DELIVERABLE

D 2.1.2 – DESCRIPTION OF THE CONSIDERED VALIDATED INDICATORS AMONG THE IDENTIFIED ONES AND ASSOCIATED METHODOLOGY, LAYING HENS WELFARE IN ALTERNATIVE HOUSING SYSTEMS.

Contents

1. Introduction

This document is part of the **sub-activities 2.1** "*Relevant animal welfare indicators*" and concerns to the priority area related to laying hens welfare in alternative housing systems.

In this welfare issue, animal (ABI), resource (RBI) and management-based indicators (MBI) and its methods of assessment for each legal requirement are identified and described. The description of the methods is based on scientific publications or Competent Authorities' official inspection documents provided to the EURCAW-Poultry-SFA. There might be some methods not described in this document, the list is not exhaustive. The experts from the EURCAW-Poultry-SFA chose the most relevant ones according to their knowledge and the available scientific data.

Afterwards, the indicators and methods of assessment are evaluated according to their validity, feasibility and reliability (see definition below) in order to deliver to Competent Authorities (CA) useful information for official controls. However, some indicators are not developed in this document because their methodology will be part of the deliverable 2.2.2 output namely to propose better methods of animal welfare assessment for the legislative requirements most difficult to implement. Thus, they will be developed in future working programs.

Definitions

Legal requirement: a requisite of the EU legislation to be assessed during the official controls.
Example: Directive 98/58 EC, Annex, Paragraph 10: *"Temperature, relative air humidity […] must be kept within limits which are not harmful to the animals"*

Indicator: an occurrence, observation, record or measurement which has a proven relationship with the legal requirement, which can be:

- **Animal-based indicator (ABI)**: a response of an animal or an effect on an animal used to assess its welfare. It can be taken directly on the animal or indirectly and includes the use of animal records.
  Example: huddling as ABI of cold stress and panting as ABI of heat stress.
- **Resource-based indicator (RBI)**: an evaluation of a feature of the environment in which the animal is kept or to which it is exposed.
  Example: Environmental temperature, humidity.
- **Management-based indicator (MBI)**: an evaluation of what the animal unit manager or stockperson does, and which management processes or tools are used.
  Example: Protocol for activation of the ventilation system.

Iceberg indicator: indicator reflecting major welfare issues in an integrative manner in order to enable an initial overview on the welfare state.

Method for the assessment (= method): a form of evaluation of the indicators that might be used in the frame of the verification of the legal requirements.
Example: Examine groups of birds at up to 5 well-distributed locations. If birds are panting, count out 100 birds (do not disturb them and leave them sitting where they are) and estimate how many of the 100 birds are panting.

Validity: The extent to which an indicator is meaningful in terms of providing information on a legal requirement concerning an animal or a group of animals.

Reliability: The extent to which results are largely the same when the same observer repeats assessments after receiving reasonable training or the agreement between two or more observers after they have received reasonable training.

Feasibility: Capacity to be applicable to different housing systems or waterbath stunning equipment and at least have the potential to be applied in the field (on-farm or in slaughterhouse).

2. Methodology used

In this document, for each legal requirement ABI, RBI or MBI are identified and their method of assessment described and evaluated according the validity, reliability and feasibility. This information is summarized in tables where their validity, reliability and feasibility are scored according to information found in the scientific literature, the ranking of the CAs and the expert knowledge. The ranking exercise of the CAs was carried out during the first meeting between the EURCAW-Poultry-SFA and the CAs of MSs (available in deliverable D.1.1.3, annexes, 5, 6, and 7). We choose a rating method with three levels, as follow in table 1 below.

Table 1: Rating method used for the assessment of the validity, reliability and feasibility of the indicators

	Gap of knowledge	**X** (low)	**XX** (moderate)	**XXX** (high)
Validity	• No data found in literature • No data on ranking exercise from Cas • No expert opinion	• Literature shows low correlation between the legal requirement and the indicator/method *And/or* • Average score from 0 to 2 (on a scale of 5) in CAs ranking exercise *And/or* • Expert opinion with experience of poor level of validity	• Literature shows moderate correlation between the legal requirement and the indicator/method *And/or* • Average score higher than 2 and lower than 4 (on a scale of 5) in CAs ranking exercise *And/or* • Expert opinion with experience of moderate level of validity	• Literature shows high correlation (with causality link) between the legal requirement and the indicator/method. *And/or* • Average score higher than 4 (on a scale of 5) in CAs ranking exercise *And/or* • Expert opinion with experience of high level of validity
Reliability	• No data found in literature • No data on ranking exercise from CA • No expert opinion	• Literature shows low reliability *And/or* • Average score from 0 to 2 (on a scale of 5) in CAs ranking exercise *And/or* • Expert opinion with experience of poor level of reliability	• Literature shows moderate reliability *And/or* • Average score higher than 2 and lower than 4 (on a scale of 5) in CAs ranking exercise *And/or* • Expert opinion with experience of moderate level of reliability	• Literature shows high reliability *And/or* • Average score higher than 4 (on a scale of 5) in CAs ranking exercise *And/or* • Expert opinion with experience of high level of reliability
Feasibility	• No data found in literature • No data on ranking exercise from CA • No expert opinion	• *Material needed:* High cost/low availability material (*e.g.* gas meter, dust meter) *And/or* • *Time to performed:* More than 60 min *And/or* • *Ease to access:* Difficult access or not possible in more than one type of structure *And/or* • *Animal manipulation:* Biological sampling (*e.g.* blood, swab)	• *Material needed:* moderate cost of the material (*e.g.* thermometer, hygrometer) *And/or* • *Time to be performed:* 30-60 min *And/or* • *Ease of access:* Not easy to access (*e.g.* to upper tiers) or not easy to apply in all farm/slaughterhouses *And/or* • *Animal manipulation*: Some animal manipulation with no biological sampling (*e.g.* check foot pad)	• *Material needed:* no or low-cost material (*e.g.* tape measurer) *And/or* • *Time to be performed:* less than 30 min *And/or* • *Ease of access:* Easy to access and feasible in all kind of structure *And/or* • *Animal manipulation:* No animal manipulation

3. Laying hens welfare in alternative housing systems

3.1. Legal Requirement: "*The stocking density must not exceed 9 laying hens per m² usable area.*" (Directive 1999/74/EC, Article 4)

3.1.1. ABI: There is no specific ABI for this requirement.

3.1.2. RBI:

- Birds per m² of usable area:
  - *Description of the method:*

1) Calculate usable area (*see Definition below*): calculate the surface of the inside of the barn (only count permanently available surface), in square meters, and add each level surface following definition instruction. A covered veranda area is included in this calculation only if it is permanently available to the animals.
2) Get the exact number of hens delivered
3) Divide the number of hens by the usable area (without deducting the number of dead and culled hens).

According to the legislation: Usable area means an area at least 30 cm wide with a floor slope not exceeding 14 %, with headroom of at least 45 cm. Nesting areas shall not be regarded as usable areas.

- *Evaluation of the method:* Referring to the plans of the farm is not sufficient, visit inside the barn is needed to check the dimensions and withdraw the surface that cannot be considered as usable area. It is recommended to use an electronic tool for length measurement.

  According to expert opinion, this method is fully valid, feasible and reliable to evaluate compliance with this requirement.

RBI	Validity	Feasibility	Reliability
Birds per m² of usable area	XXX	XXX	XXX

3.1.3. MBI: There is no specific MBI for this requirement.

3.2. Legal Requirement: "*The floors of installations must be constructed so as to support adequately each of the forward-facing claws of each foot*." (Directive 1999/74/EC, Article 4)

3.2.1. ABI:

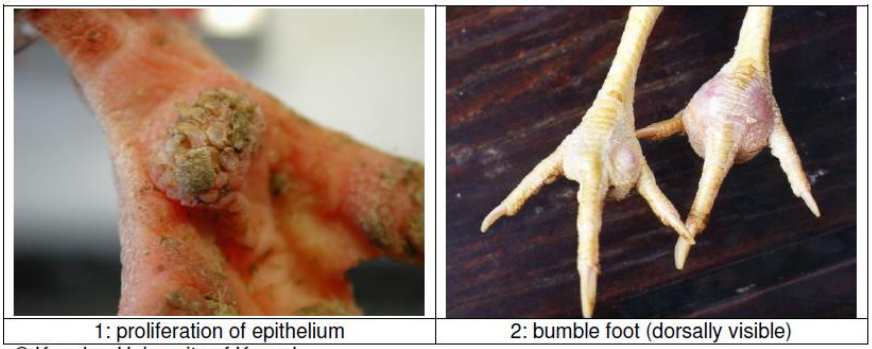
- Foot lesions: Foot lesions are described and used in literature, for example in the Welfare Quality Protocol (2009) in terms of thickening epithelium or bumble foot. Bumble foot is a swelling of the foot which may result in a very swollen balloon-shaped foot. However, the causes of bumble foot are not very clear. Bumble foot could be influenced by perch design, genotype or hygiene. Toe damage can also be checked, it is defined as "wounds on one or more toes and/or missing (parts of) one or more toes" (WelfareQuality®, 2009). Toe damage seems to be more relevant to assess poor equipment design than bumble foot but it could

also result from cannibalism. So, foot lesion is an ABI which may be used for the assessment of this requirement, but it should be used with caution. It could give information on the flooring design, but it can also be induced by other parameters.

- *Description of the method:*

1. Take 100 hens in the barn at random (10 birds from ten different locations)
2. Evaluate their feet according to their state, you can use the scoring of Welfare Quality (2009) for example. For foot lesions, there are 3 levels:
   - Feet intact, no or minimal proliferation of epithelium, no wounds
   - Necrosis or proliferation of epithelium or chronic bumble foot with no or moderate swelling, not dorsally visible
   - Swollen (dorsally visible)

Figure 5: *Pictures from Welfare Quality Protocol (2009) about foot lesions*



1: proliferation of epithelium | 2: bumble foot (dorsally visible)

© Keppler, University of Kassel

Concerning toe damages, there are also 3 levels (same sample of 100 birds):
- No damaged toes
- Fewer than 3 birds with damaged toes
- 3 or more birds with damages toes

- *Evaluation of the method:* Methods of assessment described in literature seem to be complicated to apply during farm inspection. For example, the instruction in the Welfare Quality Protocol (2009) includes handling of 100 laying hens (10 birds from ten different locations) to score their feet from 0 (feet intact) to 2 (swollen, dorsally visible). In various scientific publications investigating feet lesions, bumble feet, missing toes or toe wound, evaluation was done on a sample of birds, usually 50 or 100 birds (Heerkens et al., 2016; Riber and Hinrichsen, 2016; Rørvang et al., 2019). These sample sizes require scoring during a certain amount of time. In addition, there is no defined trigger level of lesions in literature which indicates that the floors of installations are not adapted. Thus, foot lesion is an indicator validated by literature concerning the evaluation of animal welfare but it has not been specifically validated to assess the compliance with this requirement. Concerning reliability between observers, Heerkens *et al*. (2016) put in evidence a good inter-observer reliability PAKAB score (equal to 0.896) using foot lesions as an indicator in their study.

ABI	Validity	Feasibility	Reliability
Foot lesions	X	X	XXX

3.2.2. RBI: There is no specific RBI for this requirement.

3.2.3. MBI: There is no specific MBI for this requirement.

3.3. Legal Requirement: *"[…] dust levels must be kept within limits which are not harmful to the animals"* (Directive 98/58 EC, Annex, Point 10)

3.3.1. ABI: There is no specific ABI for this requirement.

3.3.2. RBI:

- Assessment of the dust level: see deliverable **D.2.2.2**.

RBI	Validity	Feasibility	Reliability
Assessment of the dust level	See deliverable **D.2.2.2**.		

3.3.3. MBI:

- Register consultation to check the frequency of respiratory troubles: see deliverable **D.2.2.2**.

MBI	Validity	Feasibility	Reliability
Register consultation to check the frequency of respiratory troubles	See deliverable **D.2.2.2**.		

3.4. Legal Requirement: "*All systems must be equipped in such a way that all laying hens have: (a) either linear feeders providing at least 10 cm per bird or circular feeders providing at least 4 cm per bird*" (Directive 1999/74/EC, Article 4)

3.4.1. ABI: There is no specific ABI for this requirement.

3.4.2. RBI:

- Feeder length per bird:
  - *Description of the method:*
    1) According to the type of feeders, calculate the length of available feeders.
    2) Get the exact number of hens delivered
    3) Divide the length of feeders by the number of hens (without deducting the number of dead and culled hens).
  - *Evaluation of the method:* Referring to the plans of the farm is not sufficient, calculation of the length of available feeders is needed to check the exact dimensions. It is recommended to use an electronic tool for length measurement, when appropriate. According to expert opinion, this method is fully valid and reliable to evaluate the compliance with this requirement. Nevertheless, it could take time depending on the size of the farm. Thus, the feasibility is between low and intermediate.

RBI	Validity	Feasibility	Reliability
Feeder length per bird	XXX	X	XXX

3.4.3. MBI: There is no specific MBI for this requirement.

3.5. Legal Requirement: "*(…) (b) either continuous drinking troughs providing 2.5 cm per hen or circular drinking troughs providing 1 cm per hen. In addition, where nipple drinkers or cups are used, there shall be at least one nipple drinker or cup for every 10 hens. Where drinking points are plumbed in, at least two cups or two nipple drinkers shall be within reach of each hen*" (Directive 1999/74/EC, Article 4)

3.5.1. ABI: There is no specific ABI for this requirement.

3.5.2. RBI:

- <u>Birds per drinker:</u>
  - *Description of the method:*
    1) Calculate the number of drinking points in one row
    2) Multiply this number by the number of lines
    3) Get the exact number of hens delivered
    4) Divide the total number of cups or nipple drinkers by the number of hens (without deducting the number of dead and culled hens)
  - *Evaluation of the method:* Referring to the plans of the farm is not sufficient, calculation of the number of available drinkers is needed. According to expert opinion, this method is fully valid, feasible and reliable.
- <u>Drinker length per bird:</u>
  - *Description of the method:*
    1) According to the type of drinkers, calculate the length of available drinkers.
    2) Get the exact number of hens delivered
    3) Divide the length of drinkers by the number of hens (without deducting the number of dead and culled hens)
  - *Evaluation of the method:* Referring to the plans of the farm is not sufficient, calculation of the length of available drinkers is needed. It is recommended to use an electronic tool for length measurement. According to expert opinion, this method is fully valid and reliable to evaluate the compliance with this requirement. Nevertheless, it could take time depending on the size of the farm. Thus, the feasibility is between low and intermediate.

RBI	Validity	Feasibility	Reliability
Birds per drinker	XXX	XXX	XXX
Drinker length per bird	XXX	X	XXX

3.5.3. MBI: There is no specific MBI for this requirement

3.6. Legal Requirement: *"[...]gas concentrations must be kept within limits which are not harmful to the animals"* (Directive 98/58 EC, Annex, Point 10)

3.6.1. ABI:

- Register consultation to check the frequency of respiratory troubles:
  - *Description of the method:* Inspectors can check the flock register to look at the frequency of respiratory troubles.
  - *Evaluation of the method:* The link between these troubles and the ambiance may be difficult to prove. In addition, determine the number of respiratory troubles which indicates a problem is complicated. Furthermore, the flock register must be complete. Because of these difficulties, the validity of this indicator is low whereas feasibility and reliability of the register consultation are high.

ABI	Validity	Feasibility	Reliability
Register consultation	X	XXX	XXX

3.6.2. RBI:

- CO_2 and NH_3 concentrations measurements in air with specific device:
  - *Description of the method:*

    Method from the French Competent Authority methodology for broilers (DGAL/SDSPA/2017-998):

    1. Take 5 representative measures of CO_2 and NH_3 with specific devices.

       CO_2 measures need to be taken at animals' height, away from heating materials, prefer to take the measures in feeding and drinking areas. When it is possible, try to take into account the air system (linked to the ventilation system).

       NH_3 measures need to be taken at animals' height (wait approximately one minute for each measure), away from the building entrance or wet areas (nipple drinkers, water leaks), prefer to take the measures in feeding areas. When it is possible, try to take into account the air system (linked to the ventilation system).

    2. Calculate the average of the 5 measures for each gas.

  - *Evaluation of the method:* It is important to take care of waiting for the stabilisation of each measure with the device. According to the Competent Authorities, this indicator is highly valid and reliable (respectively grades of 4/5 and 4.7/5). The feasibility is slightly lower with 3.5/5.

- Sensorial evaluation of ammonia concentration:
  - *Description of the method (DGAL/SDSPA/2017-998)*: Stay at least 5 minutes in the barn and proceed of a sensorial evaluation of ammonia concentration (i.e., evaluate

your eyes/nose irritation). If you have a stinging sensation in the nose or eyes, the ammonia concentration is too high.

- *Evaluation of the method:* If there is any doubt, a specific device needs to be used to complete the sensorial evaluation. This indicator is not valid or reliable because of the considerable sensibility difference existing between people, and difference in time for a same person. However, it requires limited amount of time and no materials, so the feasibility of this indicator is high.

RBI	Validity	Feasibility	Reliability
CO_2 and NH_3 concentrations measurements in air	XXX	XX	XXX
Sensorial evaluation of ammonia concentration	X	XXX	X

3.6.3. MBI: There is no specific MBI for this requirement.

3.7. Legal Requirement: *"All buildings shall have light levels sufficient to allow all hens to see one another and be seen clearly, to investigate their surroundings visually and to show normal levels of activity. After the first days of conditioning, the lighting regime shall be such as to prevent health and behavioural problems. Accordingly it must follow a 24-hour rhythm and include an adequate uninterrupted period of darkness lasting, by way of indication, about one third of the day, so that the hens may rest and to avoid problems such as immunodepression and ocular anomalies." (Directive 1999/74/EC, Annex, point 3)*

3.7.1. ABI: There is no specific ABI for this requirement.

3.7.2. RBI:

- Light intensity measurements at animals' level:
  - *Description of the method:*

    Method from the French Competent Authority methodology for broilers (DGAL/SDSPA/2017-998):

    1) Use a lux meter with 5 measures at animal head's level, horizontally, in areas free of shadows (of animals, inspector or farmer). These 5 areas need to be representative of light distribution in the barn. Prefer feeding and drinking areas and avoid resting areas.
    2) To have a mean value of the light intensity in the barn, extract the lowest value and average these 4 measurements.

  - *Evaluation of the method:* Do not take measure if there is a temporary reduction in the lighting level allowed following veterinary advice, or in the twilight period.
    According to the Competent Authorities, this indicator is highly valid and reliable (respectively grades of 4.1/5 and 4.7/5). The feasibility is slightly lower with 3.9/5.

RBI	Validity	Feasibility	Reliability
Light intensity measurements at animals' level	XXX	XX	XXX

3.7.3. MBI:

- Lighting programme records checking:
  - *Description of the method:* check the lighting programme when it is recorded and verify that the dark period is adequate.
  - *Evaluation of the method:* According to the Competent Authorities, this indicator is highly valid and reliable (respectively grades of 4.3/5 and 4.4/5). The feasibility is slightly lower with 3.4/5.

MBI	Validity	Feasibility	Reliability
Lighting program records checking	XXX	XX	XXX

3.8. Legal Requirement: *"A period of twilight of sufficient duration ought to be provided when the light is dimmed so that the hens may settle down without disturbance or injury."* (Directive 1999/74/EC, Annex, Paragraph 3)

3.8.1. ABI:

- Proportion of hens on perches during dark period: There is no literature or studies using this indicator.

ABI	Validity	Feasibility	Reliability
Proportion of hens on perches during dark period	**Gaps of Knowledge**		

3.8.2. RBI: There is no specific RBI for this requirement.

3.8.3. MBI:

- Lighting program records for checking presence and duration of twilight:
  - *Description of the method:* Inspectors can check the lighting programme when it is recorded.
  - *Evaluation of the method:* According to the Competent Authorities, this indicator is highly valid, feasible and reliable (grade of 4.4/5 for validity, feasibility and reliability).

MBI	Validity	Feasibility	Reliability
Lighting program records for checking presence and duration of twilight	XXX	XXX	XXX

3.9. Legal Requirement: "*Where there is natural light, light apertures must be arranged in such a way that light is distributed evenly within the accommodation*." (Directive 1999/74/EC, Annex, Paragraph 3)

3.9.1. ABI: There is no specific ABI for this requirement.

3.9.2. RBI*:*

- Light evenness: There is no literature, protocol or studies using this indicator.

RBI	Validity	Feasibility	Reliability
Light evenness	**Gaps of knowledge**		

3.9.3. MBI: There is no specific MBI for this requirement.

3.10. Legal Requirement: *"[…] temperature, relative air humidity […] must be kept within limits which are not harmful to the animals"* (Directive 98/58 EC, Annex, Point 10)

3.10.1. ABI:

- Panting (high effective temperature) or Huddling (low effective temperature)
  - *Description of the method:* During the inspection, be attentive to birds performing panting ("Breathing rapidly and in short gasps" (WelfareQuality®, 2009)) or huddling behaviour ("Birds grouping together into tight groups, sitting closely alongside each other, often in 'clumps' with areas of empty space in between." (WelfareQuality®, 2009)). The Welfare Quality Protocol (2009) can be used. Estimate the percentage of animals panting and huddling at three moments:
    1) At the start of your inspection, walking through the pen.
    2) Halfway through your inspection
    3) At the end of your inspection

    Then, pick the worst percentage of animals that performed panting and huddling behaviour and use them to evaluate the thermal comfort of the hens.
  - *Evaluation of the method:* It is important to know how to recognize panting and huddling behaviour. With huddling, be careful to only count animals that huddle due to thermal reasons and not gathering together following fearful stimulus. Panting behaviour can also be seen with stressful animals without any thermal discomfort.

According to the Competent Authorities, this indicator is highly valid with a scoring of 4/5. However, the reliability and the feasibility are slightly lower with respectively grades of 3.2/5 and 3.5/5.

- Shivering (low effective temperature, extreme case): Definition: "Shaking slightly and uncontrollably" (Strawford et al., 2011)

  Shivering is rarely observed on farm, but it may happen with very low temperatures. There is a gap of knowledge in literature about the assessment of this indicator rarely used probably because it is not common to see animals shivered on farm. Nevertheless, the Welfare Quality Protocol (2009) method to assess panting and huddling behaviours (see above) can be used in the same way, to assess animals shivering.

ABI	Validity	Feasibility	Reliability
Panting, huddling and shivering	XXX	XX	XX

3.10.2. RBI:

- Environmental temperature measurements in the barn or recordings in the control panel

  - *Description of the method:* Use a temperature assessment device (thermometer) at the height of birds to evaluate the temperature in the barn. Measure temperature in several area in the barn where the temperature could vary (near to the drinkers, near to the feeders, in the middle of the barn without any facilities, along the walls, in the nests, near to popholes, …). You can also check the control panel.

  - *Evaluation of the method:* If you check the control panel, use a temperature assessment device to be sure of the veracity of the data. Temperature sensor problem could occur.

According to the Competent Authorities, this indicator is highly valid, reliable and feasible with a respectively scoring of 4.8/5, 4.5/5 and 4.6/5.

- Humidity measurements in the barn or recordings in the control panel:

  - *Description of the method:* Use a relative humidity assessment device (hygrometer) to evaluate the humidity level in the barn. Measure it in several area in the barn where it could vary (near to the drinkers, near to the feeders, in the middle of the barn without any facilities, along the walls, in the nests, near to popholes, …). You can also check the control panel.

  - *Evaluation of the method:* If you check the control panel, use a hygrometer to be sure of the veracity of the data. Sensor problem could occur.

According to the Competent Authorities, this indicator is highly valid, reliable and feasible with a respectively scoring of 4.8/5, 4.5/5 and 4.6/5.

- Temperature Humidity Index

  - *Description of the method:* THI is calculated with the environmental temperature and the relative humidity and can be used to detect heat stress conditions. There are several THI formulations, for example: THI = 1.8 x T – (1-RH) × (T-14.3) + 32 (Kibler 1964 in (Bouraoui et al., 2002)) where T is the dry bulb temperature of indoor air hourly measured (C°) and RH is the relative humidity of indoor air hourly measured (as a fraction of the unit) (Karaman et al., 2007). According to Karaman and colleagues, a value of THI above 70 indicates a heat stress for the laying hens.

  - *Evaluation of the method:* Differences of THI formulas and thus different THI values show the complexity of using this indicator alone to evaluate heat stress. In addition, the formula does not take into account parameters affecting animals' thermal comfort like their genotype, their age, the ventilation level or the stocking density. Thus, its validity is considered low. Nevertheless, according to expert opinion, calculate a THI is feasible and reliable.

RBI	Validity	Feasibility	Reliability
Environmental temperature measurements in the barn or recording in the control panel	XXX	XXX	XXX
Humidity measurements in the barn or recordings in the control panel	XXX	XXX	XXX
Temperature Humidity Index	X	XXX	XXX

3.10.3. MBI: There is no specific MBI for this requirement.

3.11. Legal Requirement: *"Ventilation shall be sufficient to avoid overheating and, where necessary in combination with heating systems to remove excessive moisture"* (Directive 98/58 EC, Annex, Point 10)

Ventilation is very related to temperature and relative humidity. It is why indicators and assessment methods are identical.

3.11.1. ABI:

- Panting (high effective temperature) or Huddling (low effective temperature) see 3.10.1.
- Shivering (low effective temperature, extreme case): see 3.10.1.

ABI	Validity	Feasibility	Reliability
Panting, Huddling and shivering	**See 3.10.1.**		

3.11.2. RBI:

- Environmental temperature measurements in the barn or recordings in the control panel: see 3.10.2.
- Humidity measurements in the barn or recordings in the control panel: see 3.10.2.
- Temperature Humidity Index: see 3.10.2.
- Ventilation: There is no literature, protocol or studies using this indicator.

RBI	Validity	Feasibility	Reliability
Environmentale temperature measurements in the barn or recording in the control panel	**See 3.10.2.**		
Humidity measurements in the barn or recordings in the control panel			
Temperature Humidity Index			
Ventilation	**Gap of knowledge**		

3.11.3. MBI: There is no specific MBI for this requirement.

3.12. Legal Requirement: "*At least one nest for every seven hens. If group nests are used, there must be at least 1 m2 of nest space for a maximum of 120 hens*" (Directive 1999/74/EC, Article 4)

According to the Directive 1999/74/EC, a nest is a separate space for egg laying, the floor components of which may not include wire mesh that can come into contact with the birds, for an individual hen or for a group of hens (group nest).

3.12.1. ABI: There is no specific ABI for this requirement.

3.12.2. RBI:

- Number of hens per nest:
  - *Description of the method:*
    1) Count the number of nest boxes available for the animals
    2) Get the exact number of hens at the moment of inspection
    3) Divide the number of hens by the number of nest boxes to have the number of hens per nest
  - *Evaluation of the method:* Referring to the plans of the farm is not sufficient, counting of the number of available nests is needed. Pay attention to the availability of nests and not only their presence, some nests could be close to animals. According to expert opinion, this method is fully valid, feasible and reliable to evaluate compliance with this requirement.
- - Hens per m^2 of nest space:
  - *Description of the method:*
    1) Measure the nest surface
    2) Multiply it by the number of available group nests
    3) Get the exact number of hens at the moment of inspection
    4) Divide the total nest space by the number of hens
  - *Evaluation of the method:* Referring to the plans of the farm is not sufficient, calculation of the surface of available nests is needed. Pay attention to the availability of nests and not only their presence, some nests could be close to animals. According to expert opinion, this method is fully valid and reliable to evaluate compliance with this requirement. Nevertheless, it could take time to measure the nest surface depending on the size of the flock and nests. Thus, the feasibility is between low and intermediate.

RBI	Validity	Feasibility	Reliability
Number of hens per nest	XXX	XXX	XXX
Birds per m² of nest space	XXX	X	XXX

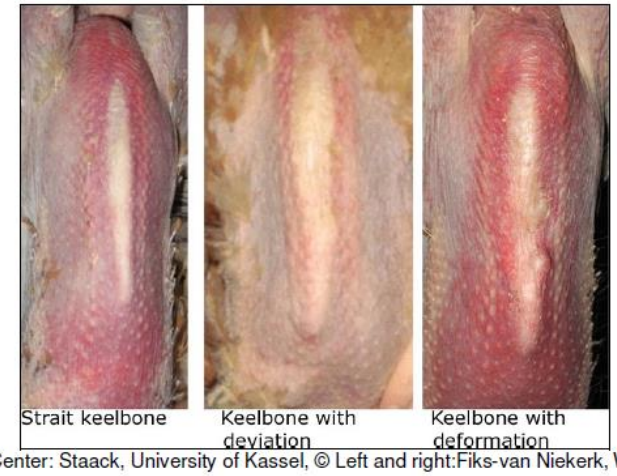
3.12.3. MBI: There is no specific MBI for this requirement.

3.13. Legal Requirement: "*Adequate perches, without sharp edges and providing at least 15 cm per hen. Perches must not be mounted above the litter and the horizontal distance between perches must be at least 30 cm and the horizontal distance between the perch and the wall must be at least 20 cm*" (Directive 1999/74/EC, Article 4)

3.13.1. ABI:

- Number of hens perching (day/night): There is no useable (during inspection) method available in literature for this indicator.
- Keel Bone Damage (KBD):
  - *Description of the method (WelfareQuality®, 2009):*

    1) Take 100 hens in the barn at random in several areas (litter, slatted floor, perches). Number of places to take hens is dependent to the housing system, in case of doubt collect hens from 10 different locations.
    2) Inspect and palpate the keel area
    3) Evaluate their state:
       - Keel bone straight, no deviations, deformations or thickened sections
       - Deviation or deformation of keel bone (thickened sections included)



© Center: Staack, University of Kassel, © Left and right:Fiks-van Niekerk, WUR

Figure 6 : *Extract from Welfare Quality Poultry Protocol (2009)*

- *Evaluation of the method:* KBD is not specific because It is related to multiple parameters such as bone fragility due to osteoporosis or genetics factors (Harlander-Matauschek et al., 2015). Nevertheless, according to EFSA (2015) KBD is part of welfare consequences of non-adequate perches. Thus, it can be used but it is not really valid for the assessment of the compliance with this requirement. In addition, CAs rated its validity at 2.8 on 5. Sampling 100 hens to evaluate the state of their keel bone takes time, this indicator with this method is thus hardly feasible during an inspection. Evaluate keel bone damage by palpation could be subjective especially without an adapted training (Harlander-Matauschek et al., 2015). CAs rated its reliability at 3.2 on 5.

ABI	Validity	Feasibility	Reliability
Number of hens perching	**Gaps of knowledge**		
KBD	XX	X	XX

3.13.2. RBI:

- Perches adequacy (height, width, materials, shape, absence of sharp edges):
  - *Description of the method:*

1) Check the absence of sharp edges or dangerous perches

Wooden and/or rectangular perches are considered to have sharp edges according to the Welfare Quality Protocol (2009) except if their edges are rounded or mushroom-shaped.

- *Evaluation of the method:* This indicator is used by the Welfare Quality Protocol (2009) in a simple way: observers have to record if there is “No sharp edges on perch” or “Presence of sharp edges on perch”.

According to the Competent Authorities, this indicator is highly valid, reliable and feasible respectively grades of 4.6/5, 4.3/5 and 4.1/5.

- Cm of perch per bird:

- *Description of the method:*
  1) Measure the perch length
  2) Get the exact number of hens delivered
  3) Divide the total perch length by the number of hens
- *Evaluation of the method:* Referring to the plans of the farm is not sufficient, calculation of the perch length is needed. It is recommended to use an electronic tool for length measurement.

According to the Competent Authorities, this indicator is highly valid, reliable and feasible respectively grades of 4.6/5, 4.9/5 and 4.6/5.

- Distance between perches and distance between perches and walls:
  - *Description of the method:* Measure distance between perches and walls
  - *Evaluation of the method:* Referring to the plans of the farm is not sufficient, calculation of the distance between all perches and between perches and walls (when close to a wall) is needed.

According to expert opinion, this method is fully valid, feasible and reliable to evaluate compliance with this requirement.

RBI	Validity	Feasibility	Reliability
Perches adequacy	XXX	XXX	XXX
Cm of perch per bird	XXX	XXX	XXX
Distance between perches and between perches and walls	XXX	XXX	XXX

3.13.3. MBI: There is no specific MBI for this requirement.

3.14. Legal Requirement: "*At least 250 cm2 of littered area per hen, the litter occupying at least one third of the ground surface*" (Directive 1999/74/EC, Article 4).

According to the Directive 1999/74/EC, the litter is any friable material enabling the hens to satisfy their ethological needs.

3.14.1. ABI: There is no specific ABI for this requirement.

3.14.2. RBI:

- Surface of littered area per hen (in cm^2):
  - *Description of the method:*
    1) Measure the littered area
    2) Get the exact number of hens at the moment of inspection
    3) Divide the total littered area by the number of hens
  - *Evaluation of the method: According to the Competent Authorities, this indicator is highly valid, reliable and feasible respectively grades of 4.4/5, 4.7/5 and 4.8/5.*

RBI	Validity	Feasibility	Reliability
Surface of littered area per hen	XXX	XXX	XXX

3.14.3. MBI: There is no specific MBI for this requirement.

3.15. Legal Requirement: *"In addition to the provisions laid down in points 1 and 2, (a) if systems of rearing are used where the laying hens can move freely between different levels, (i) there shall be no more than four levels; (ii) the headroom between the levels must be at least 45 cm; (iii) the drinking and feeding facilities must be distributed in such a way as to provide equal access for all hens; (iv) the levels must be so arranged as to prevent droppings falling on the levels below."* (Directive 1999/74/EC, Article 4)

3.15.1. ABI: There is no specific ABI for this requirement.

3.15.2. RBI:

- Description and measurements of the levels and furniture:
  - *Description of the method:*
    1) Count the number of levels
    2) Measure the height between levels
    3) Check the general organization of the system of rearing and locations of furniture
  - *Evaluation of the method:* According to expert opinion, this method is fully valid, feasible and reliable to evaluate compliance with this requirement.
- For (iv): Presence of manure belt under each level or continuous floor:
  - *Description of the method:* Check the presence of a manure belt under each level or the presence of continuous floor below.
  - *Evaluation of the method:* According to expert opinion, this method is fully valid, feasible and reliable to evaluate compliance with this requirement.

RBI	Validity	Feasibility	Reliability
Description and measurements of the levels and furniture	XXX	XXX	XXX
Presence of manure belt under each level of continuous floor	XXX	XXX	XXX

3.15.3. MBI: There is no specific MBI for this requirement.

4. References

BOURAOUI, R., LAHMAR, M., MAJDOUB, A., DJEMALI, M. & BELYEA, R. 2002. The relationship of temperature-humidity index with milk production of dairy cows in a Mediterranean climate. Animal Research, 51, 479-491.

CASEY-TROTT, T., HEERKENS, J. L. T., PETRIK, M., REGMI, P., SCHRADER, L., TOSCANO, M. J. & WIDOWSKI, T. 2015. Methods for assessment of keel bone damage in poultry. Poultry Science, 94, 2339-2350.

DAVID, B., MEJDELL, C., MICHEL, V., LUND, V. & MOE, R. O. 2015a. Air quality in alternative housing systems may have an impact on laying hen welfare. Part II-ammonia. Animals, 5, 886-896.

DAVID, B., MOE, R. O., MICHEL, V., LUND, V. & MEJDELL, C. 2015b. Air quality in alternative housing systems may have an impact on laying hen welfare. Part I—Dust. Animals, 5, 495-511.

DAVIS, N. J., PRESCOTT, N. B., SAVORY, C. J. & WATHES, C. M. 1999. Preferences of growing fowls for different light intensities in relation to age, strain and behaviour. Animal Welfare, 8, 193-203.

DGAL/SDSPA/2017-998, 2017. Instruction technique sur les contrôles officiels bien-être animal en poulets de chair : utilisation d'appareils de mesures pour la lumière et la concentration en NH3 et CO2.

EFSA 2005. Opinion of the Scientific Panel on Animal Health and Welfare (AHAW) on a request from the Commission related to the welfare aspects of various systems of keeping laying hens. The EFSA Journal, 197, 1-23.

EFSA 2015. Scientific Opinion on welfare aspects of the use of perches for laying hens. EFSA Journal, 13, 70.

FEATHERWEL 2013. Improving feather cover - A guide to reducing the risk of injurious pecking occurring in non-cage laying hens. University of Bristol.

GUNNARSSON, S. & HERMANSSON, A. 2011. Lighting system for laying hens - pre-testing of new technique in Sweder. Animal hygiene and sustainable livestock production. Proceedings of the XVth International Congress of the International Society for Animal Hygiene, Vienna, Austria, 3-7 July 2011, Volume 1 2011 pp.111-113 ref.19.

HARLANDER-MATAUSCHEK, A., RODENBURG, T. B., SANDILANDS, V., TOBALSKE, B. W. & TOSCANO, M. J. 2015. Causes of keel bone damage and their solutions in laying hens. World's Poultry Science Journal, 71, 461-472.

HEERKENS, J. L. T., DELEZIE, E., RODENBURG, T. B., KEMPEN, I., ZOONS, J., AMPE, B. & TUYTTENS, F. A. M. 2016. Risk factors associated with keel bone and foot pad disorders in laying hens housed in aviary systems. Poultry Science, 95, 482-488.

ICFAW 2017. Recommendations for the on-farm welfare of laying hens - submission to the OIE by the international coalition for animal welfare.

JONES, E. K. M., WATHES, C. M. & WEBSTER, A. J. F. 2005. Avoidance of atmospheric ammonia by domestic fowl and the effect of early experience. Applied Animal Behaviour Science, 90, 293-308.

KARAMAN, S., TARHAN, S. & ERGUNES, G. 2007. Analysis of indoor climatic data to assess the heat stress of laying hens. IJNES, 1, 65-68.

KRISTENSEN, H. H., BURGESS, L. R., DEMMERS, T. G. H. & WATHES, C. M. 2000. The preferences of laying hens for different concentrations of atmospheric ammonia. Applied Animal Behaviour Science, 68, 307-318.

LIU, K., XIN, H. & CHAI, L. 2017. Choice between fluorescent and poultry-specific LED lights by pullets and laying hens. Transactions of the ASABE, 60, 2185-2195.

LONG, H., ZHAO, Y., WANG, T., NING, Z. & XIN, H. 2016. Effect of light-emitting diode vs. fluorescent lighting on laying hens in aviary hen houses: Part 1 - Operational characteristics of lights and production traits of hens. Poultry Science, 95, 1-11.

MOHAMMED, H. H., GRASHORN, M. A. & BESSEI, W. 2010. The effects of lighting conditions on the behaviour of laying hens. Archiv fur Geflugelkunde, 74, 197-202.

RIBER, A. B. & HINRICHSEN, L. K. 2016. Keel-bone damage and foot injuries in commercial laying hens in Denmark. Animal Welfare, 25, 179-184.

RITZ, C. W., FAIRCHILD, B. D. & LACY, M. P. 2004. Implications of ammonia production and emissions from commercial poultry facilities: A review. Journal of Applied Poultry Research, 13, 684-692.

RODENBURG, T. B., VAN KRIMPEN, M. M., DE JONG, I. C., DE HAAS, E. N., KOPS, M. S., RIEDSTRA, B. J., NORDQUIST, R. E., WAGENAAR, J. P., BESTMAN, M. & NICOL, C. J. 2013. The prevention and control of feather pecking in laying hens: Identifying the underlying principles. World's Poultry Science Journal, 69, 361-374.

RØRVANG, M. V., HINRICHSEN, L. K. & RIBER, A. B. 2019. Welfare of layers housed in small furnished cages on Danish commercial farms: the condition of keel bone, feet, plumage and skin. British Poultry Science, 60, 1-7.

STRAWFORD, M. L., WATTS, J. M., CROWE, T. G., CLASSEN, H. L. & SHAND, P. J. 2011. The effect of simulated cold weather transport on core body temperature and behavior of broilers. Poultry Science, 90, 2415-2424.

WELFAREQUALITY® 2009. Welfare Quality® assessment protocol for poultry (broilers, laying hens). Welfare Quality® Consortium, Lelystad, Netherlands.

YASMEEN, R., ALI, Z., TYRREL, S. & NASIR, Z. A. 2019. Estimation of particulate matter and gaseous concentrations using low-cost sensors from broiler houses. Environmental Monitoring and Assessment, 191.