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Risk assessment on the animal welfare and animal behaviour consequences of light intensity and light programmes in rooms where poultry are kept

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VKM has asked the University of Copenhagen to prepare a background report concerning the animal welfare and animal behaviour consequences of light intensity and light programs in rooms where chickens are kept. VKM has used this report as a basis to answer the request from the Norwegian Food Safety Authority.

The author of this background report, Dr. Helle Halkjær Kristensen, is acknowledged for her valuable contribution with the report that was prepared as a basis for this opinion.

SUMMARY

Council directive 2007/43/EC of 28 June 2007 lays down minimum rules for the protection of chickens kept for meat production. The directive contains requirements for the raising of chickens for meat production. These requirements differ from the existing Norwegian requirements laid down in Norwegian regulations for the keeping of hens and turkeys (Forskrift 12. desember 2001 om hold av høns og kalkun), transport of live animals (Forskrift 5. januar 2007 om vern av dyr under transport og tilknyttede aktiviteter) and animal welfare in slaughterhouses (Forskrift 28. august 1995 om dyrevern i slakterier).

Directive 2007/43/EC states that when raising chicken for meat production, minimum 80 % of accessible area shall be lighted with a light intensity of at least 20 lux measured at animal eye level. The light program shall have a 24-hours rhythm, from the latest seven days restocking until earliest three days before suggested time of slaughter. The 24-hours rhythm shall include periods of darkness lasting at least six hours in total, with at least one uninterrupted period of at least four hours, excluding dimming periods. A gradual change in the light intensity before and after the periods of darkness must not infringe on the minimum periods of darkness.

The Norwegian Food Safety Authority requested the Norwegian Scientific Committee for Food Safety, Panel on Animal Health and Welfare to prepare a risk assessment concerning the animal welfare and animal behaviour consequences of light intensity and light programmes in rooms where chickens are kept. This risk assessment reviews the evidence for the effects of 1) light intensity, 2) gradual changes between light and dark, and 3) the definition of darkness, on the welfare of broiler chickens, laying hens, pullets and turkeys.

A scientific report concerning the animal welfare and animal behaviour consequences of light intensity and light programmes in rooms where chickens are kept was made for the Norwegian Scientific Committee for Food Safety (Vitenskapskomiteen for mattrygghet, VKM) by an expert from the University of Copenhagen.

The report was prepared as a basis for this opinion.

Summary of the main findings in the report

The light intensity may affect many aspects of welfare in broiler chickens, laying hens and turkeys. Poultry may develop eye abnormalities if reared in dim and/or continuous lighting. There is conflicting evidence for the effects of light intensity on feather pecking; some studies have found increased feather pecking in high light intensity, although others have found no effects of light intensity that may be due to confounding different aspects of the light environment. Birds appear to show reduced fear of humans in 5 lux but it is uncertain whether this is due to the light intensity *per se* or to relative changes in light intensity. Layers, broilers and turkeys prefer brightly lit environments (200 lux) at two weeks of age, whereas 6-weeks old layers and broilers prefer dimmer light environments (6 lux). Turkeys maintain their preference for the brighter environments (20-200 lux) and avoid entering environments lit by

<1 lux. The findings on the effects of light intensity on poultry welfare require commercial scale validations before firm conclusions can be drawn.

Poultry may indeed benefit from a gradual transition between light and darkness, particularly to signal the oncoming night (dusk), whereas there is less evidence for the benefits of signalling the oncoming day (dawn). Although more work is needed on this topic, the evidence reviewed here all suggest that providing a dusk period will allow particularly laying hens in non-caged systems to find a suitable perch for the night whilst the visual environment permits this. In addition, the signal of the oncoming dark period has been shown to stimulate feeding behaviour in broilers and laying hens which may prevent food deficit occurring during the night. In the wild, fowl has been shown to fly onto their perches 30-60 minutes before darkness, although even much shorter periods of artificial dusk (5-10 minutes) have been shown to be beneficial to laying hens in experimental studies. The optimal lengths of the dusk and dawn periods need confirmation.

Very few scientific papers have defined the light level during the dark period, and there is great variability in how darkness has been defined in these papers. From the sources available, it is not possible to give an absolute threshold for darkness perception in poultry; this is likely to depend on whether the process in question is the lower limit for visual abilities, maintaining the circadian rhythm, based upon the nocturnal behaviour or the physiological responses of the birds. This is indeed an area in urgent need of research attention, due to the potential effects on animal welfare.

KEY WORDS

Animal welfare, light program, light intensity, dark period, nocturnal behaviour, physiological response, poultry, chicken, turkey, hens

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BACKGROUND

For decades, there has been much focus on the effects of lighting on different aspects of poultry production, behaviour, physiology and welfare. In addition, several comprehensive reviews exist on the subject, dealing with animal welfare (Manser 1996, Martrenchar 1999), vision (Prescott et al. 2003), and production (Lewis and Morris 1999) in laying hens (Morris 1994), broilers (Buyse et al. 1996; Kristensen 1999) and turkeys (Nixey 1994). Much is known about the effects of lighting on poultry, although some essential questions still need addressing, as will become apparent in this risk assessment.

Several recommendations and regulations on lighting for poultry exist, both for broiler chickens, laying hens and turkeys. The request from the Norwegian Food Safety Authority is based upon the recent Council Directive 2007/43/EC.

Council directive 2007/43/EC of 28 June 2007 lays down minimum rules for the protection of chickens kept for meat production. The directive contains requirements for the raising of chickens for meat production. These requirements differ from the existing Norwegian requirements, laid down in Norwegian regulations on the keeping of hens and turkeys (Forskrift 12. desember 2001 om hold av høns og kalkun), transport of live animals (Forskrift 5. januar 2007 om vern av dyr under transport og tilknyttede aktiviteter) and animal welfare in slaughterhouses (Forskrift 28. august 1995 om dyrevern i slakterier).

Directive 2007/43/EC states that when raising chicken for meat production minimum 80 % of accessible area shall be lighted with a light intensity of at least 20 lux, measured at animal eye level. The light programme shall have a 24-hours rhythm, from the latest seven days restocking until earliest three days before suggested time of slaughter. The 24-hours rhythm shall include periods of darkness lasting at least six hours in total, with at least one uninterrupted period of at least four hours, excluding dimming periods. A gradual change in the light intensity before and after the periods of darkness must not infringe on the minimum periods of darkness.

The Norwegian Food Safety Authority requested VKM to prepare a risk assessment concerning the animal welfare and animal behaviour consequences of light intensity and light programmes in rooms where chickens are kept. The Norwegian Food Safety Authority requests for recommendations based on risk assessments of animal welfare as follows: minimum light requirements in directive 2007/43 for chicken kept for meat production, applied to laying hens, other categories of chickens than kept for meat production and turkeys, secondly; a gradual change of the light intensity compared to the light simply being turned on and off, and the optimal dimming time between maximum light and dark and vice versa, and finally; the maximum light intensity in the dark period according to the different species and categories of poultry.

Commissioned by VKM, the University of Copenhagen was asked to prepare a scientific background report concerning the animal welfare and animal behaviour consequences of light intensity and light programmes in rooms where chickens are kept. The report was prepared as a basis for this opinion.

The scientific report “Report on light and poultry” - a report to the Norwegian Scientific Committee for Food Safety from the University of Copenhagen can be found at http://vkm.no/eway/default.aspx?pid=0&oid=-2&trg=__new&__new=-2:17934.

The importance of light for poultry

Light is important for poultry for many reasons. Vision is the predominant sense in birds, where a large proportion of the total brain size is devoted to eyes and visual cortex (Güntürkün 2000). Light provides the main exogenous regulator for the diurnal rhythm of most animals (Nuboer et al. 1983; Robbins et al. 1984). Chickens recognise conspecifics via visual signals which requires light (Houser and Huber-Eicher 2004) and also use vision to forage and explore their environment (Osorio et al. 2001; Maddocks et al. 2001). Naive chicks will avoid conspicuously coloured prey insects and the evolution of such aposematic signals confirms the adaptive value of visual selection of prey items (e.g. Guilford 1990; Osorio et al. 1999a). Indeed, responding to light may have had an adaptive value for chickens and turkeys through evolution and may still influence the visual perception and behaviour of the birds today. However, the ancestor of domestic fowl, the Red Jungle Fowl and similar birds, are adapted to forest habitats with rather dim light. As strong light intensity is found in more open spaces where the birds are more susceptible to being caught by predators, the preferred light intensity should be expected to be rather moderate. This probably explains the high rate of fearfulness and feather pecking sometimes reported in poultry houses with strong light intensity.

Light perception in poultry

Poultry possess simple diurnal eyes where light reaches the retina after passing through the cornea, anterior chamber, lens and the vitreous body (Güntürkün 2000). The outer segments and outer nuclear layer of the retina contain the photoreceptor cells, which initiate visual information processing by converting light into action potentials which then travel via various inter-neurons to the ganglion cells, whose axons form the optic nerve, and further to the visual cortex in the brain (Güntürkün 2000). The two main classes of photoreceptors, rods and cones, differ in anatomical structure as well as in their ability to absorb light of different wavelengths and illuminances (e.g. Osorio et al. 1999b).

In addition to retinal light perception, poultry may receive light through other routes, for example via the pineal gland (epiphysis cerebri), situated on the dorsal surface of the brain between the telencephalon and the cerebellum (Gwinner and Hau 2000). The avian pineal gland is particularly involved in the control of circadian rhythms (Lu et al. 1995) and has the ability to absorb light, penetrating the skull (Nyce and Binkley 1977). Long wavelengths penetrate the skull more efficiently than short wavelengths, which may aid the synchronisation of circadian activity (Nuboer et al. 1983) since long wavelengths are particularly abundant at dusk under natural light (Théry 2001).

Artificial light

Artificial light can vary in at least four respects:

1) The photoperiodic regime describes the number of hours of light and dark in each 24-hour period

2) The spectral composition describes the distribution of wavelengths of the light, which varies between light sources

3) The light intensity (also known as the illuminance or light level) describes the total amount of power emitted from the visual part of the light spectrum

4) The flicker of light can be described as temporal modulations due to the electrical current and its perception depends on the light intensity, the modulation depth as well as the modulation frequency.

In addition, the temporal and spatial variation in the light environment may be important in relation to each of the four characteristics of light. For example, the changes between light and dark (dawn and dusk) and the variations in light conditions over the different areas of the poultry house may affect the behaviour and welfare of the birds.

Light intensity and how is it measured

Light intensity is synonymous with illuminance and light level. It describes the quantity on light falling on a unit area and is measured with a light meter (or lux-meter) to produce the photometric unit "lux" (e.g. Lewis and Morris 2006). The readings of a lux-meter will depend upon several factors. Firstly, the readings from a lux-meter will largely depend upon the height of measurements, and most specify that the light intensity should be measured at bird eye height (CoE 1995; FAWC 1995; FAWC 1997; CoE 2001; CEU 2007). Secondly, the reading will depend on whether the sensor of the lux-meter is held horizontally, pointed towards maximum illuminance or measured in 3 planes at right angles to each other (Prescott et al. 2003; Lewis and Morris 2006). Current recommendations and regulations vary with respect to whether the light intensity should be measured horizontally (FAWC 1995), or given as the average between readings in 3 planes at right angles to each other (CoE 1995; 2001). The Council Directive for chickens kept for meat production (CEU 2007) specifies that light should be measured at bird eye level but unlike the Council of Europe Recommendations (CoE 1995; 2001), it does not specify whether the minimum illuminance of 20 lux should be measured horizontally or as the average of measurements in 3 planes at right angles to each other.

The photometric unit for measuring illuminance (lux) is adjusted to the human spectral sensitivity. Since the spectral sensitivity of chickens and turkeys is different to that of humans (Wortel et al. 1987; Prescott and Wathes 1999b, Barber et al. 2006), it is not appropriate to use the lux-unit for these species. Indeed, the alternative unit of "clux" (chicken-lux) or "galluiminance" describes the illuminance adjusted to the spectral sensitivity curve of fowl (Prescott and Wathes 1999b, Lewis and Morris 2006) and a similar alternative unit could be suggested for turkeys (turkey-lux). Matching the perceived illuminance of different light sources for the particular poultry species is important in order to compare the independent effects of illuminance and light sources with different spectral contributions. For example, due to differences between human and chicken spectral sensitivity, chickens will perceive an incandescent light source as approximately 30 % brighter than a fluorescent light source, when these are measuring the same lux values. In addition, a common error in studies on light intensity has been to use a voltage dimmer to adjust incandescent light sources to different light intensity levels. This is problematic since this method of dimming an incandescent light source will change the colour of the light as well as the light intensity, and any effects of the different light conditions may be due to either the difference in light intensity or the difference in light colour.

TERMS OF REFERENCE

Directive 2007/43/EC states that when raising chicken for meat production, minimum 80 % of accessible area shall be lighted with a light intensity of at least 20 lux measured at animal eye level. The light programme shall have a 24-hours rhythm, from the latest seven days restocking until earliest three days before suggested time of slaughter. The 24-hours rhythm shall include periods of darkness lasting at least six hours in total, with at least one uninterrupted period of at least four hours, excluding dimming periods. A gradual change in the light intensity before and after the periods of darkness must not infringe on the minimum periods of darkness.

Although the directive's scope only includes chickens kept for meat production, The Norwegian Food Safety Authority requests an evaluation on whether this parts of the directive also should include laying hens and turkeys.

A gradual change in the light intensity is not required by the directive, but The Norwegian Food Safety Authority also wishes to asses whether such a requirement should be introduced.

Directive 2007/43/EC states a minimum time that the rooms of the animals must be lighted. The Norwegian Food Safety Authority asks the Norwegian Scientific Committee for Food Safety to evaluate whether or not a maximum period of darkness should also be specified.

The Norwegian Food Safety Authority requests for recommendations based on risk assessments of animal welfare as follows:

1. Minimum light requirements in directive 2007/43/EC for chicken kept for meat production, applied to laying hens, other categories of chickens than kept for meat production and turkeys.

2. A gradual change of the light intensity compared to the light simply being turned on and off, and the optimal dimming time between maximum light and dark and vice versa.

3. Maximum light intensity in the dark period according to the different species and categories of poultry.

ASSESSMENT

1. LIGHT INTENSITY AND THE BEHAVIOUR AND WELFARE OF POULTRY

Risk assessment on light intensity and the welfare of broiler chickens

There have been several reviews on lighting for broilers. Manser (1996) and Buyse et al. (1996) both review some of the literature available, but came up with different recommendations (20 lux and 5 lux respectively). The SCAHAW (2000) also reviews evidence for the effects of light intensity on broiler welfare. The studies reviewed here suggest that young broilers are more active and prefer brighter lit environments than older broilers, although the interaction between age, light and activity needs further confirmation. Recommendations suggest 20 lux as a minimum light intensity for the welfare of broiler chickens, comprehensive studies on commercial scale should confirm this.

Risk assessment on light intensity and welfare of pullets and laying hens

Light intensity may affect the egg production, nest choice, activity and feather pecking in pullets and laying hens. Hens appear to be able to sustain production in light intensities above 5 lux, and although increasing light intensities have been shown to increase general activity in hens, this does not appear to affect production. Pullets prefer higher light intensities at 2 than at 6 weeks of age. Light intensities at or above 5 lux appear to allow hens to jump between perches, thus indicating that this level is at least required for environmental perception. Young pullets also respond to increased light intensity with increased activity, although they may require periods of darkness or a dark brooder for resting and social synchronisation. Feather pecking appears to be influenced by different environmental factors; some experiments suggest that feather pecking increases with increasing light intensity in hens, although this was not confirmed in a commercial survey in Switzerland. The interactive effects of light intensity and light source appear to be confounded in several experiments and should be studied further before making any firm conclusions.

Risk assessment on light intensity and the welfare of turkeys

Light intensity has been investigated in turkeys in relation to preferences, feather pecking, production, leg health, eye morphology and mortality amongst others. Siopes et al (1984) suggests that the threshold level of light intensity for turkey poults is between 1.1 and 11 lux (incandescent) based on evidence of altered performance, adrenal and eye morphology and mortality in turkeys housed in 1.1 but not 11 lux or above for the first two weeks of life (Siopes et al. 1984). When given a free choice, turkeys prefer to occupy familiar or bright light environments (20-200 lux), with younger individuals preferring the brighter environments. Higher illuminance may increase the risk of feather pecking in turkeys, although the interactions with photoperiods and light source need confirming. In addition, the effects of higher light intensity on feather pecking may be influenced by the level of environmental complexity. Environmental enrichment may thus allow the use of brighter light environments than barren environments. Leg disorders were less frequent in birds reared in natural daylight of 220 lux than in artificial light of 19 lux (Davis and Siopes 1985). Other studies on leg health revealed no effect of light intensity, and the evidence on activity and mortality is conflicting and needs verifying.

2. GRADUAL CHANGES IN LIGHT INTENSITY AT DAWN AND DUSK

Risk assessment on poultry welfare and gradual changes between light and dark

Manser (1996) recommends a gradual onset and offset of light for poultry on the basis that it appears less stressful for the birds than sudden changes in light intensity. Bryant (1987) advocates the importance of a dusk (and dawn) period but also state that the inclusion of a dawn and dusk may require a higher light intensity during the day to allow a twilight period to be noticeable for the animals. Lewis and Morris (2006) argue that although lighting for poultry is usually turned on and off abruptly, there may be benefits to production and welfare by providing particularly dusk periods.

Overall, laying hens have been found to use a reduction in light intensity as a sign for night roosting, and a gradual dusk period would give the birds the opportunity to settle onto their perches whilst they can still do so without injuries. Laying hens in the wild jump onto their perches in approximately 15 lux, although the lower limit of when they can safely navigate between perches appear to be approximately 2 lux. The very few studies on broiler chickens suggest that they do not use dusk as a cue for perching, although dusk may still be a cue for the oncoming dark period for other behavioural purposes, such as filling their crop and settling down for the night. Under natural conditions, laying hens may fly to their roosting sites 30-60 minutes before dusk, although the minimum period required for perching under artificial dusk may be lower. Even a 5-10 minute period of dusk has been shown to be beneficial for the welfare of laying hens (Tanaka and Hurnik 1991). The period of dusk may be required to be longer than the dawn period, since the visual system takes longer to adapt to a decrease in light intensity than an increase in light intensity and the birds would be expected to adjust faster to increasing than decreasing light intensity. In addition, dusk rather than dawn has been shown to stimulate feeding behaviour, so giving the birds the opportunity to fill their crops for the night during a long dusk period, would probably increase bird welfare as well as production.

3. DARKNESS FOR POULTRY

Risk assessment on the effects of darkness on poultry welfare

Light has several effects on avian pineal physiology, synchronising pineal circadian rhythm, inhibiting melatonin release (Hamm 1983). It is uncertain whether one single exact darkness threshold for poultry exists. Such a darkness threshold is likely to depend on the processes in question, be this i) visual abilities, where the change from photopic to scotopic vision (cone to rod dominated vision) occurs at retinal level; ii) circadian rhythm, which may be dependent upon melatonin synthesis and rely on input from the retina and the pineal gland; iii) nocturnal behaviour, which may depend upon the bird's perception of the relative difference between the relative light during the "day" and "night", which may change with experience; iv) physiological or production responses, such as photorefractoriness and photosensitivity for stimulating egg production.

Several papers (e.g. Savory 1980; Tucker and Charles 1993) refer to a Morris (1968) for a believed darkness threshold for laying hens to be 0.4 lux, although the basis for this threshold would need further confirmation. Tucker and Charles (1993) found that layers did not respond differently to 0.75 lux and 12.4 lux in terms of egg production and thus speculated whether the current darkness threshold of modern layers may be lower than 0.4 lux. In contrast, turkeys have been shown to respond to 0.5 lux both in terms of photorefractoriness and photostimulation (Siopes 1991), which suggests that the darkness threshold in turkeys is below 0.5 lux. Whether turkeys, broilers and laying hens have the same threshold for darkness perception is not possible to judge from the reviewed papers. The perception of darkness in poultry is indeed an area, which needs further research since this may affect several aspects of poultry behaviour, production, physiology and overall welfare.

CONCLUSIONS

Light intensity and poultry welfare

Light intensity is synonymous with illuminance and has been investigated in relation to many aspects of poultry welfare. This chapter of the report from the University of Copenhagen reviewed the scientific evidence for the effects of light intensity on different aspects of welfare in broilers, layers and turkeys.

Light intensity and eye abnormalities

In terms of eye morphology, dim continuous lighting may cause abnormal development of the eyes of broilers, laying hens and turkeys. Illuminances below 6 lux of blue light for laying hens and below 11 lux (between 1.1 and 11 lux) for turkeys caused eye abnormalities, although these values are based upon studies confounding illuminance with light colour and light programme. Broilers and layers appear less fearful in lower illuminances (5 lux appear to reduce fear in a human approach test and at shackling in triads), although it needs to be confirmed whether this is due to the inherent light intensity level or to the relative change in light intensity to 5 lux.

Light intensity and inspections

Regarding flock inspections, there is a trade-off between providing enough light for the stockperson to identify birds with welfare problems without inducing fear responses in the birds. Familiarisation with the stockperson as well as variations in light intensity may overcome this dilemma, although this has not been confirmed experimentally.

Influence on feather pecking

Feather pecking is influenced by the light environment in laying hens and turkeys, although most studies have confounded the effects of light intensity, light colour and light programme. Whilst several studies on laying hens and turkeys suggest that high levels of light intensity may be associated with increased feather pecking, other studies have failed to find any effect of light intensity, and a commercial survey in Switzerland did not find light intensity to be a significantly contributing factor to feather pecking in laying hens.

Influence on activity and leg health

There is conflicting evidence on the effects of light intensity on leg health in broilers and turkeys. Light intensity level and dynamic properties may influence activity in broilers and laying hens, where young individuals generally show higher levels of activity than older birds.

Preference of light intensity

When given a free choice, turkey poults, laying pullets and broiler chickens all prefer to occupy brightly lit environments (200 lux) at two weeks of age. At six weeks of age, layer and broiler chickens preferred the dimmer environments (6 lux), whereas turkey poults still

preferred brighter environments (20-200 lux) at this age. Several preference experiments agree that broilers and turkeys avoid environments <1 lux.

Light intensity and age

The evidence reviewed here suggests that light intensity should be higher for juvenile than for adult poultry, although the particular illuminance will depend upon the type of fowl as well as other environmental factors. Commercial applicability of research results as well as dynamic properties of the light environment should be a focus for future attention in order to define the optimal light environment allowing poultry to express a full behavioural repertoire.

Gradual light change: The significance of dimming periods to poultry welfare

A gradual change from light to darkness appears important to poultry as a cue for the oncoming dark period. It may be more important to provide the birds with a gradual dusk period rather than a gradual dawn period. The length of the dusk period should allow the birds to fill their crop for the night and find an appropriate place (perch or ground) to settle for the night.

Maximum light intensity in the dark period

Whether turkeys, broilers and laying hens have the same threshold for darkness perception is not possible to judge from the reviewed papers. Very few scientific papers have defined the light level during the dark period, and there is great variability in how darkness has been defined in these papers. From the sources available, it is not possible to give an absolute threshold for darkness perception in poultry; this is likely to depend on whether the process in question is the lower limit for visual abilities, maintaining the circadian rhythm, based upon the nocturnal behaviour or the physiological responses of the birds. This is indeed an area in urgent need of research attention, due to the potential effects on animal welfare.

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