Utrecht University

MANAGEMENT GUIDE

FOR THE CARE AND HOUSING OF CAGE-FREE EGG LAYING HENS IN HOT AND TROPICAL CLIMATES

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WAGENINGEN UNIVERSITY & RESEARCH

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1. Introduction

Cage-free systems for laying hens can be floor housing systems or aviary systems with multiple tiers. These can be indoor systems or systems combined with covered verandas or free range access. Successfully keeping laying hens in a cage-free environment requires an appropriate building construction, a fitting housing design and efficient management procedures which include stimulating natural behavior of the birds, as well as taking good biosecurity measures.

Egg production of layers in a cage-free environment is common practice for several decades in some parts of the World, particularly in Western-Europe. To keep laying hens successfully in a cage-free environment during lay, it is required that the rearing of the pullets is also cage-free. Decades of scientific research has led to understanding laying hen behavior, health, performance and animal welfare. Animal welfare is defined as successful adaptation to the environment, leading to the animal experiencing the environment as positive. Experience and research in cage-free laying hen husbandry has led to recommendations regarding management and house design. Regarding the design of a cage-free housing system for pullets and laying hens, it is important that the design can be newly built but can also be incorporated in existing houses. The design should also be compatible with the local climatic conditions. Within the current project, we have developed several designs for cage-free systems suitable for hot and tropical climates (appendix 1). This management guide aims to provide guidance to successfully keep laying hens in these systems.

We advise that the company owner, farm manager, farm personnel and others involved in keeping and managing the birds acquire basic knowledge regarding cage-free pullet rearing and laying hen husbandry prior to setting up or working in such a poultry operation. There are national and international institutes, universities (e.g. Aeres University of Applied Sciences, Utrecht University; Wageningen University) or companies (e.g. BelgaBroed, Jansen Poultry Equipment, Vencomatic, Hendrix Genetics, Lohmann Tierzucht) that can provide advice, training and support prior to building and/or retrofitting a new or existing pullet rearing or laying hen egg production facility. Training, guidance and support during the rearing and production phase are strongly recommended. This can be done by connecting to local and international experts.

This Management Guide is intended to provide basic information and tools to help farm managers and farm personnel successfully house and care for a flock of cage-free laying hens in a hot and/or tropical climate.

THIS MANAGEMENT GUIDES PROVIDES GUIDELINE RECOMMENDATIONS. INFORMATION GIVEN IN THIS DOCUMENT IS BELIEVED TO BE UP-TO-DATE AND CORRECT. HOWEVER, THE AUTHORS AND AFFILIATED INSTITUTES DISCLAIM ANY RESPONSIBILITY FOR BIRD HEALTH, WELFARE AND BEHAVIOR, PRODUCTION RESULTS, LOSSES OR ANY OTHER PROBLEMS THAT MAY OCCUR IN YOUR POULTRY OPERATION.

2. Rearing cage-free pullets

A prerequisite for keeping cage-free layers is to rear them from day-old chicks in a cage-free environment. Rearing the pullets cage-free ensures that the birds are well trained and adapted for the cage-free housing system during the production period, ultimately improving welfare, health and production. Already in the first few days the pullets develop species-specific behavior. They develop foraging behavior by pecking to find out what is edible and to find water. They roam and explore their environment. They will eat starter feed from chick paper or from feeding plates. They learn to scratch the ground and to take dust baths. They develop play behavior and start to roost during the night. This chapter will describe some standard practices for pullet rearing in a cage-free environment.

2.1 Stockmanship

The keeper having daily responsibility for the pullets should have received appropriate training and be competent in the care and handling of pullets. It is important that the keeper ensures that the staff, which has the daily responsibility for the pullets, has the necessary skills in good management procedures and in understanding the welfare, including the health and behavioral needs, of the pullets under their care. To this end appropriate training is important to obtain understanding on how to comply with relevant legislation. It is important that the staff is able to recognize normal behavior and signs of good health, as well as abnormal behavior and signs of illness. Staff should also be able to quickly take effective corrective measures when necessary. It is good practice for the keeper to maintain records of staff training.

Animal handling should minimize stress and fear and injury. Each bird should be handled gently, upright with two hands, and never picked up or carried by their head, neck, wings, legs, or feet.

2.2 Inspection

The birds should be inspected at least two times daily at different times by the keeper or by competent staff under the responsibility of the keeper. Attention should be given to habituating the pullets to humans and to standard operating procedures and noise, to minimize fear reactions. Habituation may for instance be achieved by conducting frequent flock inspections and by varying the routine, personnel, numbers of personnel and their clothing, as well as by increased inspection at the time when the chicks have been placed in the house. Such procedures have been shown to help reduce fearfulness in hens. Both daily flock inspections as well as more thorough, individual sample

inspections should be conducted. These should include at least an assessment of plumage condition, skin condition, nutritional status, mortality, need for medical treatment, signs of heat stress and fearfulness (Table 1). An example of a basic inspection sheet is provided in Appendix 3. Inspection should identify birds that are sick, injured or behaving abnormally, and include the functioning of automatic systems (e.g. feeding- and drinking system, climate control) necessary for the health and welfare of the pullets. Any dead birds must be removed at inspection. Mortality found at every inspection should be recorded and possible causes should be investigated.

Collecting and documenting major animal welfare indicators is in the own interest of the keeper, as well as the animals, as it provides information on the welfare of the flock and enables the keeper to detect deficiencies and take corrective actions.

Table 1. List of most important animal welfare indicators for pullets and their possible causes.

Animal welfare indicator	**Possible causes**
Plumage condition Plumage condition, recorded especially in weeks 4, 12 and 16 of age and at the time of transfer to the laying hen farm	Feather-pecking, cannibalism; nutritional inadequacies; feed form
Skin condition Skin lesions, mainly around the back, wings, rump, cloaca and toes, recorded especially in week 4 and 12 and at the time of transfer to the laying hen farm	Feather-pecking, cannibalism; overstocking
Nutritional status Weight development and flock uniformity; ideally recorded every week, but at least in week 4, 8 and 16	Nutritional inadequacies; disease
Animal losses High mortality (above normal), recorded daily	Increased morbidity (disease); thermal stress; nutritional deficiencies; injurious pecking, cannibalism; predation or other causes
Water intake Daily water consumption (below or above normal), recorded daily, if possible	Water shortage; dripping water troughs; house climate too warm; incorrect drinker height; water contamination
Thermal condition Panting or wing spreading (indicating heat stress); huddling (Indicating temperature too low), observed daily	Temperature too high or too low
Fearfulness Excessive withdrawal from personnel; panic reactions (piling), observed daily	Lack of habituation to human contact

Feather pecking and cannibalism can result in poor plumage and skin conditions, as feathers are pulled out and the birds may be wounded when pecking continues in denuded areas. Inappropriate feeding may also affect plumage condition, as feed restriction or shortage of specific essential amino acids (methionine and cysteine) may induce molting in the neck area. Overstocking can also affect skin condition, as birds may damage other birds when climbing over each other, resulting in scratches on the back. To evaluate nutritional status, feed intake and weight development should be monitored. The latter can be done by weighing a subsample of birds. Together with animal losses and use of veterinary drugs, nutritional status is also an important indicator of disease and morbidity, as sick animals will often stop eating. Changes in water intake can indicate water shortage, dripping water throughs (leakage), a too warm climate in the house, or an unfavorable position of the drinkers (too high or too low). Observation of birds panting in the house can also be used as a sign of heat stress. Finally, excessive withdrawal from personnel and panic reactions when people enter the house are signs of a lack of habituation to human contact and activities (see appendix 2).

Records should also be kept of all veterinary medical products used, and these should be documented daily. Over time, patterns may indicate changes in disease status of the flock.

2.3 Housing

In order for pullets to have enough space to fulfil their needs, stocking density and space per feature (nest, drinker line, feeder line, foraging area, perch) should be sufficient (Table 2). At higher stocking densities the keeper should pay special attention to the amount and quality of the foraging material since this becomes increasingly needed for the birds to express their natural behavior and prevent development of feather pecking behavior (see box 1 in paragraph 2.13).

At higher stocking densities, the keeper should have special attention to indicators of welfare problems, in particular feather pecking. High stocking density can be a risk to the welfare of the animals.

The space allowance for birds should be decided in relation to their demands on the whole environment, their age, sex, live weight, genetics, health and their needs to show certain behavior, taking account of the size of the group. The stocking density should be such that it does not lead to behavioral or other disorders or injuries. Each bird should be able to express her natural behavior including feeding and drinking, wing flapping, dust bathing, foraging, perching and resting/sitting.

Table 2. Recommendations regarding maximum stocking density and space at drinkers and feeders at 0-1 week of age, 2 to 5 weeks of age and 6 to 17 weeks of age.

	Age of the bird		
	0-1 week	**2 to 5 weeks**	**6 to 17 weeks**
Stocking density	25 chicks/m^2	15 pullets/m^2	8-10 pullets/m^2
Starter drinkers	1/70 chicks		
Bell drinkers	1/150 chicks	1/75 pullets	1/75 pullets
Hanging drinkers	1/75 chicks	1/75 pullets	1/75 pullets
Nipple drinkers	1/10 chicks	1/10 pullets	1/10 pullets
Starting feeding pans	1/50 chicks		
Linear chain feeders	2.5 cm/chick	4 cm/pullet	6 cm/pullet
Pan feeders	1/30 chicks	1/25 pullets	1/25 pullets

2.4 Climate, temperature and relative humidity

After hatch, the chicks should be housed at the appropriate temperature (see Table 3). Note that chicks from a young parent flock (i.e. below 30 weeks of age) might require a 1°C higher house temperature on the day of arrival. The pullet rearing farmer should receive information from the supplier regarding the parent flock. The farmer can also weigh the day-old chicks to know if he received light or heavy chicks. In general, the preferred relative humidity (RH) is around 55-65% during the first days of life and may increase up to 75% towards the end of the rearing period (see Table 3). To check whether the temperature at placement is correct, the body temperature of a sample of chicks from different locations in the house can be measured with an ear thermometer. The normal temperature is 40-41°C. When the measured body temperature is too low or too high, the house temperature should be adjusted accordingly.

When heating the rearing house, attention should be given to the floor temperature, which should be at approximately 20 °C before adding litter to avoid condensation, resulting in moist litter, and to avoid cold stress of chicks at placement. The house should be heated at least 96h before arrival of the chicks to 29-30°C.

Table 3. Example of a temperature schedule for rearing pullets

Age	Temperature (°C)	Relative Humidity (%)
0-3 days	34-35	55-65
4-7 days	31-33	55-60
2 wks	30	55-60
3 wks	28-29	55-60
4 wks	25-27	<70
5 wks	22-24	<70
6 wks	20-21	<75
7-17 wks	18-20	<75

2.5 Brooder guard with heat source

For brooding, both whole-house heating and spot heating can be applied. Spot heating can be defined as heating only certain specific spots in the house up to 35°C, using electrical heaters or gas hoods. Spot heating has the advantage that a temperature gradient is created, allowing chicks to choose a temperature zone in which they feel comfortable. With spot heating, the environmental temperature can be lower, although it should not be lower than 25°C during the first week. Chick behavior should be monitored carefully during the first week to avoid birds becoming either too warm (indicated by dispersal away from the heat source and/or panting) or too cold (indicated by huddling close to heat source and/or emitting distress calls). If spot heating is applied, appropriate measures should be taken to avoid chicks from wandering too far from the heat source during the first week of life, for instance by using a brooding guard (see Figure 1) that confines a group of chicks to the part of the house that includes a heater.

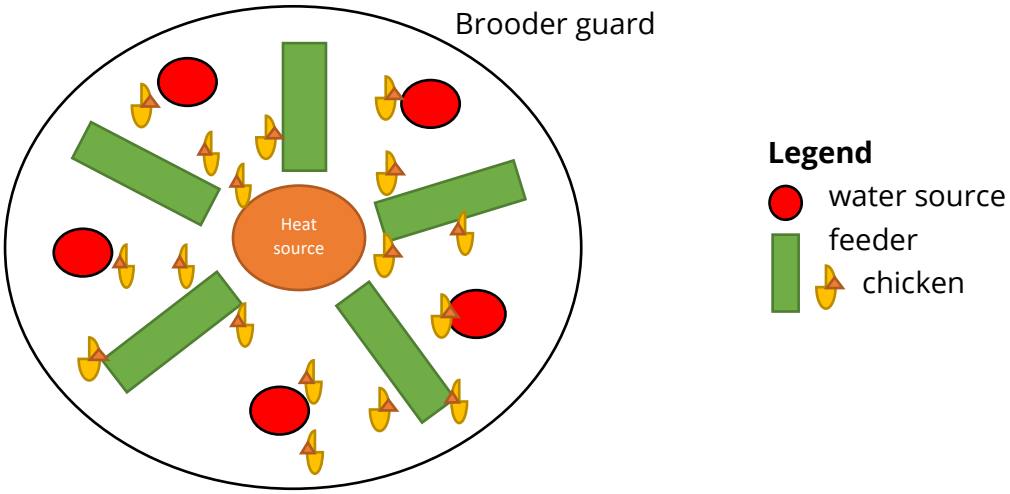

Figure 1. Brooder guard with heat source, water sources and feeders. Chicks are well distributed.

A 40 cm high, wire or solid brooder guard around the heat source is recommended. A diameter of 3 to 4 m (at maximum) is recommended, with no less than 25 cm^2 per chick. The guard should be located 150 to 200 cm from the heat source. In hot temperatures, enlarge the diameter so that chicks do not get too hot. Regarding the heat source: a 250-watt infra-red bulb can accommodate approximately 75 chicks. Provide at least two 4 liter waterers and two 30-cm or 45-cm feeders for every 100 chicks. Enlarge the area after one week and continue to expand the diameter each day (at approximately a 20-25% increase) until the chicks are 14 days of age.

2.6 Dark brooders

Chicks like shelter when they are young, similar to that provided by a mother hen in natural conditions. They will search for cover in dark places or hide under objects. When spot brooding is applied, dark brooders may be considered. Dark brooders are heat sources that do not produce visible light (supplying heat using infrared heat lamps, gas hoods, or electrical heating) and that offer a dark and protective environment to the chicks, mimicking a brooding mother hen. Dark brooders have been shown to have a strong suppressive effect on fear and on the development of feather pecking during rearing.

Dark brooders should be adjustable in height and winchable (able to be raised). They can be placed above the floor of the house or on the tier of a housing system (Figure 2). During the first few days, the brooders should be lifted up or winched up at every flock inspection by farm personnel, to prevent the chicks from staying under the brooder and not finding feed and water and to ensure that all chicks are visible for inspection. After inspection, they can be lowered again. Each week the brooder should be elevated to match the size of the chicks and to prevent overheating. After 5 weeks of age, when most pullets are perching, the brooder can be removed.

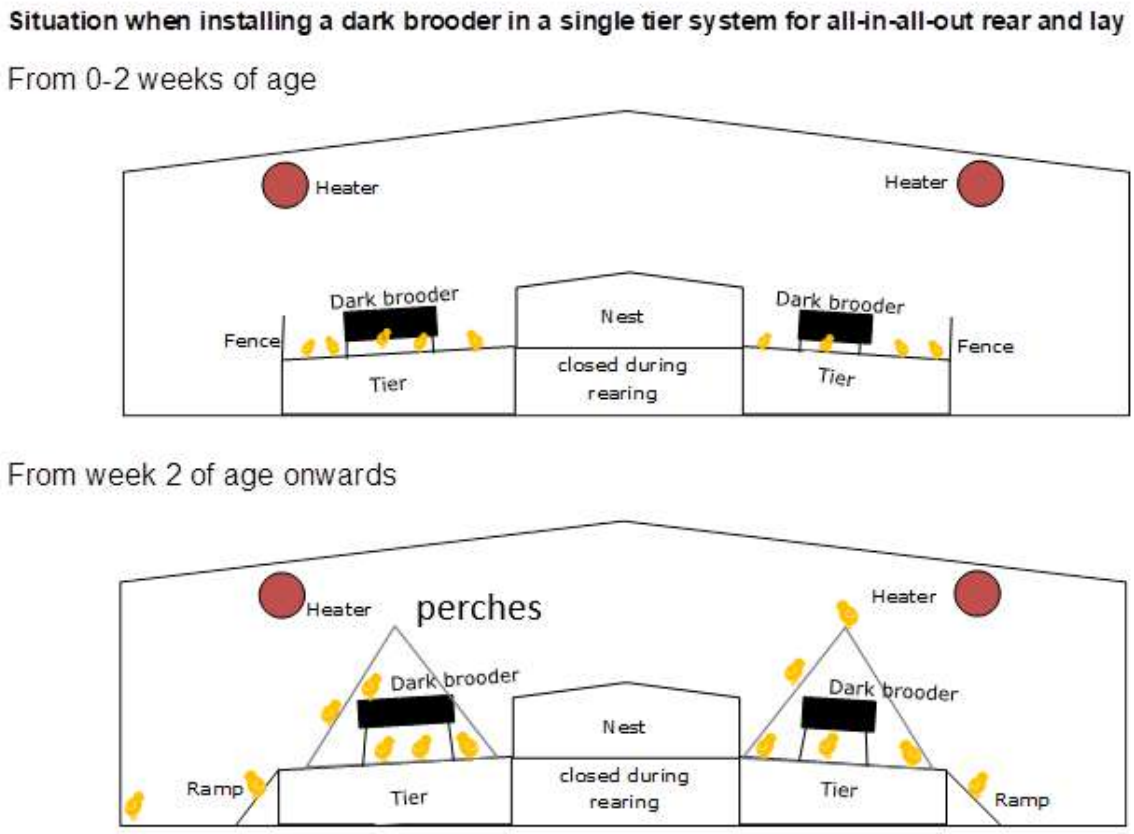

Figure 2. Example of a dark brooder set-up in a rearing house. From 0 to 2 weeks of age, the chicks will rest under the dark brooder (top panel), from 3 weeks of age onwards they will also start to use the perches (bottom panel).

2.7 Ventilation

Ventilation is required to provide sufficient oxygen (fresh air) and to remove harmful gasses from the house. The minimum quantity of fresh air needed (minimum ventilation rate) mainly depends on the weight and age of the pullets. In general, the minimum ventilation rate is 0.7 m^3/hour/kg live weight.

The maximum ventilation rate is approximately 4 m^3/hour/kg live weight with wind speeds that should not exceed 3 m/s. The airflow should be uniform with no excessive draughts. When pullets are 2 weeks old or younger, the air flow should not be higher than 0.1 m/s. Furthermore, CO_2 should be <3,000 ppm and NH_3 <10-20 ppm. These parameters are usually monitored by climate computers installed in the house or can be measured by hand-held devices. If these are not available, high NH_3 levels can also be detected by smell by the caretakers during inspection and appropriate measures to increase ventilation rate can be taken.

2.8 Training of pullets

To guarantee the uniformity of pullets, the stocking densities per *available living space* as presented in table 2 are considered acceptable, although this is highly dependent on the housing design and management. Pullets can start on the floor, after which additional living surface may be provided as they grow by offering tiers and winchable slats from 3 weeks of age. In an aviary rearing system the pullets should be placed in the middle tier, before they are released.

Easily accessible feeders and drinkers should be used. Preferably, the same drinking and feeding system (e.g. nipples with red cups and chain feeders) should be used during both the rearing and production period. The height of the feeders and drinkers should be adjusted for the age of the birds (Figure 3).

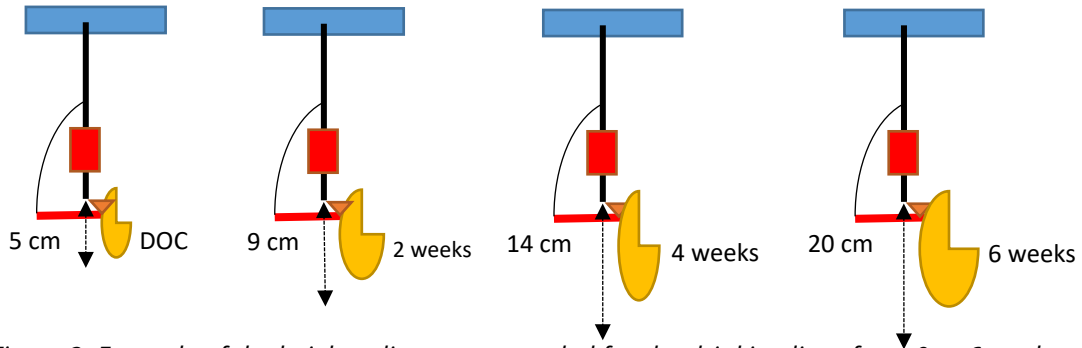

Figure 3. Example of the height adjustments needed for the drinking lines from 0 to 6 weeks of age.

2.9 Water training with adjustable water lines and platforms

Training pullets to gain access to water is especially important when birds need to navigate different levels in the egg production facility (such as in an aviary system; Figure 4). If the rearing facility provides winchable platforms, place the water lines above the platforms. From day 10-14 of age onwards, half of the platforms should to be elevated to such a height that pullets can jump onto them (10 -15 cm). After 20 days of age the other remaining platforms should be gradually elevated to such a height that all pullets are still able to reach the water, forcing the pullets to go to the elevated platforms to find water. This is called 'water-training'.

When farm personnel inspect the flocks, the pullets will be more active, further stimulating bird movement and ensuring the pullets are more acquainted with their living environment, which can also prevent large groups of birds from piling and smothering. After six weeks of age, chain feeders should be raised from floor level to a height of approximately 15 cm. Providing different elevated structures to the birds also helps to

prevent smothering. At the time of vaccination, a drinking line on the slatted area should be lowered to floor level to help pullets that show a strong vaccination response, but this waterline should be removed/elevated after week 12, otherwise hens will not get proper water training. For floor systems without any winchable platforms these adjustments are not needed.

Figure 4. An aviary rearing farm in Canada.

2.10 Increase living space by perches and platforms

To increase the living space of the pullets, and to provide additional resting space, platforms and elevated surfaces such as tables should be made accessible by gradually providing ramps or perches that enable the pullets to reach higher locations. Any kind of elevation should be carefully constructed so that it does not fall on or harm the birds. When using winchable surfaces make sure that the roof construction is strong enough to hold the weight of the platforms. For safety of farm personal and animals, installation by qualified personnel is strongly recommended. Pullets should have access to perches, ramps and slats from 10 days of age onwards. Offer variation in heights, if possible. At 7-8 weeks the hens should be able to reach the highest platforms and perches. Ramps should not be steeper than 45□ and be at least 20 cm wide. This will stimulate the pullets to use these facilities during the rearing phase to find feed and water and will train the birds to be able to use these facilities during their adult life in the production facility. For this reason, it is advisable to use the same type of perches in the rearing and laying facility. Not only will birds learn to seek feed and water on elevated levels, they will also

become stronger and more agile so they can more easily move through the housing system and access nest boxes during the production phase. The approximate perch space needed per pullet is 12 cm. Horizontal space between perches should be at least 30 cm. The preferred shape of the perches is rectangular with rounded edges or mushroom-shaped (Figure 5). Round-, and oval- shaped can be used as well, but those perches are less optimal regarding gripping and comfort. Perches should be made of durable materials that are not slippery and should easily be cleaned and disinfected after each flock cycle. Perches should be placed on the slats or above a manure removal system to prevent manure piling and to maintain good litter quality.

Figure 5. Preferred shape of perch (mushroom shaped).

2.11 Lights

In the first week of life, the chicks should be provided with an intermittent dark and light cycle which stimulates feeding and resting. A 4-hour light and 2 hour dark cycle is recommended. After the first week, day length should gradually be reduced from 20 to 10 hours of light per day at 7 weeks of age (see Figure 6). Light intensity at floor level should be 20-40 lux. The light source should be dimmable LED and/or high frequency TL-lights with warm white color of light (3000-3500 K). A house with no daylight during rearing, with a covered veranda (covered outdoor run) where daylight can be dimmed is recommended. Provide equal distribution of light over the house or smooth transitions of light intensity in different zones to prevent overcrowding and wet litter spots.

In the morning the lights should be gradually switched on over 10 minutes. In the evening dim the lights over 15-30 minutes, depending on the type of rearing system. It is recommended to never abruptly turn the light off. In aviary rearing systems always first switch the lights off in the scratching area, followed by the lights within the tiered system (from the floor upwards). In this way, the pullets are stimulated to move to the night perches. Dimmable dawn/dusk lights can also be used over the A-frame of perches or the top tier of an aviary system.

An example of a dimming schedule for a more extensive system where the pullets need to move from the scratching area into the system follows:

0-9 weeks: dimming OFF in 20 minutes*

17:00 – 17:05 Turn on Dusk/Dawn lights
17:00 – 17:10 Dim Main lights (scratching area) from 100% to 0%
17:10 – 17:18 Dim system lights from 100% to 0%
17:15 – 17:20 Dim Dusk/Dawn lights from 100% to 0%

10-12 weeks: dimming OFF in 32 minutes

17:00 – 17:05 Turn on Dusk/Dawn lights
17:00 – 17:10 Dim Main lights (scratching area) from 100% to 0%
17:10 – 17:30 Dim system lights from 100% to 0%
17:25 – 17:32 Dim Dusk/Dawn lights from 100% to 0%

13-17 weeks: dimming OFF in 27 minutes

17:00 – 17:05 Turn on Dusk/Dawn lights
17:00 – 17:10 Dim Main lights (scratching area) from 100% to 0%
17:10 – 17:25 Dim system lights from 100% to 0%
17:20 – 17:27 Dim Dusk/Dawn lights from 100% to 0%

*In case of smothering as the pullets move to their roosts, dim the lights faster, in 2-3 minutes.

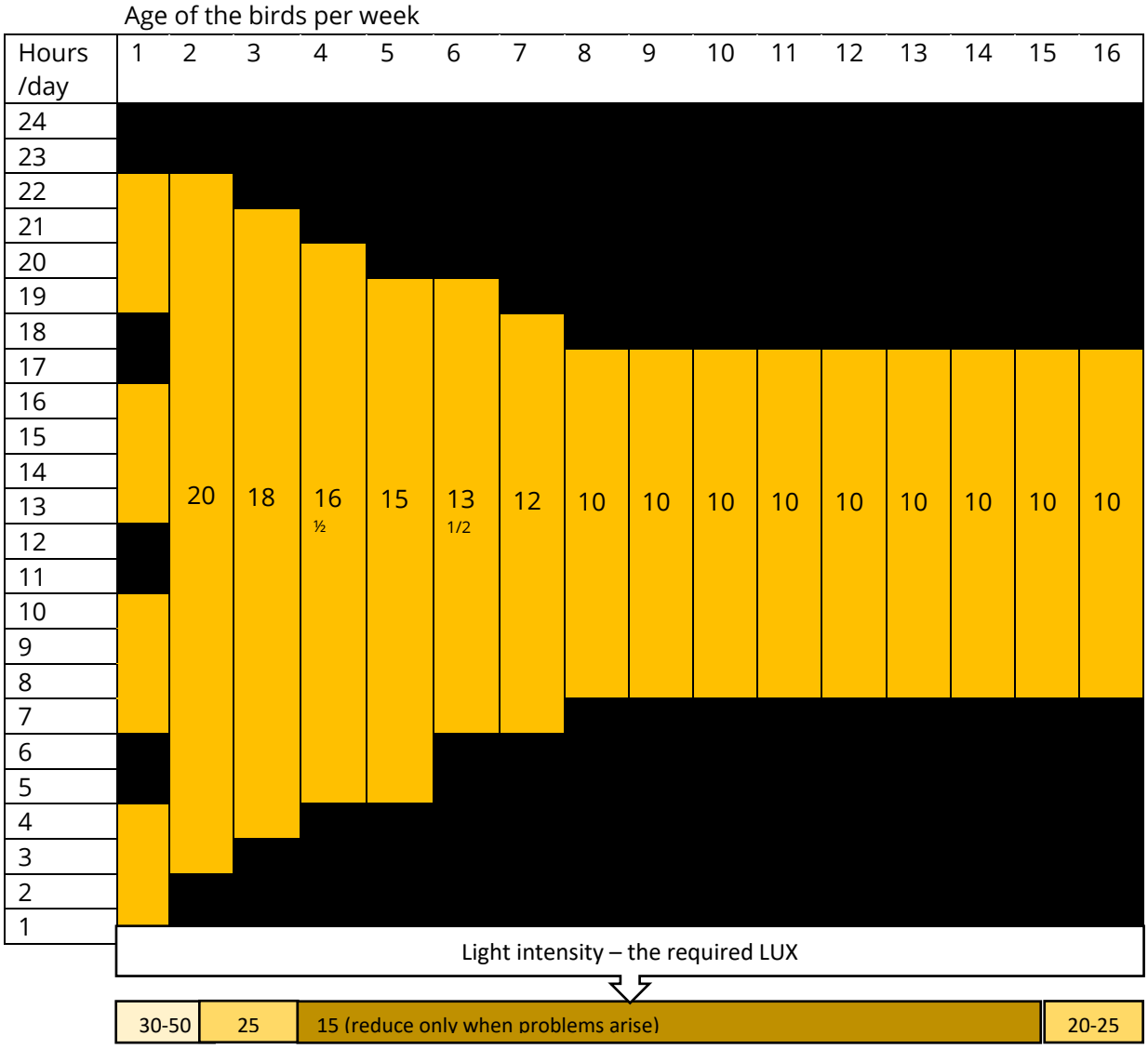

Figure 6. Light program and intensity in during rearing and production based on Lohmann Management Guide for rearing layer pullets.

2.12 Environmental Enrichment for pullets

Environmental enrichment can be defined as improvement in the biological functioning of captive animals resulting from modifications to their environment. Birds should be provided with appropriate enrichments to encourage activity and natural behavior, including foraging. The development of different behaviors typically takes place at an early age. Early experience with a variety of enrichment types is therefore important as it affects behavioral development. If pullets are deprived of enrichment, it may have long-lasting consequences (due to stress and frustration). An example of this is feather pecking, which may be the result of lack of dust bathing and foraging material at an early age.

A variety of interesting objects and resources, which are safe for the birds, should be placed throughout the house, and alternated. The types of enrichment should target the behavioral needs of the birds, i.e. be biologically relevant. Effective environmental enrichment will be used well by the birds. Any items which are not well used may be replaced with alternatives. There should be close liaison between the pullet rearer and the layer site to ensure that birds have a smooth transition on the access to (preferably the same) enrichment in the laying farm.

The different types of enrichments are numerous. Bales of hay, alfalfa, rice straw, chopped bamboo leaves or similar roughage materials can be placed in the litter area (e.g. monthly 1 bale of 15-20kg per 1,000 hens). Hens will peck and scratch at the bales creating additional substrate in the litter. Not only will this encourage these positive behaviors, it also helps to keep the litter in good condition. Furthermore, providing a roughage source stimulates the development of the gastro-intestinal tract and helps to train the pullets to spend more time on eating related behavior. Once hens are used to having substrate in the litter it is encouraged to always have some substrate at which to peck and scratch. Once bales have disappeared and no more substrate is visible in the litter, new bales should be placed to prevent hens from getting 'bored' and starting to pecking at each other. An indicator for the development of feather pecking is the disappearance of downy feathers from the litter (because the pullets are eating them). Another indicator of feather pecking is that the pullets show a very high intake of the roughage provided and the bales are disappearing fast.

Hanging objects can also be used as a form of enrichment. Objects can be bunches of rope or string, empty bottles, shiny metallic discs, bundles of hay or straw and others in the litter area. Changing and renewing these items regularly will ensure that the pullets stay interested.

Another option for environmental enrichment is commercially available pecking blocks, usually made from compressed aerated concrete. Pecking blocks not only offer an opportunity to perform pecking behavior, they also help to gently blunt the tip of the beak. A blunt beak reduces damage due to feather pecking.

2.13 Litter

Pullets should have access to litter during rearing in order to increase foraging behavior and to reduce feather pecking (Box 1). Absence of litter may induce the development of feather pecking behavior. Litter should be available from day one of age. Fresh litter substrate should be of a suitable material (see Table 6 in paragraph 3.5) and particle size, and should be managed to maintain it in a dry, friable condition. Small particle materials, such as peat or sand, are best able to satisfy a pullets' need to dust bathe. Separate areas with peat or sand can be considered as well.

Litter should be of sufficient depth (1-5 cm new litter at the start of the flock) for dilution of feces and should be dry and friable to stimulate foraging and dust bathing behavior. Partially removing the litter or changing the complete litter (followed by providing fresh litter substrate) is also a form of enrichment as it reactivates the pullets' curiosity to explore the newly provided litter and provides further positive association with the caregiver when this practice is performed with care.

In aviary rearing systems, where litter cannot be used before the system is opened, it is recommended to place chick paper and leave it during the rearing period. It has been shown that the presence of chick paper on the floor of the aviary rearing system may prevent feather pecking, because feces, feed and dust which accumulates on the paper supplies the chicks with a basic foraging substrate.

Box 1. Feather pecking and litter availability

In the wild, chickens spend about 65% of their active time on exploratory and foraging behaviour, expressed by scratching and pecking the ground in search of food items. In the domestic chicken, this foraging motivation is less strong than in their wild ancestor, the Jungle fowl, but it is still present. Therefore, litter availability is very important for both chicks, pullets and adult laying hens. If birds have no access to litter, they will direct their pecking behaviour to the feathers of other birds and feather pecking will develop. Research has shown that the risk of feather pecking outbreaks is strongly reduced if birds have access to good quality, dry and friable litter. This is also the reason why in many cage-free systems it is recommended to have a litter area in the house that measures at least 1/3 of the total floor space (as can be seen in the photo above of a commercial flock of laying hens in a floor housing system).

3. Keeping cage-free laying hens

3.1 Design and equipment

Cage-free housing of laying hens is characterized by different functional areas where the hens can find feed and water, lay their eggs, rest on perches or perform other behavior such as foraging and dust bathing. Allowing hens to freely perform these natural behaviors improves their welfare.

While some regions have extensive experience with cage-free egg production, it is a fairly new idea in other areas of the world. General guidelines and recommendations for the management of cage-free hens are commonly based on EU regulations, scientific findings, field experience, management guides from supplying companies (e.g. breeding companies, equipment suppliers) and recommendations by poultry experts and NGO's. When designing and constructing a new cage-free facility in a tropical climate, where cage-free egg production is relatively new, each barn should be considered separately. It is recommended to consult with local experts.

Table 4 describes the general space and equipment requirements for adult laying hens. The given numbers are approximate. Under tropical conditions lower densities are advised due to the risk of heat stress. Brown laying hen breeds are generally larger than white laying hen breeds, and so require more floor, perch and feeder/drinker space.

Table 4. General equipment and minimum space requirements for cage-free laying hens.

Stocking density	6-8 hens/m^2 useable surface(1)
Litter area	1/3rd of useable surface with a minimum of 250 cm^2/hen
Feeder space	Feeding troughs /chain feeder: 8-10 cm/hen(2)
	22-25 birds per feeding pan
Drinkers	8-10 hens/nipple
	60-80 hens per hanging bell drinker
Laying nests	100-120 birds per 1m^2 nest space
	5-6 birds per individual nests
Perches	Approx. 15-18 cm/hen (3,4,5)

[1] In aviaries this could add up to approx. 17-19 birds/m^2 floor space

[2] 20 hens/m trough or chain feeder if the feeder can be approached from both sides

[3] Perches are preferably rectangular-, mushroom-, or oval shaped

[4] Recommended horizontal distance between perches is 30 – 70 cm, 20 cm between perch and wall, vertical distance 30 – 50 cm, and angles of <45 degrees

[5] Recommended perch diameter 3 – 5 cm

Perches should be made of durable material without sharp edges that could injure hens or workers. Cracks, crevices and other narrow spots in the system should be closed off to prevent ectoparasites from manifesting themselves near the hens. The preferred shape of the perch is rectangular with rounded edges or mushroom shaped and this should be the same as hens are used to during rearing (see Figure 5. in paragraph 2.10). These shapes allow the best grip for the hens. Round or oval shaped perches are less favorable because they provide poorer grip. Laying hens are strongly motivated to seek high sites for resting and roosting (sleeping). Also, hens that are being pecked and try to escape as well as hens that are not feeling well often seek refuge in higher situated areas. Strategically placed, elevated perches offer the opportunity for the hens to perform those behaviors. Perches also contribute to better movement through the system, especially in aviary systems.

The laying nest should be an attractive, comfortable, easily accessible and clean place for the hens to lay their eggs. This ensures that hens will lay their eggs in this designated area, whereas cleaner eggs are better for premium price sales and food safety. Furthermore, provision of good laying nests helps to prevent floor eggs, which are laborious to collect and could be pecked at and eaten by the laying hens. For the nest to be attractive for the hens, the nests should be dark inside (approximately 1 lux), easily accessible, evenly spread through the house, at the same height as much as possible, free of drafts, no hot air accumulation or condensation, made of laminated wood, plastic or concrete plex (not metal sheeting). Flaps or curtains in front of the nest (not closing the nest completely) make the nest an enclosure, which the laying hens experience as a safe place to lay their eggs (Figure 7). The lining of the nest should allow scratching behavior and dust should be able to fall through (e.g. perforated AstoTurf). This allows the hen to perform her nesting behavior and keeps the eggs cleaner. Preferably, the nest should be a rollaway nest. In such a nest the eggs are laid on a surface that is on a slight angle. Due to the angle the eggs roll onto a collection belt when the hen stands up after laying her egg. This prevents hens pecking and eating the egg and keeps the eggs cleaner. An expel system in the nest allows the farmer to close the nests prior to the onset of laying. The expel system also expels the hens out of the nests at the end of the day. This prevents hens from sleeping in the nests and soiling the nest during the night. However, the nests have to be opened again well before the hens wake up. Additionally, an expel system with a fence generally creates space between the back wall of the nest and the expel fence. This extra space ensures a better nest environment and breathing space, especially in hot climates.

Figure 7. Group nests in a commercial cage-free system in Canada, with nest curtains and space between the nests to allow easy passage through the system.

Individual nests with litter may be a lower cost initial investment but have some disadvantages. There is a substantial increase in labor due to manual collection of the eggs and replacement of the litter. There is also an additional cost of litter for nest lining, and there can be a higher risk of production loss due to more floor eggs if the hens are not well adapted to the nests. Hens may start pecking at floor eggs, if not collected quickly, and they are generally dirtier eggs.

3.2 The start of a new flock in a cage-free barn

When rearing and laying takes place in one system, transfer of the hens from the rearing facility to the laying facility is not needed (see Appendix 1, design 1.d, the "All-in-All-out" system). When pullets are moved into the laying house from another pullet rearing facility however, the catching, transport and adaptation to a new house is stressful for the birds thus, care is needed when these procedures take place. Having a similar house design, light management program, feeding time and feed type between rearing and laying houses will help smooth the transition of hens from the rearing to the laying house.

Preparation of the cage-free barn:

- Transfer pullets to cage-free system before they begin laying eggs, usually at 16-18 weeks of age.
- Plan the arrival. Confirm the date and time of the hens arrival with the pullet moving company or rearing farmer. Hens preferably should arrive before midday

so they can settle in the poultry house before 14.00 hours (2 pm) and find feed and water before the lights are turned off for the night.

- Arrange a sufficient number of people (dependent on type of system, number of birds to be handled, type of transport and crates, etc.) to help unload the hens so that hens can be unloaded in a short time span and placed in the house with care.
- During the first few days apply the same light and feeding schedules as in the rearing house.
- All automatic equipment, back-up equipment and warning systems should be tested (water lines, feed chains, ventilation, computers, time clocks, etc.) before arrival of the birds.
- When using computer programmed management tools and/or timer-controlled equipment, program the computer management programs and timers well before arrival of the birds.
- Begin adjusting the house temperature 48 hours in advance to the desirable 18-21^{o}C.
- Disinfect the drinker lines or other drinking sources at least 48 hours prior to arrival of the birds. Shortly before the hens arrive, flush the water lines thoroughly and refill them with clean fresh water.
- Check the drinking system carefully by testing (individual) nipples for presence of water and absence of leaks.
- Check the water pressure of the drinking lines (in front and back of the house).
- Fill feeders with feed before the hens arrive.
- Check light systems, replace defective lights, and check the dimming system.
- Provide 1 cm of litter. Litter will accumulate quickly after hens are placed in the house and this provides a good basis for a dry and friable litter layer, while preventing the risk of birds nesting on the floor and laying eggs on the floor, instead of in the nests.
- Nests should be closed (and only opened for the first time after the first few eggs are found).

Placement of the laying hens:

- All hens should be evenly spread on the slatted area (if available) close to the drinkers and feeders or, in an aviary, directly into the tiers of the aviary system.
- It is important that the laying hens start to drink as soon as possible. Check and monitor this carefully. After several days 'dried-up' hens can be recognized by a shrunken comb. Assist these hens in finding water. Weak birds can be separated from the flock to give them extra attention.
- Run feed chains only one time during the first day. This prevents startling the hens but also attracts the hens to the feeders.
- A high light intensity will encourage hens to discover their new environment.
- After lights have been switched off the layers that remain in the litter area should be placed into the system or on the slatted area manually. The farmer should repeat this daily until at least 99% of the birds enter the system or slats by themselves when the lights are switched off. This ensures that the hens can easily find the drinkers and feeders in the morning. This will also prevent the hens from

becoming accustomed to resting overnight on the floor, which may be a risk for laying floor eggs.

If pullets are transferred into the house from another location, they should be loaded gently into and out of transport crates, without causing harm or injury. Each bird must be carried upright, using two hands to hold the wings against the bird's body (to prevent injuries and stress from wing flapping). Hens or pullets should never be picked up or carried by their head, neck, wings, legs or feet.

3.3 Ventilation and climate control

The three most important elements regarding climate are maintaining the correct temperature, humidity and sufficient ventilation. In general, 18-21^{o}C is the recommended temperature with a relative humidity of 50-70%. Laying hens can adapt to maximum temperatures of 26^{o}C after which heat stress becomes a serious problem. The bandwidth (difference between minimum and maximum temperature) should be set at 5-6^{o}C. Temperature changes that are too large are stressful for the hens.

Ventilation in closed barns ensures provision of fresh air and removal of stale air and harmful gasses (CO_2 should be <3,000 ppm and NH_3 <10-20 ppm). Ventilation can also be used to lower the ambient (effective) temperature in the cage-free barn with the use of wind speed (with a maximum of 3 m/s wind speed), the so-called wind chill effect. Tunnel ventilation allows large quantities of air to be pulled through the barn at considerable wind speeds. With tunnel ventilation, the fresh air enters in the front of the barn and is pulled through the barn in a longitudinal direction by means of exhaust fans that are placed in the back of the barn. The minimum ventilation rate for laying hens is 0.7 m^3/hour/kg live weight present in the house and the maximum ventilation rate is approximate 4 kg/m^3/kg live weight. Evaporative cooling (pad cooling) allows incoming air temperature to be lowered. This is possible if the incoming air is not yet saturated with water. High air humidity limits the effect of pad cooling.

Air flow can be checked with smoke to ensure there is no draft directly onto the hens when they perch at night. Airflow should also not go directly into the nests, because this is aversive to the birds.

3.4 Daily management procedures

Hens and housing should be inspected at least twice per day. Collecting and documenting certain indicators for major animal welfare problems is in the own interest of the keeper, as well as the animals, as it provides the maximum information on the welfare of the flock and enables the keeper to detect deficiencies and take corrective actions. The following

table contains recommendations for collecting major animal welfare indicators during the laying phase (Table 5).

Table 5. List of most important animal welfare indicators for laying hens and their possible causes.

Animal welfare indicator	**Possible causes**
Plumage condition Frequently damage develops from 30 weeks of age onwards	Feather-pecking, cannibalism; nutritional inadequacies; feed form; flock age
Skin condition Skin lesions, mainly around the back, the wings, the rump, the cloaca and the toes	Feather-pecking, cannibalism; overstocking
Nutritional status Weight development and feed consumption	Nutritional inadequacies; disease
Animal losses High mortality, recorded daily	Increased morbidity rate (disease); thermal stress; injurious pecking or cannibalism; nutritional deficiencies; predation, or other causes
Water intake Water consumption (below or above normal), recorded daily, if possible	Water shortage; dripping water troughs; house climate too warm; incorrect drinker height; water contamination
Thermal condition Panting or wing spreading (indicating heat stress); huddling (indicating temperature too low), observed daily	Temperature too high or too low
Fearfulness Excessive withdrawal from personnel; panic reactions (piling), observed daily	Lack of habituation to human contact

Feather pecking and cannibalism can result in poor plumage and skin conditions, as feathers are pulled out and the birds may be wounded when pecking continues in denuded areas. Inappropriate feeding may also affect plumage condition, as feed restriction or shortage of specific essential amino acids (methionine and cysteine) may induce molting in the neck area. Overstocking can also affect skin condition, as birds may damage other birds when climbing over each other, resulting in scratches on the back. To evaluate nutritional status, feed intake and weight development should be monitored. The latter can be done by weighing a subsample of birds. Together with animal losses and use of veterinary drugs, nutritional status is also an important indicator of disease and morbidity, as sick animals will often stop eating. Changes in water intake can indicate water shortage, dripping water throughs (leakage), a too warm climate in the house, or an unfavorable position of the drinkers (too high or too low). Observation of birds panting in the house can also be used as a sign of heat stress. Finally, excessive withdrawal from

personnel and panic reactions when people enter the house are signs of a lack of habituation to human contact and activities (see appendix 3).
Dead hens should be removed daily and sick hens should be placed in a recovery pen with feed and water and only returned to the flock once they have sufficiently recovered. Hens in the recovery pen should be checked at least twice a day.
Records should also be kept of all veterinary medical products used, and these should be documented daily. Over time, patterns may indicate changes in disease status of the flock.

3.5 Litter management

A laying hen spends 40-60% of her daily activities foraging and scratching. Therefore, providing good quality litter and implementing good litter management may substantially contribute to improved welfare and production. Several materials can be used as litter material, depending on cost and local availability (Table 6). Good litter management also contributes to worker health by improving air quality in the barn.

Table 6. Potential litter materials for cage-free laying hen facilities.

Wood shavings	Shredded paper
Saw dust	Dried pineapple waste
Rice hulls	Coffee hulls
Chopped oat, rice, wheat straw	Ground maize cobs
Shredded maize stalks	Broadleaf leaves
Groundnut shells	Sand
Shredded sugar cane stalks	Peat moss

Good ventilation is important in litter management. Especially cold drafts may cause wet litter and also make the hens more vulnerable to disease. Leakages of waterlines and drinkers may also cause wet litter. Wet litter results in high ammonia levels which is detrimental for both bird and worker health. The litter should not accumulate above 15 cm in depth. Litter that is too deep is a risk for increased floor eggs, high ammonia and fine dust levels, adverse working conditions, wet litter and litter plaques. Timely removal of litter should be part of the farm management to keep the litter in good condition and at an appropriate depth (5-10 cm). If applicable, litter under slats may also be removed if ammonia levels are too high or manure comes through the slats. Manure under the slats

may be collected and transported out of the house manually or with the use of manure belts. Automated manure scrapers in the litter area can be used to remove litter and help to prevent the laying of floor eggs.

Stimulating scratching behavior of the hens helps to keep the litter friable and dry. This behavior can be stimulated by providing enrichments in the litter or by scattering feed/whole grain in the litter area. Stimulating scratching and foraging behavior not only helps to keep the litter in good condition, it also helps to prevent feather pecking.

3.6 Light management

Light should be evenly spread throughout the different areas of the barn. Warm white light (2700-3500K) is preferred. The light source should be either LED or a light source with a photo flicker frequency of 100Hz or higher to prevent hens experiencing the light as a flickering light.

There should be no beams of light or shadowy areas in the litter area and these should also be kept to a minimum on the slatted areas. The light intensity in the litter area should be around 40 lux. Starting with a higher intensity (e.g. 50 lux) permits the lights to be dimmed at a later stage and/or during the afternoon to a lower intensity to calm the hens. Dimming lights is a measure for managing stress sensitivity of the flock and helps to prevent smothering and feather pecking. This dimming should not be standard practice from the start but should only be implemented if feather pecking or significant smothering events start to develop.

Near the drinking line the light intensity should be around 20 lux. Hens prefer a darkened nesting area. Only 1 lux of light in the nest is sufficient for the hens to perform their nesting behavior and comfortably lay their egg.

In the evening, light should be switched off gradually (in 20-30 minutes) and in stages to simulate sunset. Dimming lights will attract hens to the roosting area (e.g. the perches on the slats or on the top of the aviary system). Guiding the hens towards the desired roosting spot can be achieved by switching off the light in the littered areas before switching off the lights near the roosting places.

The recommended number of hours of light per day differs with the age, breed of laying hen and production goals. Follow the breeder organization guidelines after consulting the local supplier for the specific breed light requirements and light management, but in general for adult laying hens, a light-dark schedule of 14-16 hours light and 6-8 hours dark will promote egg production. Strategically placed, translucent windows in sidewalls and/or above 5-10% of the scratching area may provide natural daylight.

3.7 Prevention of floor eggs

Good management can encourage hens to lay their eggs in the designated nest boxes and prevent them from laying on the floor. Floor eggs result in lost flock productivity (some floor eggs are never found) and increased manual labor. Furthermore, laying eggs outside the nests increases the risk for vent pecking (pecking at the cloaca) and thereby increased mortality. To prevent floor eggs, take the following steps:

1. Avoid (unnecessary) obstacles in the litter area because these can create attractive surfaces against which hens may nest.
2. Avoid areas with extensive shadows in the litter or in the system because hens are attracted to the shadows to lay eggs.
3. Keep nests closed at arrival of the hens. Nests should be opened for the first time after the first few eggs are found.
4. Walk through the barn several times per day (e.g. 6 times per day) for the first few weeks during the onset of egg laying and collect all floor eggs. This is the critical time to prevent hens from developing a pattern of laying their eggs on the floor, and the presence of floor eggs is attractive to other hens to lay their egg nearby.
5. Place floor eggs in the nests. This attracts hens to lay more eggs in the nest.
6. Ensure there is no draught in the nests. Draughts can come directly from the inlets into the nests as well as via the egg belt into the nest.
7. Make sure the feeders are filled with feed when the hens wake up and/or run the feeder lines 15 minutes after the lights are switched on. Do not otherwise run the feeder line during the laying period (the first 5-7 hours after the lights are switched on) as this will attract the birds out of the nest boxes.
8. Place fences or wires near corners, edges, and partition walls of the house. (Partition walls are used in large laying houses, where for instance a flock of 30,000 hens is split up in five groups of 6,000 hens using wire-mesh partition walls inside the house.)
9. Ensure all hens sleep in the designated roosting area (e.g. the perches on the slats or in the aviary system) by placing all birds that remain on the floor after the lights are switched off in the system or on the slats.

3.8 Feather pecking

Feather pecking is the pecking at, or pulling out, of feathers of other birds. Feather pecking can have a severe impact on the welfare of laying hens as well as on the economics of the farm. It can result in plumage damage (naked areas), injuries, increased disease susceptibility, productivity declines, increased feed consumption and increased mortality due to cannibalism. Two major risk factors for the development of feather pecking are lack of environmental stimulation and high fear and stress sensitivity. Lack of environmental stimulation can be prevented by supplying good quality floor litter (see section 3.5) and environmental enrichment (see section 3.11). To prevent high fear and

stress sensitivity, frequent inspection and varied routines can help. This may include changes in routes taken, keepers' clothes and appearance, activities in the barn and a playing a radio. These kinds of activities are especially important in the early rearing period. By habituating hens to varied experiences, the flock will be more resilient and tend to remain calm under novel conditions. Conversely, it also important to try and prevent sudden transitions, for instance in feed composition or noise levels, as these are known risk factors for outbreaks of feather pecking.

To be able to respond to outbreaks of feather pecking in a timely manner, it is very important to inspect the birds properly during daily rounds. Carefully listening and observing while standing still or sitting allows the caretaker to detect early signs of feather pecking behavior. Vocalizations such as pain squawks can indicate an outbreak of severe feather pecking or injurious pecking. If the caretaker responds at the first signs of feather pecking, for instance by providing a pecking substrate (alfalfa hay, pecking blocks, straw bales, etc.), an outbreak of feather pecking can often be prevented. Once the outbreak becomes more serious, it is very hard to prevent the birds from continuing to feather peck.

As a last resort, the light can temporarily be dimmed to lower flock activity level, but this also has negative welfare implications because social behavior can be hampered, and eye health can deteriorate in the long-term.

Other measures to prevent injurious pecking include providing perches of sufficient height (over the hens' head height) to offer a refuge for potential victims, reducing the stocking density and by choosing a laying hen strain specifically bred for cage-free production (see section 5, and the Assurewel, Feather cover advice guide for further information).

3.9 Piling & Smothering

To control birds' distribution and prevent overcrowding and piling, it is advisable to partition the house into different compartments (e.g. of 3,000 hens per compartment). Overcrowding in the nest may lead to birds getting stuck, birds suffocating by piling or overheating, broken eggs, and vent pecking. Nest capacity should be 100-120 birds per 1 m^2 collective nest or a maximum of 5 birds per individual nest. Nest partitions placed in front of the nest help to prevent overcrowding and piling in the nests. Such partitions should be placed perpendicular to the nest every 5-8 meters. At the onset of egg laying, the nests on the outside of the row can be left open to prevent smothering in the nests (as these nests are usually the most attractive to the hens). Crossover areas between the nests (approx. 2 meters wide per 3,000 hens; Figure 7 or over the nest roof facilitate easy movement and accessibility throughout the whole compartment for both the hens as well as for the workers.

3.10 Feeding and nutrition of cage-free hens

Hens kept in cage-free housing require more feed than those kept in cages. Table 7 shows an example of a typical cage-free hen diet in the first half of the laying period. As laying hens age, they require a bit less protein, a bit more calcium and a bit less phosphorous in their diets. The same amount of energy is needed to produce a cage-free egg as compared to a cage egg. However, cage-free hens have more space and opportunities to perform natural behavior such as walking, flying, dustbathing and scratching the litter. Because of this increase in activity, laying hens in cage-free systems use approximately 10-15% more energy than hens in cages. To reach this 10-15% increase in required energy, the daily feed allowance can be increased by 10-15% (e.g. +12g/hen/day). However, this strategy can only be implemented when the climate within the poultry house is well controlled. Under hot conditions hens produce more heat, and in order to balance their thermoregulation, they reduce their daily feed intake. Providing more feed will not match their energy requirements, since the birds will not consume the initial allowance.

Table 7: Example of a cage free diet in Europe (g/kg) (layer phase 1).

Diet	**Inclusion**
ME (MJ)	11.8
Crude ash	127.9
Crude protein	160.9
Crude fat	58.4
Crude fibre	36.8
NSP	153.4
dig lysine	6.9
dig meth. + cys	6.1
dig threonine	4.8
dig tryptophan	1.5
Na	1.5
Cl	2.5
Ca	38
P (g)	4.9
Available P (g)	2.8

Under hot conditions, therefore it is advisable to increase the energy density of the diet by 10-15%, aiming for approximately 363 kcal/day instead of 330 kcal/day (typical in a caged hen diet). Increase the energy density when temperature is long lasting above 26 °C degrees (target value) or when behavioral signs indicate the temperature is too high (i.e. drinking increases drastically, laying on the floor with wings spread out and panting). To reach this increase in metabolizable energy in the diet, a grain (±12-14 MJ/kg) or lipid source (± 30-40 MJ/kg) should be used such as animal fat or sustainably sourced palm oil.

Not all fats are appropriate, i.e. too much linoleic acid, which is naturally found in plant-based oils such as soya-oil, maize oil and sunflower oil, increases the egg weight. If an egg weight increase is undesirable, the total linoleic acid content of the diet should not increase. Protein sources are less appropriate to increase the energy density. Protein from the diet is used in small amounts for maintenance (±20%) and growth (±4%) and to a greater extent for egg production (±76%). Thus, an increase in protein will result in higher egg weights. It is recommended to include 16-17% crude protein in the diet.

The amino acid requirements for cage-free hens differ from that of caged hens. For commercial hybrids, the specific amino acid requirements vary, therefore always follow the management guides and consult the breeding company. In general, the lysine, threonine and tryptophan should be increased in cage-free diets (Table 8).

Table 8. Several recommendations on the amino acid requirements (mg / hen / day) of laying hens in non-caged systems from research, feeding table (CVB) and practice.

Amino acid	Schutte (1996)	Van Krimpen (2015)	CVB (2018)	ISA (2008)	Lohmann (2009)	Adisseo
Lysine	700	810	620	805	830	838
Methionine + Cysteine	650	650	550	690	755	714
Threonine	460	520	430	560	580	577
Tryptophan	130	165	130	178	174	155

It is important to use the same feeder and watering systems that were available during rearing as possible. An automated chain feeder is advantageous because it permits fast distribution of the feed and feeding can be done directly on the slats.

It is recommended to feed the hens within 15 minutes after the lights have been switched on completely. The following 5-7 hours the hens should not be fed. During this 5-7 hour timespan most hens will lay their eggs. If the feeder line runs in that period hens that are about to lay their egg in the nest might get distracted and leave the nest. This may lead to more floor eggs, broken eggs, vent pecking and restlessness. The feeder should be emptied by the hens at least once per day. In this way the fine particles will be ingested, which consist mostly of vitamins and minerals. Furthermore, the hens will have a higher motivation to ingest the newly provided feed, which is beneficial for the total daily feed intake. Feeders and drinkers should be cleaned regularly.

Laying hens should be fed *ad libitum* and frequently to maintain their nutritional requirements for egg production. Laying hens should not be force-molted, which involves feed and sometimes water restriction. Feeding schedules are depended on the light schedule and can range from 5 – 8 runs per day. Midnight feeding is an option in hot conditions to increase feed intake. When midnight feeding is applied, there must be a

dark period of at least 3 hours before and after the lights will be switched on for 1-2 hours in the middle of the night. The feeders should be filled before the lights are turned on. An example of a feeding schedule (depending on amount of hours light) is as follows:

- 15 minutes after lights on (feeder run 1)
- 5 – 7 hours after lights on (feeder run 2)
- 8 – 10 hours after lights on (feeder run 3)
- 12 – 14 hours after lights on (feeder run 4)
- Last feeding 1-2 hours before lights out. This ensures there is feed available in the morning (feeder run 5)

A balanced diet is important to maintain laying hen health and productivity and to prevent feather pecking and cannibalism. Feather pecking and feather damage result in a higher energy requirement. When half of the feather cover has disappeared, the heat production for maintenance increases approximately 8%. Nutrition is a promising strategy to influence behavior since it causes quick responses from the hens and dietary adjustments can be implemented quickly. Diet composition and feeding strategy can influence feather pecking behavior during laying. Protein or amino acid shortages in the diet can increase feather pecking. The diet should include 16-17% crude protein. The protein source does not influence feather pecking. It has been shown that the inclusion of appropriate levels of lysine and tryptophan can reduce feather pecking. It is advisable to include at least 810 mg digestible lysine / hen / day to contribute to a good feather cover and to prevent possible feather pecking issues. Furthermore, the level of digestible tryptophan should be 130 mg/hen/day. Tryptophan is used by laying hens to produce hormones that influence behavior. Feather pecking can sometimes be decreased by feeding increasing the tryptophan content of the diet.

Dietary coarse fibers can also help to reduce feather pecking. By providing fibers the birds are more satiated due to gizzard filling. Birds that are more satiated perform less feather pecking. Furthermore, the provision of fibers positively influences gizzard development, by increasing its weight and form. Feed with high fiber content will remain longer in the foregut, again aiding satiety of the bird. It is recommended to use insoluble fibers (non-starch polysaccharides) such as oat hulls or barley to dilute the diet. If dilution of the diet is not possible due to hot conditions, at least 14g/hen/day of a fibrous source should be included in the diet.

Another aspect that is important to consider is the feed form. Feeding a coarse mash or crumble reduces feather pecking compared to feeding pellets. This is because birds spend more time pecking in the feeder with mash or crumble, reducing their pecking motivation. The mash or crumble should be homogenous to prevent selection of preferred feed particles. Furthermore, providing a coarse mash stimulates the development and activity of the gizzard. Improved digestion due to the gizzard activity increases gut health and makes the birds more resistant against possible infections.

If the climate can be managed according to the mentioned recommendations in section 3.3 on ventilation and control, it is possible to dilute the diet with sand, grit or high fibrous

raw materials. Due to the lower energy content of the diet, the birds will increase their fed intake. Time that is spent on eating cannot be spent on feather pecking. Furthermore, by diluting the diets the hens are more satiated. If dilution of the diet is not possible due to hot conditions, roughages should still be provided as an environmental enrichment.

Consultation of a local poultry nutritionist is strongly advised in order to maintain good health and good egg production of the flock. Feeding companies can provide detailed advice when a non-cage flock is developing early signs of feather pecking.

3.11 Environmental Enrichment

Enrichments should be provided to keep the hens occupied with scratching and pecking at objects and substrates. This may prevent the development of damaging behaviors like feather pecking and cannibalism and improve the overall quality of life of the hens. There are numerous types of enrichments (see section 2.12). Bales of hay, alfalfa, rice straw or similar local products can be placed in the litter area (e.g. monthly 1 bale of 15-20kg per 1,000 hens; Figure 8). Hens will peck and scratch at the bales creating additional substrate in the litter. Not only will this encourage positive behavior, it also helps keep litter in good condition. Once hens are used to having substrate in the litter it is encouraged to always have some substrate at which hens may peck and scratch. Once bales have disappeared and no more substrate is visible in the litter, new bales should be placed to prevent hens getting 'bored' and start pecking each other.

Figure 8. Example of roughage provision in a laying hen farm: provision of alfafalfa bales at the Kipster farm in The Netherlands.

3.12 Covered veranda

Additional space can be created in a semi-outdoor area by providing a covered veranda on either one or both longitudinal sides of the house (Figure 9). Typically, the covered veranda is a littered area in which the hens can perform behavior such as foraging, scratching and dust bathing. Additional waterlines may also be provided in the covered veranda. If the area of the covered veranda is included in the calculated living space to determine the allowed flock's size, access to the covered veranda must be provided at all times. Hens enter the covered veranda through internal pop-holes, hen-sized exits on the side of the house. The roof of the veranda may contain translucent windows, or the sides of the covered veranda may be constructed of mesh, translucent windows or perforated material to provide daylight to the hens. The roofing should be waterproof and exclude wild birds or other animals from the outside. A covered veranda may strongly affect the ventilation capacity and air flow in the house, and this should be taken into consideration in the house design and installation of ventilation equipment.

Figure 9. Laying hens sunbathing in a covered veranda in The Netherlands.

3.13 Health

Cage-free hens can be kept in indoor systems, indoor systems with a covered veranda or free-range systems with an outdoor run. Free-range systems have the benefits of providing the hens with fresh air, extra foraging opportunities, a lower stocking density outside and sunlight (a natural antiseptic) but can also present health risks.

This is especially true in areas where the laying hens can come into contact with wild birds or their droppings.

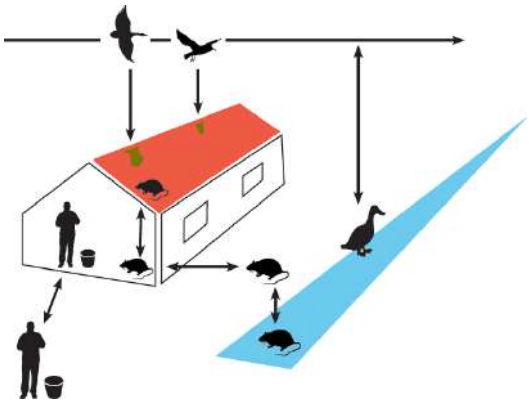

Figure 10. Potential routes of infection for indoor and free range systems.

In closed, indoor systems, there is no contact with droppings from migratory birds, no predation, climatic conditions can be better controlled, and rodents can be controlled easier (Figure 10).

Free-range systems require additional management to ensure healthy, safe hens. In free-range systems, new airborne viral and bacterial infectious agents may be introduced to the flock. Furthermore, infections with bacteria, protozoa (such as Histomonas) and helminths (worms) can also occur through contact with contaminated soil. In areas where migratory waterfowl are present (geese or ducks), poultry are especially susceptible to diseases that they carry. Covered veranda systems offer many of the positive features that are present in an outdoor free range, with fewer risks of pathogen exposure. Foraging enrichments offered in either the litter area or the covered veranda can help compensate for lack of foraging on the free range. Inspiring examples of farms designed around this principle are the Dutch Rondeel system (www.rondeeleieren.nl/) and the Dutch Kipster system (www.kipster.farm/ Figure 8).

The risks of free-range access can be reduced by proper range management. This includes limiting the stocking density and using several pieces of land consecutively in rotation, to prevent the buildup of infectious agents. Keep the area directly around the house dry and clean (Figure 11). There should be at least one exit per 500 birds and exits should be wide enough for two birds to pass freely without touching each other or the side of the exit. The space surrounding exits tends to become denuded quickly and requires special attention. Exit areas should be managed to prevent muddy conditions or standing water. This can be done by maintaining the area with short vegetation and/or by covering the area with a draining material, such as rock, gravel, pebble, straw, overlaying platforms, or concrete. Gravel can also help clean the birds' feet before going back into the hen house, which helps ensure litter quality. However, loose rock must be of a size and material that does not cause injury to the birds' feet. Puddles and standing

water are sources of bacterial and parasitic infection, particularly if the hens drink from them, and should be avoided. Land should be well-drained and vegetated, where possible.

Hens and pullets should be protected from both aerial and terrestrial predators. Overhead cover, either natural (trees, bushes, shrubs) or purpose-built (platforms, shade cloth), will encourage the birds to exit the house, range over the outdoor areas and will provide protection from the sun and the threat of aerial predators. Movable cover can be used to encourage the birds to range over different areas of the outdoor space and can help prevent the denuding of vegetation in one well-used place.

Enclosed, indoor facilities, should always be available to protect birds from adverse climactic conditions and for in the event of an eminent disease outbreak and to safely enclose all birds at night. Such shelter must be large enough to accommodate all birds at the same time.

It is important to let the poultry house rest between flocks and to clean it thoroughly. A period of four weeks without chickens is recommended. A thorough cleansing of walls and equipment and removal of organic matter of the floor should always be done, to prevent the build-up of litter or spots where *E. coli* could reside in large numbers. Consider if, and which, infectious agents are to be removed. If no disease is present, disinfection may not be needed in a dirt-floor house. Otherwise use a commercial disinfectant solution.

Figure 11. A free-range farm in The Netherlands, where the area around the house is covered with pebbles, to avoid muddy and dirty areas in the vicinity of the house.

The location of egg farms should be chosen to be safe from the effects of floods and other natural disasters. Additionally, farms should be sited to avoid or minimize biosecurity risks, exposure of birds to chemical and physical contaminants, noise, and adverse climatic conditions.

Each farm should have a written animal health plan developed in consultation with a qualified, local veterinarian that includes a vaccination schedule and other preventive treatments such as routine parasite control. The animal health plan should include monitoring and reducing any incidence of keel bone fractures and other common injuries of laying hens. The animal health plan should be kept up to date, with daily recordings. Regular monitoring of records aids management by permitting the detection of underlying problems enabling timely intervention. Indicators of health problems in the flock are reductions in feed intake, egg production, or flock activity and changes in comb coloration (pale combs). During inspection rounds, the fresh feces in the house should be inspected for abnormalities. In cases of diarrhea, the veterinarian should be consulted.

If persons in charge are not able to identify the causes of diseases, ill-health or distress, or to correct these, or if they suspect the presence of a reportable disease, they should seek advice from licensed veterinarians or other qualified advisers. Veterinary treatments must only be prescribed and performed by or under the direct supervision of a licensed veterinarian.

In case of disease or injury, when treatment has failed, or recovery is unlikely (e.g. birds that are unable to reach feed and water), or severe pain that cannot be alleviated, the animal should be euthanized as soon as possible. Euthanasia is killing an animal in a humane (quick and painless) manner to alleviate suffering. Allowing a sick or injured animal to linger unnecessarily results in poor welfare and should not occur. A prompt diagnosis should be made to determine whether the bird should be treated or humanely killed.

The farm should have documented procedures and the necessary equipment for on-farm euthanasia. Staff should be trained by a licensed veterinarian in euthanasia procedures appropriate for the age of the birds. Each farm should have an emergency response plan. This should be designed to minimize and mitigate the effect of natural disasters (e.g. earthquake, fire, flooding, and hurricanes), power or equipment failure, water or feed supply shortages, and emergency disease outbreaks. Disaster plans should include evacuation procedures, identifying high ground, maintaining emergency feed and water stores, and destocking and humane killing when necessary. Procedures for humane killing of sick or injured animals should be part of the disaster management plan. Contingency plans should be documented and communicated to all responsible parties. A method for providing clean, fresh water for a period of at least 24 hours during a shut-off of the main water supply should be available on-site.

3.14 Biosecurity

Biosecurity can be defined as all the activities designed to keep diseases from entering (or leaving) the farm. Each egg production site should have a good biosecurity plan including the hygiene measures needed to reduce the risk of infection. An example of a hygiene barrier for persons visiting the poultry house can be seen in Figure 12. Here, the outer footwear is disinfected upon entry and the outer footwear and clothing are left at one side of an area divider or demarcation, often a bench. On the other side, the inner clothing and footwear are put on, to avoid contaminating the birds with bacteria and viruses that may be on the outer clothing and footwear. Ideally, showers are available for changing, rather than simply a bench, so that when contagious poultry diseases are in the area, farm personnel and visitors can shower before entering the farm and again when exiting. At the very minimum, the hands should be washed and disinfected at the bench/demarcation.

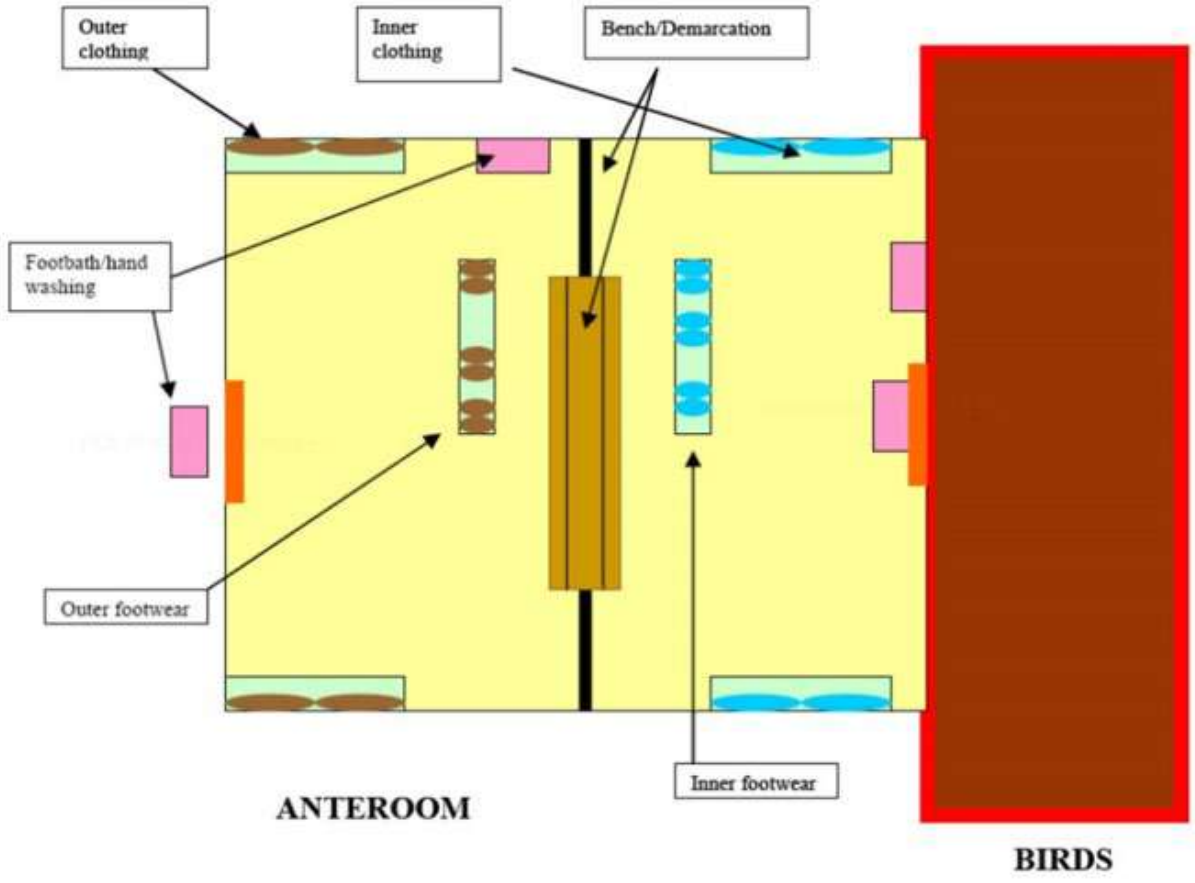

Figure 12. Example of a hygiene barrier for visitors to the poultry house.

For the entire farm, a plan should be made regarding the routing of people, trucks, and animals. An easy way to organize this is the traffic light system (Figure 13). The green area is the outside world, the dirty area. The orange area is the fenced off farm area, which is the buffer area, here visitors should change clothes and footwear and trucks should clean

and disinfect their wheels before entry. The red areas are the animal houses. Here, access is highly restricted and for each house designated footwear is available at the door of the house. To maintain good biosecurity on-farm, it is important that a proper biosecurity plan is in place and that it is implemented and clear for all visitors. Systems in which whole, new flocks are brought in and depopulated together, and where mortality is not replaced, can prevent the infection of the flock by new birds carrying in pathogens. While it is best not to house multiple age birds on the same site (because older birds can infect younger birds), if pullets are reared on the same site, they should be cared for first, before older flocks, in the daily management routine. In addition, risks of infection by rodents and wild birds should be minimized by keeping the farm area tidy, the houses well maintained and properly closed and by having a rodent control program in place. In high-welfare farms, rodent control must be humane. Poisons, drowning and traps that can maim animals must be avoided. Feed is secured in rodent-proof bins.

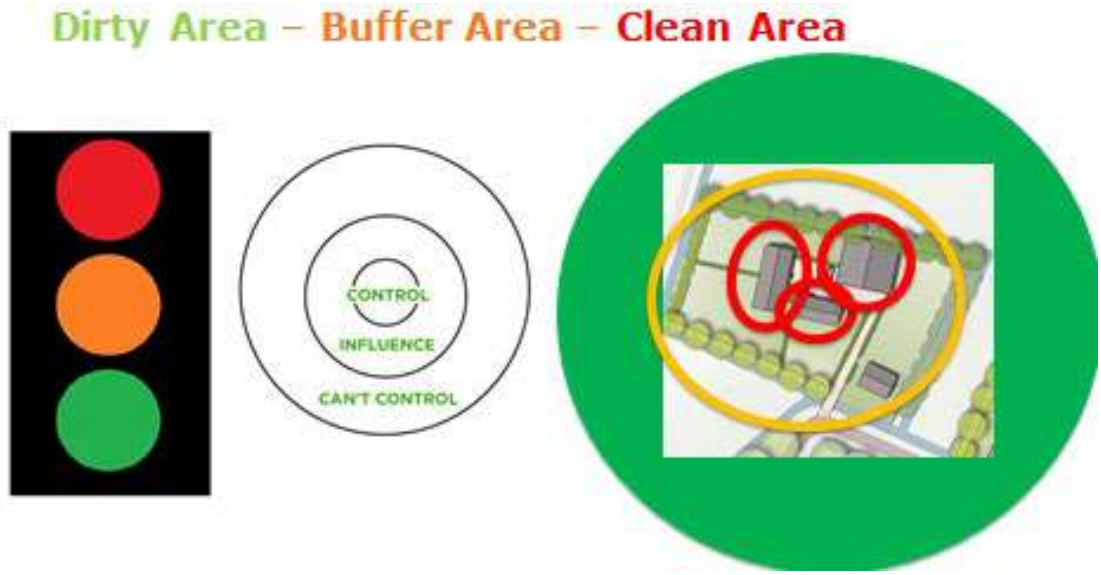

Figure 13. Example of the traffic light system for designing the biosecurity plan.

4. Concluding remarks

This management guide is aimed to provide basic information and tools to help farm managers and farm personnel successfully house and care for a flock of laying hens in a cage-free environment in a hot and/or tropical climate. The guide shows that housing and management during the rearing phase (0-17 wk) and the laying phase (17-approximately 80 wk) are equally important. During the rearing phase, the foundation is laid for the laying phase, as behavior of the pullets is shaped during rearing. By adjusting housing and management to the behavioral needs of the pullets, the pullets will make good use of the system and problem behaviors such as feather pecking, cannibalism and smothering can be avoided. Of course, the laying phase includes the majority of the laying hens' lives, so appropriate housing and management are also of the utmost importance. Lighting, nutrition, and air quality are all key factors for the productivity and welfare of the birds. In free-range systems, additional protection of the hens is needed to ensure their health, comfort and safety. In indoor systems, behavioral freedom can be increased by adding a covered veranda or an indoor foraging area with appropriate enrichments for pecking and scratching.

5. Suggestions for further reading

- Assurewel. Feather cover advice guide. www.assurewel.org/Portals/2/Documents/Laying%20hens/Feather%20Cover%20advice%20guide.pdf

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Appendix 1. Cage-free housing designs suitable for hot/tropical climates

In the following section, several housing designs are presented for hot and/or tropical climates to raise and keep cage-free layer pullets and laying hens in existing or newly built pullet and laying hen barns. The purpose of the presented designs and additional information is to give farmers, advisors, agricultural entrepreneurs, and all others involved and interested general information of possibilities and recommendations.

The following designs and recommendations will be presented in this section:

Single-tier barn system for laying hens

1a. Cage-free laying hen facility with integrated perch-feeder system

1b. Cage-free laying hen facility with modified A-frames

1c. Small-scale cage-free facility

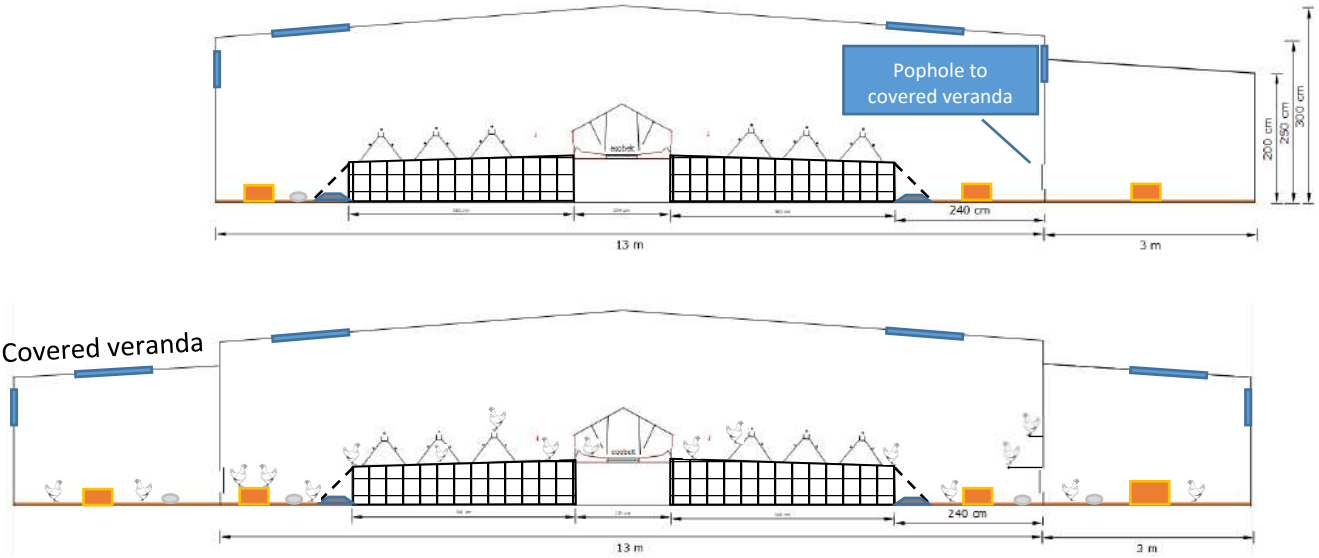
1d. All-in-all-out system (pullet rearing + egg production in one single facility)

Rearing system for pullets

2. Rearing system for pullets from Day-old-Chick (DOC) till 16-17 weeks of age

NOTE: all dimensions are approximate. In flock size calculations, non-accessible or non-countable space taken into account (e.g. space in front/back of house, nest space, egg belt). Covered veranda is not counted as useable surface.

1a. Cage-free laying hen facility with integrated perch-feeder system

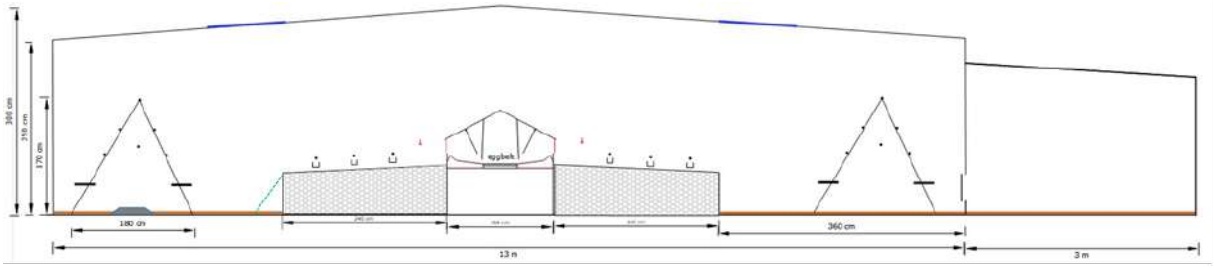


The principle of cage-free single-tier barn systems for laying hens is that laying hens can freely move around the house. The litter area provides sufficient space, enrichments and substrates for foraging, dustbathing and other behavior. Perches, feeders and drinkers are located on the slatted area. The eggs can be laid in a safe, comfortable and secluded nesting area. An optional covered veranda to allow hens more space in a surrounding with more fresh air and sun light may be provided. Section 3 of the Management Guide provides further information on equipment standards, management practices and other additional information.

Indication of house dimensions with flock size and housing requirements:

- E.g. 100m*13m: 7,000 hens (6 hens/m^2) to 10,500 hens (9 hens/m^2)
- E.g. 75m*8m: 3,000 hens (6 hens/m^2) to 4,500 hens (9 hens/m^2)
- Raised slats (plastic, hardwood, bamboo), approx. 2/3rd of available space. Height between floor and slats ≤ 55 cm. Additional ramps or steps to aid movement from floor to slats.
- Deep pit manure collection. Optional to have a manure belt under the slats. Optional to have manure scrapers in litter area.
- Automatic nests with expel system. Nests are lined with Astroturf. On top of nests an anti-perch system is placed or a flat-top roof that allows bird movement on top of the nests.
- Integrated feeder-perch system with 15 cm perch/hen and 5 cm feeder space/hen
    - Feeder system with chain or spiral.
    - Preferred perch shape is rectangular, oval, mushroom-shaped
    - Optional to place additional perches near the wall
- Drinkers in front of nests (min. 20 cm between drinker and nest entrance), 10 hens/nipple
- Tunnel ventilation with pad cooling
- Strategically placed lights to ensure correct light intensity at the different functional areas
- Divided in compartment of 3,000-5,000 birds per compartment
- See Management Guide for space requirements (e.g. hens/m^2, birds/m^2 nest space, birds/m^2 feeders, birds/nipple)
- Covered veranda optional (on one or both sides)
    - For more enrichments see Management Guide
- Considerable to combine with All-in-all-out system (See All-in-all-out system)
    - Side inlets should then be applied too

1b. Cage-free laying hen facility with modified A-frames (no rearing)

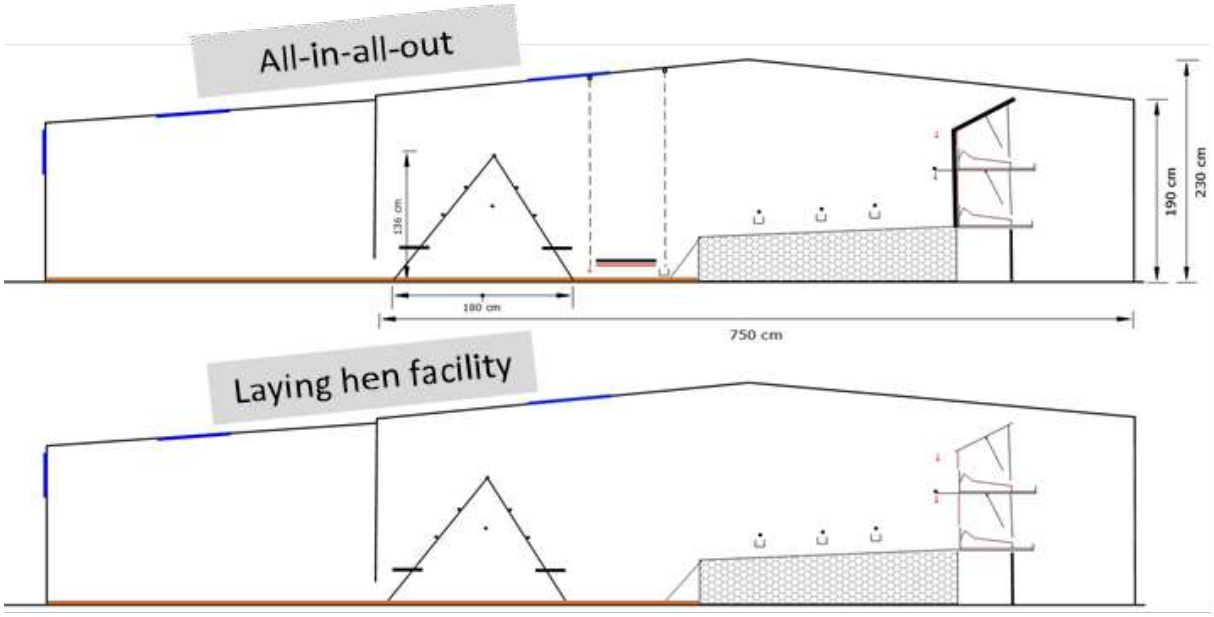


The principle of a cage-free single-tier barn system for laying hens with modified A-frames is that laying hens can freely move around the house. The litter area provides enough space, enrichments and substrates for foraging, dustbathing, and other activity. Feeders and drinkers are located on the slatted area, whereas perches and platforms are placed on A-frames that are located in the litter area. These A-frames can be former battery cage frames. A manure scraper can be installed under these frames to collect the manure. The eggs can be laid in a safe, comfortable and secluded nesting area. Optional is to provide a covered veranda to allow the hens more space in a surrounding area with more fresh air. Section 3 of the Management Guide provides further information on equipment standards, management practices and other additional information.

Differences compared to design 1a:

- More narrow slats with deep pit manure collection
- Feeders on the slats (with perch on top of feeder)
- Modified A-frames (e.g. former cage stands) with perches and platform placed in the litter area
- Optional to install manure scraper under the A-frames
- For enrichments see Management Guide (section 2.12)

1c. Small scale cage-free facility



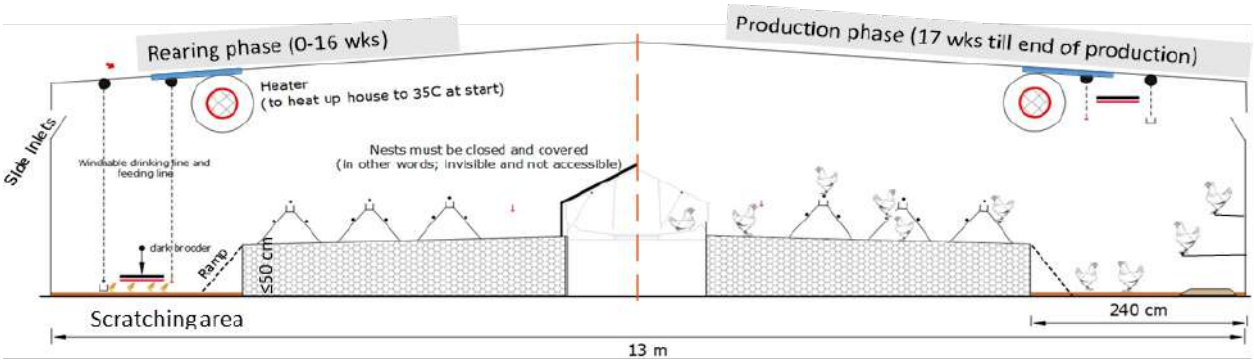
The principle of small-scale cage-free facility for laying hens is that laying hens can freely move within the house. The litter area provides enough space, enrichments and substrates for foraging, dustbathing, and other behavior. Feeders and drinkers are located on the slatted area, whereas perches and platforms are placed on A-frames located in the litter area. These A-frames can be former battery cage frames. The eggs can be laid in a safe, comfortable, and secluded nesting area. A corridor behind the nests allows manual collection of the eggs. Providing a covered veranda to allow the hens more space in a surrounding with more fresh air is an option.

Another option is to do the pullet rearing in the same facility (top figure, All-in-all-out). For rearing, dark brooders, or other measures to ensure a brooding temperature of 32-34^{o}C, should be implemented in the house for the first 14 days. During the start of the rearing period, feed and water must be provided in the scratching (litter) area. Furthermore, the nests should be closed and covered until the first eggs are being laid. Sections 2 and 3 of the Management Guide provide further information on equipment standards, management practices and other additional information.

Indication of house dimensions with flock size:

- Flock capacity from 2,000 hens (e.g. house dimensions 50m*6m) up to 5,000 hens (e.g. house dimensions of 75m*9m) at 9 hens/m^2
- Flock capacity from 1,300 hens (e.g. house dimensions 50m*6m) up to 3,500 hens (e.g. house dimensions of 75m*9m) at 6 hens/m^2
- Nests can be with manual or automatic egg collection
- Walkway behind the nests (not accessible for the hens)
- Modified A-frame with perches and platform
- Feeders on the slats
- Considerable to combine with All-in-all-out system (top figure)
    - Ventilation side inlets should then be applied too
    - Dark brooders could be considered for the start
    - Nests need to be covered until onset of lay
    - See 1.d “All-in-all-out system” for additional requirements
- Covered veranda optional only on one side
- For enrichments see (section 2.12) Management Guide

1d. All-in-all-out system Pullet rearing + egg production in one single facility

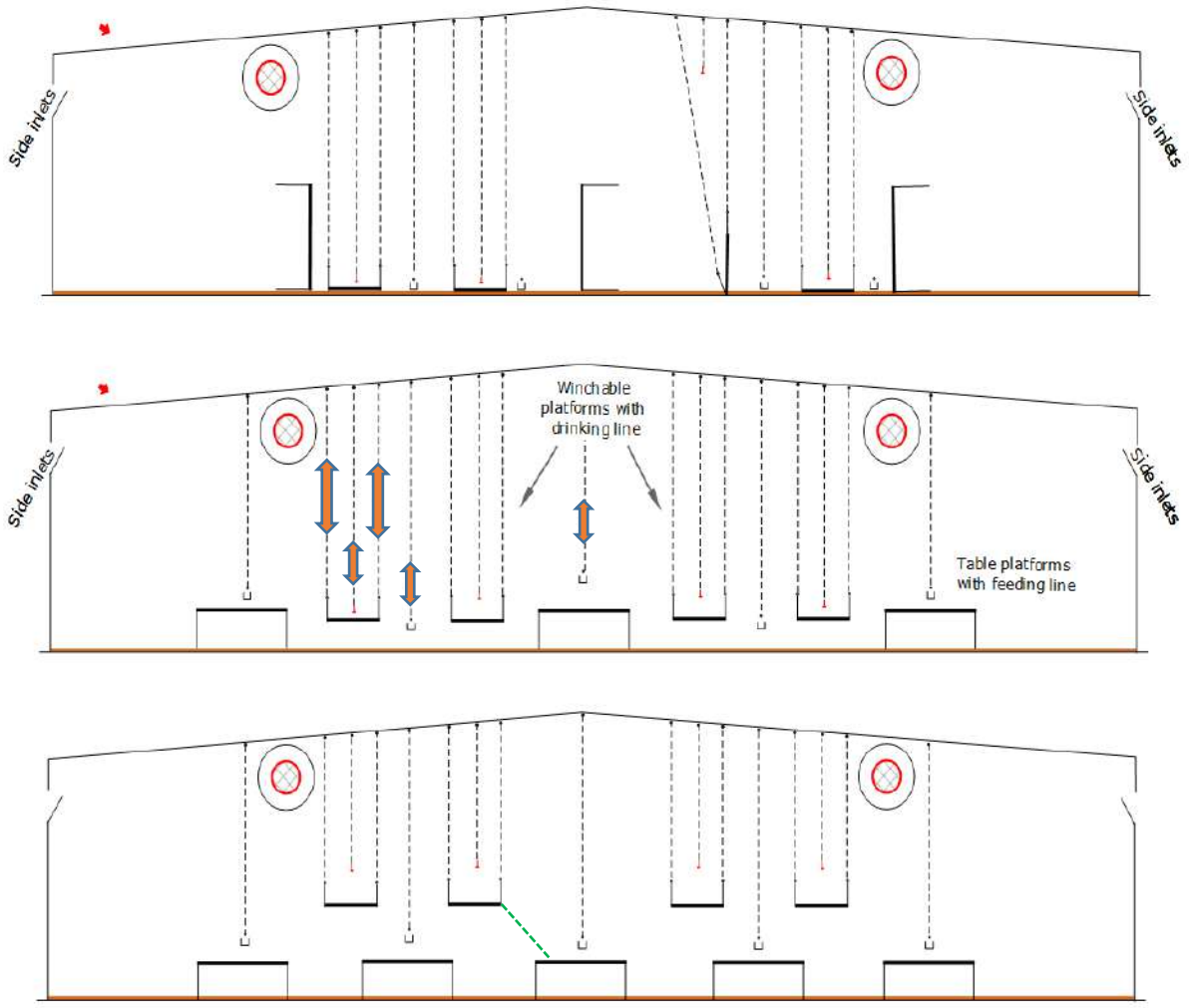


The principle of All-in-all-out systems with pullet rearing + egg production in one single facility is that pullets are reared in the same cage-free facility as where they will be kept as laying hens. The pullets (and later the laying hens) can freely move around the house. The litter area provides enough space, enrichments and substrates for foraging, dustbathing, and other behavior. The day-old-chicks start in the scratching are, hence feeders and drinkers are located in the scratching (litter) area. During the brooding period dark brooders, or other measures to ensure a brooding temperature of 32-34°C, should be implemented in the house. Once the pullets get older and stronger, they will go up to the slats and find additional feed and water. When all pullets are able to eat and drink on the slatted area, the feeding and drinking lines in scratching area are elevated. The drinking line may be lowered during difficult periods (e.g. after vaccination or during extreme warm conditions).

Furthermore, the nests should be closed and covered until the first eggs are being laid. Once the pullets reach adulthood and start to lay eggs the nests can be revealed, enabling the hens to lay their eggs in a safe, comfortable, and secluded nesting area.

An option is to provide a covered veranda to allow the hens more space in a surrounding area with more fresh air. See previous laying hen housing system designs for requirements during the production phase. Sections 2 and 3 of the Management Guide provides further information on equipment standards, management practices and other additional information.

2. Rearing system for pullets from DOC till 16-17 weeks of age



The principle of this rearing system for layer pullets is that pullet training occurs by winchable slats and/or table platforms that are raised as pullets grow, e.g. slats raised 10 cm after 10 days. By providing feed and water on these raised surfaces pullets are trained to seek water at higher levels, become stronger, more robust and become better in navigation and orientation skills. Utilization of slats and platforms increases useable surface. Section 2 of the Management Guide provides further information on the rearing and training of cage-free pullets.

Stocking density per ***useable surface*** (platforms increase useable surface available):

- 0-2 weeks: 20-25 hens/m^2
- 2-5 weeks: 15 birds/m^2
- 5 wks and older: 10 birds/m^2

Further

- DOC can be enclosed in smaller compartments at the start (top figure)
- Heaters are needed to create a constant 35^{O}C during brooding
- Side inlets are needed for proper minimal ventilation at start (tunnel ventilation is not suitable for young chicks!)
- Chick paper with feed should be placed near the feeders and drinkers

- See Management Guide (section 2.11) for light program
- Feeders, drinkers, slats and perches should be of the same material as in the hen production facility
- A-frames with perches can be added to create additional perching space
- Width of raised slats with water approx. 50cm
- Width feeder platforms feeders 75-100 cm
- Height feeder platforms 50-70 cm
- Ramps aid weaker pullets to go up
- Covered veranda is optional

Appendix 2. Example of a daily inspection sheet of welfare indicators – rearing

Animal welfare indicator	**Select the appropriate box**		
Plumage condition neck, back, rump and vent area week 4, 12 and 16	No feather damage or hardly any feather damage (no bald patches)	Some feather damage (bald patches, <50% body area)	Severe feather damage (bald patches, >50% body area)
Skin condition back, wings, rump, cloaca and toes, week 4, 12 and 16	No wounds or lesions	Some evidence of wounds and/or lesions (<50% of the body area)	Severe wounds and/or lesions (>50% of the body area)
Nutritional status week 4, 8 and 16	Body weight according to breeder guide Feed intake normal	Body weight slightly too low (<20% under) Feed intake too low	Body weight significantly too low (>20% under) Feed intake too low
Animal losses daily	No mortality	Low mortality (cumulative mortality < 5%)	High mortality (cumulative mortality > 5%)
Use of veterinary medicinal products daily	No veterinary treatment	Veterinary treatment according to standard (dosages/animal/day)	Veterinary treatment higher than standard (dosages/animal/day)
Water intake / Heat stress daily	Normal water consumption No Signs of panting / water spillage	Water consumption slightly deviates from normal Signs of panting / water spillage	Water consumption strongly deviates from normal Signs of panting / water spillage
Fearfulness Excessive withdrawal from personnel Panic reactions (piling)	No withdrawal from personnel No panic reactions	Some withdrawal from personnel (<5 m) No panic reactions	Excessive withdrawal from personnel (>5 m) Panic reactions

Appendix 3. Example of a daily inspection sheet of welfare indicators – laying

Animal welfare indicator	**Select the appropriate box**		
Plumage condition neck, back, rump and vent area week 20, 30, 40, 50	No feather damage or hardly any feather damage (no bald patches)	Some feather damage (bald patches, <50% body area)	Severe feather damage (bald patches, >50% body area)
Skin condition back, wings, rump, cloaca and toes, week 20, 30, 40, 50	No wounds or lesions	Some evidence of wounds and/or lesions (<50% of the body area)	Severe wounds and/or lesions (>50% of the body area)
Nutritional status daily	Body weight according to breeder guide Feed intake normal	Body weight slightly too low (<20% under) Feed intake too low	Body weight significantly too low (>20% under) Feed intake too low
Animal losses daily	No mortality	Low mortality (cumulative mortality < 5%)	High mortality (cumulative mortality > 5%)
Use of veterinary medicinal products daily	No veterinary treatment	Veterinary treatment according to standard (dosages/animal/day)	Veterinary treatment higher than standard (dosages/animal/day)
Water intake / Heat stress daily	Normal water consumption No Signs of panting / water spillage	Water consumption slightly deviates from normal Signs of panting / water spillage	Water consumption strongly deviates from normal Signs of panting / water spillage
Fearfulness Excessive withdrawal from personnel Panic reactions (piling)	No withdrawal from personnel No panic reaction	Some withdrawal from personnel (<5 m) No panic reactions	Excessive withdrawal from personnel (>5 m) Panic reactions