatments)
 - Randomized latin square design or other row column design
 - Complete randomized factorial design (2*2 factors of interest, 3*2 factors of interest etc)
 - Randomized split plot design
 - Complete not-randomised experimental design (assumes balance)
 - Block not-randomised design (blocked to reduced variation)
 - Incomplete block not-randomised design (blocked to reduced variation but block size is < treatments)
 - Complete not-randomized factorial design (2*2 factors of interest, 3*2 factors of interest etc)
 - Non-randomized latin square design or other row column
 - Non-randomized split plot design
 - Observational design – cohort- outcome is incidence rate or risk over time.
 - Observational design – cross sectional- a single point in time
 - Observational design – multiple cross sectional studies (outcome measured on different birds at each time point with different analysis at each time point)
 - Observational design – multiple cross sectional studies (outcome measured on same birds but different analysis at each time point)
 - Observational design –prevalence case control (birds with lesions compared to birds without lesions, and exposure determined after defining outcome- likely a very rare design and only post mortem)
 - What is the experimental unit?
 - The cage- perch height is common to all birds in the cage, there are multiple birds in each cage and comparisons can only be made across cages. Perch height differs between cages.
 - The aviary- perch height is common to all birds in the aviary and comparisons can only be made across aviaries. Perch height differs between aviaries.
 - The bird- perch height is allocated to only one bird, i.e., one bird per cage.
 - Other – add
 - Does the design appear to have pseudo replication?

- Yes- data collected on multiple chickens within experimental unit when units is not the bird
- No, all observations are independent.

As these data are common to the study, these data will only be extracted once from each study.

For each outcome at each time point for each intervention arm

At present we propose to extract outcome data into a table similar to the one below. This tables allows us to collect data from multi-arm trials and those that provide only summary effect sizes. This may need to be modified based on the designs used.

	<10 cm	10-20	20-30	30-40	40-100	Summary
Number of experimental units in group						
Number of pseudo replicates per experimental unit						
Outcome	LSM or similar	Effect size				
Measures of precision						
Probability of the null hypothesis. If the study includes contrast this will have multiple rows with a +to indicate comparison.						

2. ASSESSMENT OF RISK OF BIAS IN INCLUDED STUDIES (PRISMA ITEM 12)

As most of the studies are likely to be experimental we will use the Cochran risk of bias tool. See Appendix C. The only modification to the tool we will make is to add for the “other biases” a question about analyses that do not take into account pseudo replication. For example, if a study has 2 perch heights, 4 cages for each perch height, and 10 birds per cage and treats the analysis as if there are 40 independent observations per treatment, this will be considered a high risk of bias. We acknowledge that this bias in truth affects precision, rather than a systematic direction bias.

Summary measures (PRISMA ITEM 13)

The summary measures will be mean differences for continuous outcomes, and summary risk ratio or summary odds ratio for categorical outcomes.

Synthesis of results (PRISMA ITEM 14)

Screening for eligibility for meta-analysis

The above questions will identify studies that report the outcomes of interest. Here we determine if the studies report an effect size for the effect of perches and therefore the study could be included in a meta-analysis to calculate a summary effect size.

Question 1: Does the study report data consistent with extraction of an effect size and variability of the effect size for inclusion in meta-analysis .

- Yes, the study is two armed study and reported least squares means (or similar) for each group and SEM and N for each group
- Yes, the study is a multi-armed study of which at least two are relevant to the review and reported least squares means (or similar) for each group of interest and SEM and N for each group therefore the contrast of interest can be obtained after calculation of the point estimate of the contrast and the variance of the contrast.
- Yes, the study is a multi-armed study of which at least two are relevant to the review and reported an adjusted effect size and variance measure.
- No, the study did not report data in a manner that enables extraction of a comparative effect size

Dealing with missing data

We will not contact authors to obtain missing data. This is a potential limitation of the review. Recently we conducted a review and around 30% of original papers did not report measures of variation and by contacting the authors, we were able to obtain information on numerous papers. However, this was a long process (months). Imputation methods for studies that do not report measures of variation for the outcomes of interest will not be used.

Assessment of heterogeneity

We propose, if the sample size is sufficient, to conduct a meta-regression to determine what factors are associated with the magnitude of effect size. Such a model would require 10 studies per covariate, therefore this may be a series of univariable models. We will initially try to use a log and logit link and determine if either modelling strategy is valid. If this is not possible we will still attempt to present possible sources of variation using tables or subgroup figures so the panel is aware of possible sources of heterogeneity but formal analysis may not be possible.

Data synthesis

The approach to evidence synthesis will depend upon the frequency of the outcomes of interest within the relevant studies. Tables that describe the outcomes used and the associations observed will be reported. We will attempt to prepare forest plots and calculate summary effect sizes for all outcomes.

Risk of bias across studies (PRISMA ITEM 15)

We will assess studies to have a high risk of bias if they have at least one high risk of bias domain. If possible we will also conduct an analysis for small study effects. However it is unclear if this will be useful as most of the studies will be small and it might not be possible to detect small study effects.

The sample size for small is based on the number of experimental units not the number of pseudo-replicates.

Additional analyses (PRISMA ITEM 16)

At this point we do not propose to do any additional analyses however if we do they will be reported here as they are not proposed *a priori*.

Study selection (PRISMA ITEM 17)

We will use a flow chart as recommended by PRISMA to present the number of papers screened, the number of relevant papers, and the number of papers included in the meta-analyses (if conducted) for each review.

Study characteristics (PRISMA ITEM 18)

We will provide a table that contains information about the relevant studies and other general characteristics collected.

Risk of bias within studies (PRISMA ITEM 19)

We will provide a table that contains risk of bias information about relevant studies.

Results of individual studies (PRISMA ITEM 20)

We will provide a table that contains this information about relevant studies. It is possible that there will be several tables, given the potential variety of outcomes. If suitable, we will provide a forest plot(s) that contains individual study data in lieu of a table.

Synthesis of results (PRISMA ITEM 21)

If a meta-analysis is conducted we will provide the results and interpretation of that analysis. If a meta-regression is conducted we will provide the results and interpretation of that analysis.

Risk of bias across studies (PRISMA ITEM 22)

If an analysis to assess small study effects is possible, we will provide the results of that analysis. If not, we will comment on the potential for small study effects.

Discussion (PRISMA ITEM 23)

We will provide a discussion about our conclusions about the review findings and interpretation for the EFSA working group to consider.

Appendix B Search strings

A1. Database: Science Citation Index Expanded (Web of Science, Thomson Reuters). 1900 to present. Last updated 29/08/14. Searched 08/09/14.

5 #4 AND #1 777

4 #3 OR #2 10,493

3 TS=(("modified" OR modify* OR modification* OR enrich* OR furnish*) NEAR/4 ("cage" OR "cages" OR house* OR "housing" OR "aviary" OR "aviaries" OR "barn" OR "barns" OR "pen" OR "pens")) 2,397

2 TS=("perch" OR "perches" OR "perching" OR "perchery" OR "percheries") 8,240

1 TS=("hen" OR "hens" OR "layer" OR "layers" OR chicken* OR "gallus domesticus" OR "g domesticus") 1,089,619

A2. Database: Conference Proceedings Citation Index – Science. (Web of Science, Thomson Reuters). 1990 to present. Last updated 29/08/14. Searched 08/09/14.

5 #4 AND #1 69

4 #3 OR #2 920

3 TS=(("modified" OR modify* OR modification* OR enrich* OR furnish*) NEAR/4 ("cage" OR "cages" OR house* OR "housing" OR "aviary" OR "aviaries" OR "barn" OR "barns" OR "pen" OR "pens")) 276

2 TS=("perch" OR "perches" OR "perching" OR "perchery" OR "percheries") 659

1 TS=("hen" OR "hens" OR "layer" OR "layers" OR chicken* OR "gallus domesticus" OR "g domesticus") 287,695

A3. Database: Biosis Citation Index (Web of Knowledge, Thomson Reuters). 1969 to 2014. Last updated 05/09/14. Searched 08/09/14.

5 #4 AND #1 713

4 #3 OR #2 11,847

3 TS=(("modified" OR modify* OR modification* OR enrich* OR furnish*) NEAR/4 ("cage" OR "cages" OR house* OR "housing" OR "aviary" OR "aviaries" OR "barn" OR "barns" OR "pen" OR "pens")) 1,991

2 TS=("perch" OR "perches" OR "perching" OR "perchery" OR "percheries") 9,959

1 TS=("hen" OR "hens" OR "layer" OR "layers" OR chicken* OR "gallus domesticus" OR "g domesticus") 477,893

A4. Database: CAB Abstracts (Web of Knowledge, Thomson Reuters). 1910 to 2014. Last updated 05/09/14. Searched 08/09/14.

- # 5 #4 AND #1 866
- # 4 #3 OR #2 6,175
- # 3 TS=(("modified" OR modify* OR modification* OR enrich* OR furnish*) NEAR/4 ("cage" OR "cages" OR house* OR "housing" OR "aviary" OR "aviaries" OR "barn" OR "barns" OR "pen" OR "pens")) 1,525
- # 2 TS=("perch" OR "perches" OR "perching" OR "perchery" OR "percheries") 4,797
- # 1 TS=("hen" OR "hens" OR "layer" OR "layers" OR chicken* OR "gallus domesticus" OR "g domesticus") 338,913

A5. Database: Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) <1946 to Present> Updated daily. Searched 08/09/14

- 1 Chickens/ (98859)
- 2 (hen or hens or layer or layers or chicken* or gallus domesticus or g domesticus).ti,ab,kf. (352238)
- 3 1 or 2 (395550)
- 4 (perch or perches or perching or perchery or percheries).ti,ab,kf. (1698)
- 5 ((modified or modify* or modification* or enrich* or furnish*) adj4 (cage or cages or house* or housing or aviary or aviaries or barn or barns or pen or pens)).ti,ab,kf. (1340)
- 6 4 or 5 (2996)
- 7 3 and 6 (296)

A6. Database: National Agriculture Library Catalog [AGRICOLA] 1970-Current <http://agricola.nal.usda.gov/>. Searched 08/09/14

Advanced: Article Citation Database

(hen OR hens OR layer OR layers OR chicken? OR "gallus domesticus" OR "g domesticus") AND (perch OR perches OR perching OR perchery OR percheries) 160 results

Advanced: Book Catalog

(hen OR hens OR layer OR layers OR chicken? OR "gallus domesticus" OR "g domesticus") AND (perch OR perches OR perching OR perchery OR percheries) 9 results

A7. Database: International Information System for the Agricultural Sciences and Technology [AGRIS] 1975 to date <http://agris.fao.org/>. Searched 08/09/14

(hen OR hens OR layer OR layers OR chicken* OR "gallus domesticus" OR "g domesticus") AND (perch OR perches OR perching OR perchery OR percheries) 170 results

A8. Database: TEKTRAN: The ARS Manuscripts Database <http://www.ars.usda.gov/services/tektran.htm>. Searched 09/09/14

Browse: Measure & Evaluate Animal Well-Being, Animal Behavior

Search: perch (appears to automatically truncate terms)

Records manually scanned; 1 unique potentially relevant record identified and added to EndNote. 5 duplicate records not downloaded.

A9. Database: National Institute of Food and Agriculture Current Research Information System [CRIS] <http://cris.nifa.usda.gov/>. Searched 09/09/14

CRIS Assisted Search (automatic truncation)

Fulltext Terms: perch

AND

Fulltext Terms: chicken; hen; layer

Records manually scanned; 12 potentially relevant records identified and added to EndNote

A10. Database: Open Grey <http://www.opengrey.eu/> Searched 09/09/14

(hen OR hens OR layer OR layers OR chicken* OR "gallus domesticus" OR "g domesticus") AND (perch OR perches OR perching OR perchery OR percherries)

(hen OR hens OR layer OR layers OR chicken* OR "gallus domesticus" OR "g domesticus") AND (cage OR cages OR house* OR housing OR aviary OR aviaries OR barn OR barns OR pen OR pens) AND (modified OR modify* OR modification OR enrich* OR furnish*)

Records manually scanned; 2 potentially relevant records identified and added to EndNote

A11. Database: Science.gov <http://www.science.gov/>. Searched 09/09/14

(hen OR hens OR layer OR layers OR chicken* OR "gallus domesticus" OR "g domesticus") AND (perch OR perches OR perching OR perchery OR percherries)

(hen OR hens OR layer OR layers OR chicken* OR "gallus domesticus" OR "g domesticus") AND (cage OR cages OR house* OR housing OR aviary OR aviaries OR barn OR barns OR pen OR pens) AND (modified OR modify* OR modification OR enrich* OR furnish*)

As not all collections seem to support Boolean/truncation/phrase searching – simple searches undertaken to try and capture any that may be otherwise missed.

hen* perch*

chicken* perch*

layer* perch*

Search full record: Science.gov websites, Biology and Nature, General Science. Agriculture and Food not searched as AGRICOLA and TEKTRAN searched separately.

99 records

A12. Database: Scienceresearch.com <http://scienceresearch.com/>. Searched 03/09/14

Full text: (hen OR hens OR layer OR layers OR chicken* OR “gallus domesticus” OR “g domesticus”) AND (perch OR perches OR perching OR perchery OR percherries)

Full text: (hen OR hens OR layer OR layers OR chicken* OR “gallus domesticus” OR “g domesticus”) AND (cage OR cages OR house* OR housing OR aviary OR aviaries OR barn OR barns OR pen OR pens) AND (modified OR modify* OR modification OR enrich* OR furnish*)

In Biology and Nature and Agriculture

Results scanned in databases – exclude potentially relevant records already identified by previous database searches. 0 records added to EndNote.

A13. Conference searches

International Conference on Assessment of Animal Welfare at Farm and Group Level, 2011, August 8-1 Guelph, Ontario. Searched 11/09/14

Proceedings available online
<http://www.uoguelph.ca/csaw/wafl/documents/WAFLproceedingsweb.pdf> ; presentations manually scanned. 1 abstract added to EndNote.

Conference was not held in 2010, 2012 or 2013 (takes place every 3 years) so proceedings from these years could not be searched. 2014 conference had not taken place at time of searches. .

OIE Global Conference on Animal Welfare. 6-8 November 2012 Kuala Lumpur, Malaysia <http://www.oie.int/eng/AW2012/presentations.htm>. Searched 11/09/14

Proceedings available online; presentations manually scanned. 0 abstracts added to EndNote.

Conference was not held in 2010, 2011, 2013 or 2014 so proceedings from these years could not be searched.

European Symposium on Poultry Welfare – 9th Meeting 2013; Uppsala Sweden 17-20 June. Searched 16/09/14

Conference proceedings not freely available online – could not be searched.

Conference was not held in 2010, 2011, or 2014 so proceedings from these years could also not be searched. 2009 conference (8th Meeting, Cervia Italy) indexed in CAB Abstracts so captured by search.

Congress of the International Society for Applied Ethology 2014 - 48th International Congress, Vitoria-Gasteiz, Spain. Searched 16/09/14

Abstracts available online <http://www.applied-ethology.org/hres/ISAE%202014.pdf>

Searched the PDF using “perch”, presentations manually scanned.

4 new records added to EndNote.

Congress of the International Society for Applied Ethology 2013 - 47th International Congress, Florianopolis, Brazil. Searched 16/09/14

Abstracts available online <http://www.applied-ethology.org/hres/ISAE%202013%209789086867790isae2013-e.pdf>

Searched the PDF using “perch”, presentations manually scanned.

2 new records added to EndNote.

Congress of the International Society for Applied Ethology 2012 - 46th International Congress, Vienna, Austria. Searched 16/09/14

Abstracts available online <http://www.applied-ethology.org/hres/ISAE%202012%20Vienna%20Proceedings%20PDF1.pdf>

Searched the PDF using “perch”, presentations manually scanned.

2 new records added to EndNote.

Congress of the International Society for Applied Ethology 2011 - 45th International Congress, Indianapolis USA. Searched 16/09/14

Abstracts available online <http://www.applied-ethology.org/hres/2011%20International%20Congress%20Proceedings,%20Indianapolis.pdf>

Searched the PDF using “perch”, presentations manually scanned.

1 new record added to EndNote.

Congress of the International Society for Animal Hygiene - XVIth International Congress in Animal Hygiene - 5 - 9 May 2013 Nanjing, China. Searched 16/09/14

Abstracts available online http://www.isah-soc.org/documents/2013/Proceeding_2013.pdf

Searched the PDF using “perch”, presentations manually scanned.

0 new records added to EndNote.

Congress of the International Society for Animal Hygiene - XVth International Congress in Animal Hygiene 3 - 7 July 2011 Vienna, Austria. Searched 16/09/14

Abstracts available online http://www.isah-soc.org/documents/2011/PRO_2011/isah2011.html

Searched the PDF using “perch”, presentations manually scanned.

0 new records added to EndNote.

Conference held bi-annually. No conference 2014, 2012 so these years could not be searched.

European Poultry Conference - Stavanger Norway June 2014. . Searched 16/09/14

Abstracts available at

<http://62.89.32.14/epc/wp-content/uploads/2012/02/scientific-program-0906-vertical.pdf>

<http://62.89.32.14/epc/wp-content/uploads/2012/02/posters-overview-010614.pdf>

Searched the PDF using “perch”, presentations manually scanned.

0 new records added to EndNote.

Cannot locate any proceedings from previous year's conferences, including via the WPSA webpages. WPSA suggests indexed by CAB Abstracts which was searched separately.

World's Poultry Congress 5 - 9 August 2012 Salvador, Bahia, Brazil. . Searched 16/09/14

Cannot locate any proceedings from this or previous year's conferences, including via the WPSA webpages. WPSA suggests indexed by CAB Abstracts which was searched separately.

Annual Meeting of the Poultry Science Association 2014 Texas. . Searched 16/09/14

Full abstract book not yet available. Programme available at <http://www.poultryscience.org/psa14/PSA14-Program.pdf>

Searched the PDF using "perch", presentations manually scanned.

2 new records added to EndNote.

Annual Meeting of the Poultry Science Association 2013 San Diego . Searched 16/09/14

Abstracts available at

<http://www.poultryscience.org/psa13/abstracts/2013-PSA-Abstracts.pdf>

Searched the PDF using "perch", presentations manually scanned.

4 new records added to EndNote.

Annual Meeting of the Poultry Science Association 2012 Georgia. . Searched 16/09/14

Abstracts available at

<http://www.poultryscience.org/psa12/abstracts/2012-PSA-Abstracts.pdf>

Searched the PDF using "perch", presentations manually scanned.

6 new records added to EndNote.

Annual Meeting of the Poultry Science Association 2011 St Louis. . Searched 16/09/14

Abstracts available at

<http://www.poultryscience.org/psa11/abstracts/2011-PSA-Abstracts.pdf>

Searched the PDF using "perch", presentations manually scanned.

3 new records added to EndNote.

ISAE Regional Meeting – Joint Canada and USA 2014, Michigan State University. Searched 17/09/14

Abstracts available at

<http://www.poultryscience.org/psa11/abstracts/2011-PSA-Abstracts.pdf>

Searched the PDF using "perch", presentations manually scanned.

1 new record added to EndNote.

ISAE Regional Meeting – Nordic 2014, Oscarsborg Fortress, Drøbak, Norway. Searched 17/09/14

Abstracts available at

<http://www.applied-ethology.org/hres/06JUL14%20Proceedings%20Nordic%20ISAE%202014.pdf>

Searched the PDF using “perch”, presentations manually scanned.

0 new records added to EndNote.

ISAE Regional Meeting – Benelux 2013, Sterksel, The Netherlands. Searched 17/09/14

Abstracts available at

<http://www.applied-ethology.org/hres/Proceedings%20ISAE%20Benelux%202013>

Searched the PDF using “perch”, presentations manually scanned.

0 new records added to EndNote.

ISAE Regional Meeting – Joint East and West Central Europe 2013, Skopje, Macedonia. Searched 17/09/14

Abstracts available at

[http://www.applied-ethology.org/hres/13Dec13%20PROCEEDINGS_reg_ISAE_2013_in_Skopje\[1\].pdf](http://www.applied-ethology.org/hres/13Dec13%20PROCEEDINGS_reg_ISAE_2013_in_Skopje[1].pdf)

Searched the PDF using “perch”, presentations manually scanned.

0 new records added to EndNote.

ISAE Regional Meeting – North America 2012, Alberta, Canada Searched 17/09/14

Abstracts available at

http://www.applied-ethology.org/hres/20Feb13%20Proceedings_of_the_11th_North_American_ISAE_Regional_Meeting.pdf

Searched the PDF using “perch”, presentations manually scanned.

0 new records added to EndNote.

ISAE Regional Meeting – Nordic 2012, Skara, Sweden. Searched 17/09/14

Abstracts available at

<http://www.applied-ethology.org/hres/2012%20-%20Nordic%20Regional%20Meeting%20Abstracts.pdf>

Searched the PDF using “perch”, presentations manually scanned.

0 new records added to EndNote.

ISAE Regional Meeting – Australasia and Africa 2012, University of Melbourne, Australia. Searched 17/09/14

Abstracts available at

http://www.applied-ethology.org/hres/01%20Nov%2012%20ISAE_meeting_programme__abstracts_booklet_24-10-2012.pdf

Searched the PDF using “perch”, presentations manually scanned.

2 new records added to EndNote.

ISAE Regional Meeting – Joint East and West Central Europe 2011, Czech Republic. Searched 17/09/14

Abstracts available at

<http://www.applied-ethology.org/hres/ISAE%20East%20and%20West%20Central%20Europe%202011%20Program%20%20Abstracts.pdf>

Searched the PDF using “perch”, presentations manually scanned.

0 new records added to EndNote.

ISAE Regional Meeting – Nordic 2011, Tartu, Estonia. Searched 17/09/14

Abstracts available at

<http://www.applied-ethology.org/hres/2011%20nordic%20proceedings1.pdf>

Searched the PDF using “perch”, presentations manually scanned.

0 new records added to EndNote.

Appendix C Studies excluded at Level 2 because they did not included an assessment of perch height as one of the characteristics

- Abrahamsson P and Tauson R, 1993. Effect of Perches at Different Positions in Conventional Cages for Laying Hens of 2 Different Strains. *Acta Agriculturae Scandinavica Section A-Animal Science*, 43, 228-235.
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Appendix D Studies excluded at Level 3 based on full text.

Author	Title	Journal	Volume	Year	Reason
M. A. F. Nasr, C. J. Nicol, J. C. Murrell	Do Laying Hens with Keel Bone Fractures Experience Pain?	Plos One	7	2012	No relevant outcomes
S. Ronchen, B. Scholz, H. Hamann, O. Distl	Use of functional areas, perch acceptance and selected behavioural traits in three different layer strains kept in furnished cages, small group systems and modified small group systems with elevated perches	Archiv Fur Geflugelkunde	74	2010	Not a valid comparison of perch heights
B. Scholz, S. Ronchen, H. Hamann, O. Distl	Bone strength and keel bone status of two layer strains kept in small group housing stems with different perch configurations and group sizes	Berliner Und Munchener Tierarztliche Wochenschrift	122	2009	Not a valid comparison of perch heights
B. Scholz, S. Roenchen, H. Hamann, H. Pendl, O. Distl	Effect of housing system, group size and perch position on H/L-ratio in laying hens	Archiv Fur Geflugelkunde	72	2008	No relevant outcomes
S. Ronchen, B. Scholz, M. Hewicker-Trautwein, H. Hamann, O. Distl	Foot pad health in Lohmann Selected Leghorn and Lohmann Brown laying hens kept in different housing systems with modified perch design	Archiv Fur Geflugelkunde	72	2008	Not a valid comparison of perch heights
S. Roenchen, B. Scholz, H. Hamann, O. Distl	Foot pad health, plumage condition, integument and claw length of Lohmann Silver laying hens kept in small aviary	Archiv Fur Tierzucht-Archives of Animal Breeding	50	2007	Not a valid comparison of perch heights

	housing systems, furnished cages and an aviary housing system					
C. Moinard, K. M. D. Rutherford, P. Statham, P. R. Green	Visual fixation of a landing perch by chickens	Exp. Brain Res.	162	2005	No relevant outcomes	
C. Moinard, P. Statham, P. R. Green	Control of landing flight by laying hens: implications for the design of extensive housing systems	Br. Poult. Sci.	45	2004	No relevant outcomes	
B. Wechsler, B. Huber-Eicher	The effect of foraging material and perch height on feather pecking and feather damage in laying hens	Appl. Anim. Behav. Sci.	58	1998	No relevant outcomes (2 duplicates)	
G. B. Scott, N. R. Lambe, D. Hitchcock	Ability of laying hens to negotiate horizontal perches at different heights, separated by different angles	Br. Poult. Sci.	38	1997	No relevant outcomes	
N. R. Lambe, G. B. Scott, D. Hitchcock	Behaviour of laying hens negotiating perches at different heights	Anim. Welf.	6	1997	Not a valid comparison of perch heights	
P. Abrahamsson, R. Tauson, M. C. Appleby	Behaviour, health and integument of four hybrids of laying hens in modified and conventional cages	Br. Poult. Sci.	37	1996	Not a valid comparison of perch heights	
E.K.F. Froehlich	Influences of raised perches and space restriction during the rearing of laying hens	KTBL-Schrift, Kuratorium fuer Technik und Bauwesen in der Landwirtschaft (Germany, F.R.)	(no.344) p. 36-46	(1990)	Not in English	
K. Ascard, E. von Wachenfelt, H. von Wachenfelt	Organic egg production Ekologisk aggproduktion	Specialmeddelande - Institutionen for Jordbrukets Biosystem och Teknologi, Sveriges Lantbruksuniversitet		2002	Not in English	
J. C. Swanson	CRIS Project Description: Optimization of poultry welfare and production systems for the			2009	Protocol	

B. Scholz, J. B. Kjaer, L. Schrader	21st century Analysis of landing behaviour of three layer lines on different perch designs	2014	Not a valid comparison of perch heights
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