Management Guide
Parent Stock

HENDRIX GENETICS

Contents

Introduction

For many years Hendrix Genetics has been known to set the standard for sustainable animal breeding, including that of laying hens. Hendrix Genetics Layers delivers Parent Stock to their valued customers all over the globe. The layer breeds of Hendrix Genetics demonstrate an ever-increasing genetic potential, both in technical and economic performance. The full genetic potential of the parent stock flocks will only be achieved through good management and the know-how of experienced parent stock farm managers and hatchery managers. The performance of the parent stock flock is the combined result of the choice for the breed (the genetics) and the way they are kept and managed (the flock management).

This manual is a guide to general and specific rules as well as advice on keeping parent stock. The objective is to help parent stock keepers and hatcheries to achieve optimum results. The information and suggestions contained in this parent stock management guide should be used for educational and guidance purposes only. Local conditions may require specific adaptations of management practices to achieve optimal results with the parent stock flocks, therefore this guide cannot cover all possible circumstances. Please ensure that you are always compliant with your local/national animal welfare regulations.

We trust that this management guide, and the recommendations that are provided in this guide, will make a positive contribution to the continuous improvement in the performance of parent stock all over the globe. We hope that each reader will be able to find some useful information from this management guide. For more detailed and tailor-made advice, please contact your Hendrix Genetics representative.

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1 Biosecurity

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1.1 Introduction

Achieving good results with your parent stock flock depends highly on the health status of your birds. A good health status is very important for two main reasons: Healthy animals are more efficient producers, as disease costs energy that affects your profitability. Secondly, your goal of keeping parent stock is to produce safe and high-quality hatching eggs. The hatching eggs need to be safe, free from pathogens and any other contamination to encourage the development of the embryo into a first quality chick. Biosecurity programs are installed to maintain a good health status. Biosecurity is the key to prevention of disease, together and in cooperation with custom made vaccination programs and disease eradication programs. Any national and local legislation, regulations and environmental restrictions must be followed. Prevention is always better and cheaper than cure.

In order to implement a biosecurity program, you need to understand what Biosecurity is about:

- Biosecurity is the prevention of introducing disease
- Biosecurity means minimizing the risk of entrance of pathogens onto a farm and into a house (flock)
- Biosecurity is the exclusion, eradication, or effective management of risks
- Biosecurity is recognizing risks and acting accordingly
- Disease can be airborne over a limited distance
- Disease can come along with the introduction of contaminated birds (direct contact)
- Disease can be introduced, attached to visitors/workers/rodents/flies/trucks/materials/feed/equipment (indirect contact)

The most important part of biosecurity programs often is changing the way of thinking about what is clean and what is dirty – and acting accordingly. An understanding of the reasons why you implement certain biosecurity measures on a farm can help significantly in persuading staff to behave according to these rules. Biosecurity measurements must be simple, easy to understand, agreed upon, and monitored.

Biosecurity is the cheapest, most effective means of disease control. The difficulty is not to implement a biosecurity program but to maintain it!

1.2 Housing

Ideally, your breeder rearing and laying farms are located well away from other poultry houses and be managed under "all-in-all-out" principles, to prevent contamination between flocks of different ages. Whatever the building style, houses should be constructed in such a way that they can be easily and thoroughly cleaned and disinfected, in between flocks. In cold and temperate climates, the walls and roofs should contain insulation with a moisture barrier and rodent proof materials. Ceiling height should be adequate for proper ventilation. Equipment used in the house should be designed for easy access and removal for clean-out, maintenance, and biosecurity considerations.

Make a strict separation between the outside and the inside of the farm premises. Install fences and facilitate the clean road / dirty road principle for the delivery of feed and the removal of manure and dead birds. This will prevent indirect contact between birds of different farms/houses. Do not allow trucks and cars on the clean part of the premises. Also maintaining the strict separation between outside and inside of the houses is important. This can be implemented quite simply by changing clothes and footwear and washing + disinfection of hands before entering a poultry house. Ideally, equipment should be dedicated exclusively to one house and if the introduction of equipment or tools from another house is necessary, this should be carefully disinfected. The risk from vehicles entering the farms must be managed also. With electrically powered equipment, it is essential to use a reliable source of electrical power. In houses with a controlled environment, standby generators and power failure alarms are necessary.

Houses should be rodent and bird-proof to prevent disease transmission from wild birds. Every air inlet should be equipped with nets to prevent this risk. Bait stations should be placed inside and outside the houses to control rodent activity. They should be checked regularly (once a month) to refill them when necessary, and the frequency of inspection should be increased during outbreaks of rodent activity. Wild animals should not have access to feed and

water to prevent vermin. Keep insects under control, as insects can also be a source of contamination. Insect activity should be monitored to be able to apply appropriate treatments at the right time. Only insecticides permitted for use near animals should be used during the rearing and production periods. When you use insecticides, we strongly recommend the use inside the house just after depletion and a second treatment, just before the arrival of the replacement flock. Storage rooms, where material to be used in the poultry houses is stocked, must also be bird, rodent and fly free.

Feed can be a major risk factor for Salmonella contamination. Please make sure that also the drinking water is free from pathogens because drinking water can be contaminated with E. coli, yeast, molds, and even with Avian Influenza virus, when surface water is used.

1.3 Personnel and visitors

Visits should be strictly controlled, and visitors should confirm that they have had no recent contact with other birds for at least 48 hours (preferably 72 hours). This seems like a long period, but please keep in mind, you are dealing with precious (Grand) Parent Stock flocks. You should keep track of your visitors; you could do this via a visitor registration form (Appendix 1). Entry should be through a cloakroom with a full change of clothes and boots, and if possible, after taking a shower. Special care should be taken with boots, which should always be disinfected before entering the poultry houses. Cloakroom design should clearly show different areas with a dirty zone to remove "civilian" clothes, and a clean one, in which to put the farm clothes on.

To prevent cross contamination, do not allow farm employees to have poultry at home. Dedicated personnel for each flock are a must to reduce the risk of contamination from house to house. If this is not possible, visits should always be done in the order from younger to older flocks, and to finish with sick/affected flocks if there are any.

1.4 Monitor your flock

Please note:

- Foot baths with disinfectant or disinfected treated pads are hard to maintain and therefore often useless.
- At any time, animals like dogs and cats, but also other farm animals, should be kept out of the farm as they are potential transmitters of diseases that can affect your flock!
- You are dealing with high value (grand)parent stock flocks, their health status is directly linked to the profitability of your hatchery.

Poultry keeping is all about the chickens, they are the ones producing the hatching eggs. By monitoring the birds carefully, you can not only tell a lot about the health of your flock, but also about the quality of the housing and care. By having a close look on the flocks' production, health, and behavior, you should be able to understand your flock better.

What to check?
Beside checking the disease-free status of your flock, as this will inform you how effective your biosecurity program is, normal production parameters should be registered and monitored to detect any abnormalities (reduction of lay, feed consumption or bodyweight). Thus, you can take early corrective actions to solve any problem that might occur.

Overview of the main production parameters that need to be monitored

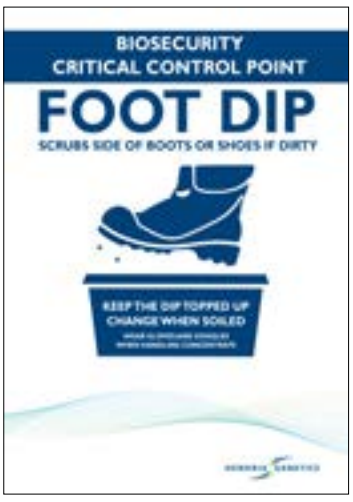
Traits	Optimal advanced practice
Feed consumption	Daily
Water consumption	Daily
Female Mortality	Daily
Male Mortality	Daily
Climate	Daily
Egg production	Daily
2nd grade eggs	Daily
Egg size	Daily
Fertility	Weekly from 25 weeks onwards
Hatchability	Weekly from 25 weeks onwards
Female bodyweight	Weekly till 30 weeks, monthly after 30 weeks of age
Male bodyweight	Weekly till 30 weeks, monthly after 30 weeks of age
Disease free status	Monthly

Dead chickens can be a source of bacteria multiplication: make sure you remove dead chickens daily. Dispose dead chickens in a hygienic way, e.g., do not store them inside the (grand) parent stock house.

Prevent access of rodents and insects to the dead birds as they can easily spread the pathogens. Register your mortality daily. By registering the mortalities and making it visual via a graph, you can better identify when your mortalities become too high. This allows you to act in time!

1.5 Clean up and disinfection

Bacteria and viruses can survive in environments for a long time. After flock depletion, houses must be cleaned and disinfected carefully, to prevent contamination with pathogens from the previous flock. The absence of stock permits unhindered access to all parts of the building and equipment, facilitating the terminal hygiene program of cleaning and disinfection. As soon as the stock have been depleted, work should commence. The sooner the program is completed, the greater the reduction in potential pathogens prior to restocking.



There are two basic tasks to be carried out:
1. Cleaning -the purpose is to remove organic matter and to make all surfaces visually clean.
2. Disinfection- the act of sanitizing the 'clean' surfaces.
3. Down time - the time the house is empty, very effective tool to kill pathogens

There are different suppliers of chemicals, and generally different products are needed for these two tasks, detergents are used for cleaning, and disinfectants for sanitizing. There are detergents available that also have some disinfecting properties, but make sure that you still apply a suitably formulated disinfectant to safeguard proper disinfection of the poultry house. In the following section we explain the different phases of a proper cleaning and disinfection program, step-by-step.

Stage 1 – removal

1. Livestock
2. Deadstock: dead birds and any carcasses
3. Feedstuffs: if you plan well, this can be minimized
4. Moveable equipment
5. Droppings and litter
6. Whilst the house is still warm it is recommended to treat for red mite/insects
7. Bait extensively for rodents

Stage 2 – preparatory

1. Drinking system – drain and refill with detergent solution
2. Soaking – all surfaces and equipment with detergent solution
3. Hand cleaning – any non-waterproof items

Stage 3 – washing

Pressure wash all surfaces with detergent solution. This should not be restricted to internal surfaces – concrete access areas, air inlets etc., should also be washed.

Stage 4 – re-assembly

Re-instate cleaned moveable equipment into the poultry house when dry.

Stage 5 – disinfection

Spray all previously washed surfaces of building and equipment with disinfectant solution. Water lines must be cleaned first with an alkaline based detergent and after, an acid-based detergent and then flushed out thoroughly. Afterwards spray all surfaces (especially nests and slats) with appropriate chemicals for insect and mite control.

Stage 6 – fumigation

Close the building before atmospheric fogging with formalin or a suitable disinfectant.

Stage 7 – sanitary break period

The building should be kept empty for at least 2 weeks. If maintenance work is to be carried out, normal biosecurity precautions should be observed and repeat stages 5 and 6 before the new flock arrives.

Stage 8 – preparation for the arrival of new stock

1. Check the proper functioning of all equipment
2. Supply the drinking system with fresh water
3. The feeders should remain empty
4. Depending on the time of the year and the flock (day old chicks), the building should be heated

2 Drinking Water Quality

2 Drinking Water Quality

2.1 Introduction

Often neglected as a source of nutrients, but water is a very important nutrient for the (grand)parent stock flocks. Besides, water can also be used as a carrier for vaccines and antibiotics/chemotherapeutics. But on the other hand, it can also be an important source of pathogens!

Good quality drinking water is clean, clear, fresh, tasteless, and free from contaminants. The birds can easily find, reach, and drink it, and they can drink as much as they need. Other salient points are the source of the water and the type of drinking water system used in the houses (storage vessels, pipelines, drinkers).

Ask yourself the following questions: what is the source of the drinking water? Is piped water used or water from a borehole? Is surface water used? Is the quality of the water checked before use, or is it treated in any way? Piped water system is normally a safe source. Borehole water sometimes needs some treatments to make it suitable for drinking. The quality of borehole water should always be checked on a regular basis, at least once every year.

Once the source has been checked, look at the quality of the water at the point of delivery to the chickens, at the end of the line, directly from the nipples or drinkers. The water quality also depends on the hygiene of the water system. The water system in the houses should be regularly cleaned and disinfected. It should always be disinfected in-between flocks and after water treatments. To keep the water system clean in longer production periods, check the water system regularly and if needed, also clean during production. The frequency of checking should be at least once every 3 months.

If the system is disinfected during the production cycle, care should be taken to follow the sanitizer manufacturer's instructions. Especially regarding adequate flushing and correct dosing. Make sure the water system is closed and cannot be contaminated from the outside. Pay extra attention to storage vessels, when used.

Surface water should never be used as a source for drinking water, because of the risk of contamination with bird pathogens. Waterfowl travel freely over the globe, carrying diseases with them (i.e. avian influenza) and dropping large amounts of contaminated droppings on their resting places along their way.

2.2 Water quality parameters

Parameter	Good Quality	Do not use
pH	5 - 8	<4 and >9
Ammonium mg/l	<1.0	>2.0
Nitrite mg/l	<1.0	>1.0
Nitrate mg/l	<100	>200
Chloride mg/l	<200	>300
Sodium mg/l	<100	>200[1] >400[2]
Sulfate mg/l	<100	>250
Iron mg/l	<0.5	>1.0
Manganese mg/l	<0.5	>1.0
Hardness in German degrees	>4 <15	>20
Oxidizable organic matter mg/l	<50	>200
H2S	Non detectable	Non detectable
Coliform bacteria's cfu/ml	<10	>100
Total germ count cfu/ml	<10.000	>100.000

[1]for (grand)parent stock under 20 weeks of age
[2]for (grand)parent stock under 20 weeks of age

In general, a good cleaning of the entire drinking system in the empty period should be sufficient for the whole 16 weeks rearing period and the rearing birds should get the chance to build up some immunity against normal environmental bacteria like E. coli. Semi-continuous use of water sanitizers can interfere with this.

Different products can be used for cleaning the system, both in-between flocks, when the houses are cleaned and disinfected, and during rearing or production. These products can contain (combinations of) acetic acid and hydrogen peroxide, chlorine, organic acids, and inorganic acids. Be careful of the percentages used when using these products in drinking water. Also be careful with the taste and with the acidity of the water. Using acids, pH should be below 4, to achieve the disinfecting effect and above 3.5, otherwise it becomes corrosive, and the birds stop drinking. High levels of chlorine have the same effect on the birds. To have an efficient disinfection with chlorine, decrease the PH.

There must be no organic matter in the water, and a low iron and manganese concentration: if these conditions are not met, a proper water disinfection with chloride is not efficient. Using only organic acids as a water sanitizer for a longer period can be dangerous. You can see growth of yeasts and molt in the water. It is better to use acids and chlorine alternatively.

Once the water supply is clean, you need to check the following:
- Can all the chickens easily find and drink the water?
- For day-old chicks, is there enough light to find the water from the start?
- Is the water fresh? Has the system been flushed shortly before the delivery of the day-old chicks?
- Is the height of the drinkers correct? Adjust it over time as the chicks will grow, make sure that you check that both the males and females can drink easily!
- Is the system of drinkers used the same in the different phases of production: rearing versus lay?
- Are bell drinkers used or nipple drinkers, what was used in rearing?
- What kind of nipples?
- Can the small birds easily activate the nipples?
- What is the nipple flow rate?
- Are there enough drinkers/nipples per bird installed? Always prevent competition around drinkers!
- What is the water pressure?

Water is a very important nutrient, but it is also used as a carrier for drinking water vaccinations and for all kinds of in-water treatments. This means that the water quality must also be suitable for that. For (modified) live vaccines, no traces of disinfectants should be in the water during vaccinations. The solubility of some antibiotics and chemotherapeutics depends highly on the pH of the water and can be influenced by the presence of minerals. Together with these minerals, additives can form a biofilm inside the water tubes. Large amounts of bacteria can bind on this biofilm. This is the reason why the water system must always be cleaned after in-water treatments.

All the chickens, at all ages, must always have easy access to good quality drinking water. The quality of the drinking water should be regularly checked, and contaminated drinking water can cause serious disease problems. When chickens don't drink, they won't eat and cannot grow or (re)produce!

3 General management during the brooding period

3 General management during the brooding period

3.1 Introduction

The brooding period (the first 5 weeks of life) is of major importance for the performance of the (grand)parent stock flock later in life. The (re)productivity of the (grand)parent stock depends to a large extent on the successful attainment of bodyweight targets from an early age.

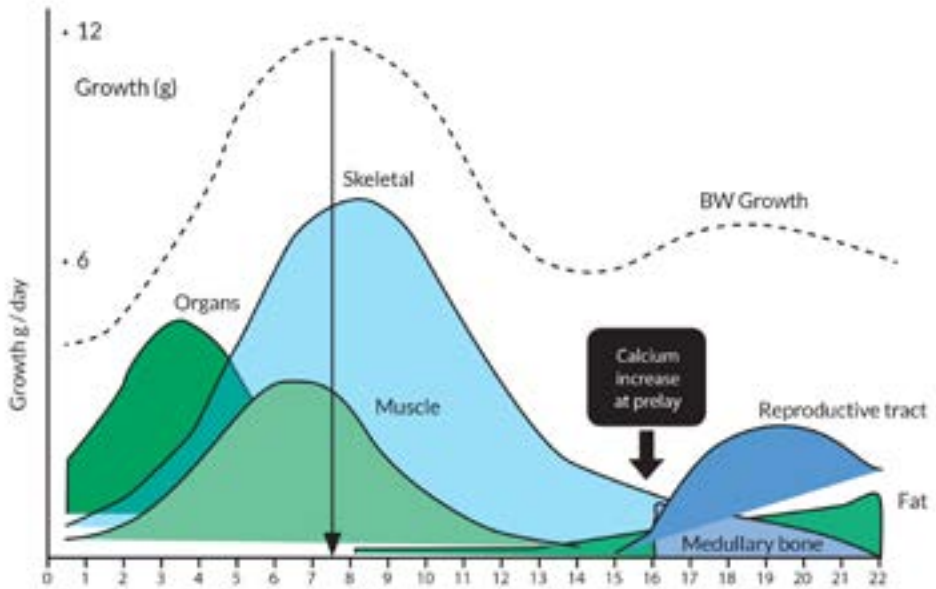
The objectives during the brooding period are:
- Rapid growth to reach body weight target at 5 weeks of age
- Good uniformity from the beginning
- Excellent livability

From day old to transfer, the chicks will grow slowly, and organ development occurs at various ages. A lack of growth during any of the development stages could have a detrimental impact on the parent stock quality, this accounts for both the males and the females. Any delay in growth at 4-5 weeks will be reflected in a reduction in bodyweight at 16 weeks and then in (re)productive performance, particularly in mean egg weight and overall fertility. Development of males and females should match at any stage in rearing, so they reach sexual maturity at the same time. Two birds with the same bodyweight haven't necessarily developed the same body composition. Good growth curves lead to good parent stock development.

Growth is split in the following stages:
- The first 3 weeks are devoted to the development of the organs and the immune system.
- From week 3 to week 6, skeleton and muscles are growing. Bodyweight at 5/6 weeks is the most important determinant of parent stock quality. Any delay in growth at this stage is harmful to the birds, as it will have a detrimental impact on parent stock quality and body composition, which will in return impact negatively the birds' performance.
- From week 6 to week 15 growth is starting to slow down.
- The final stage is characterized by ovary and testis development and rapid growth of these organs. Sexual hormonal regulation takes place around 18 weeks and leads to sexual maturity around this age.

At all stages flock uniformity needs to be reviewed. The objective is to have a very high uniformity in order to facilitate flock management and stimulation. Low uniformity leads to poor (re)productive performance! The number of feeders and drinkers, feed distribution, the presentation of the feed and the farmers' management are strong contributors to ensure uniformity of both males and females. Heterogeneity at early age has a negative impact on uniformity during transfer.

Bodyweight development



3.2 Equipment and Environment

The recommended standards set out in this section have been proven to give excellent performance in the production stages. At all times: check your regional/national legal requirements.

		Floor		Cages	
		0 - 2 Weeks	2 - 5 Weeks	0 - 3 Weeks	3 - 5 Weeks
Ventilation	Minimum ventilation rate	0.7 m³/hour/kg	0.7 m³/hour/kg	0.7 m³/hour/kg	0.7 m³/hour/kg
	Required capacity of the	4 m³/hour/kg	4 m³/hour/kg	4 m³/hour/kg	4 m³/hour/kg
Stocking densities	Birds/m	20	12	80	45
	Cm bird			125	220
Water supply	Chicks/Chick drinker	75		80	
	Birds/drinker	75	75		
	Birds/nipple	10	10	10	10
Feed supply*	Birds/starting pan	50			
	Cm of chain feeders	4	5	2.5	5
	Birds/round feeder	38 - 63	38 - 63		

*To calculate feeder space availability when chain feeders are used, both sides of the trough should be taken into account.
When round feeders are used, calculate pan circumference based on diameter to get at least 50% (2.5 cm) of the recommended feeder space for the chain feeder.

Pan diameter per number of birds

Pan diameter	Number of birds/feeder (max)
30	38
40	50
50	63

Respecting recommended stocking densities and available equipment is essential for successful rearing of breeder flocks. Rearing at high stocking density or reduced feed and drinker space will:

- Negatively affect growth and uniformity of both the males and females
- Increase the potential for disease challenges
- Negatively impact litter quality
- Induce aggressive behavior

3.3 Preparing for Chick arrival

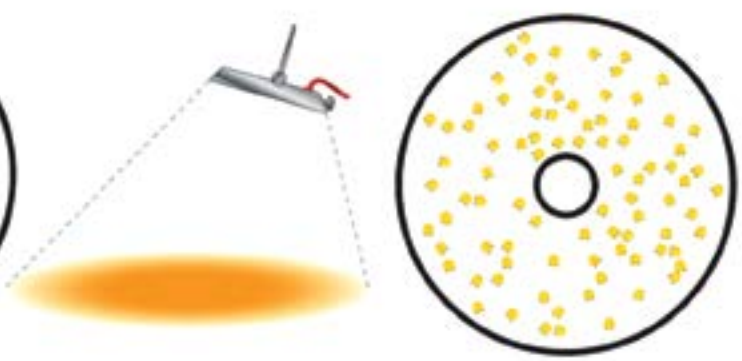
The success of brooding depends a lot on a good start for the chicks. Most of the (grand) parent stock flocks travel for quite some time, and they are looking for a safe place that provides them with water, feed, a comfortable environment, and a good place to rest. We have listed here the key points:

- The houses have been cleaned, disinfected and are empty for at least 14 days. The houses and its content should be dry before the new chicks come in.
- Start the heating system 24 to 36 hours before the chicks arrive (depending on the local climatic conditions). The brooder area and litter area should be warm enough with a constant temperature in the range of 33 – 35°C when the chicks arrive.
- Flush water lines prior to arrival of the chicks, and make sure that no disinfectant is left in the water lines when the chicks arrive.
- Make sure that the nipples and round drinkers are at the correct height: nipples should be at eye level of the chicks and round drinkers placed on the floor.

- Whatever drinking system is in use check whether the water supply is sufficient. When nipples are used, adjust the water pressure so that the chicks can see the water drop on the nipple and the water flows easily, at the lightest touch.
- If the chicks have been infrared beak treated in the hatchery, it is very important to use sideways activated nipples (360°) or nipple drinkers with cups and to use supplementary starting mini drinkers.
- Put paper under the nipples to attract the chicks and put extra feed on the paper or in cardboard trays.
- Check that all the birds, even the smaller ones, have access to feed and water.
- After a long transport duration, it is useful to wait for 3 to 4 hours before distributing feed, to make sure chicks first drink enough water to restore their body fluid.
- During the first 2 days use tepid water at 25°C to 30°C.
- In hot conditions, be careful not to let the water temperature increase too much, as this may reduce the feed intake of the chicks. Regularly flush the water lines to maintain the temperature.
- The removal of the supplementary starter drinkers should be done gradually, making sure that the chicks have acquired the habit of using the other drinkers.
- Monitor and register the water consumption daily.
- To maintain litter quality, it is necessary to avoid water spillage, by carefully regulating the drinkers or the nipples.
- The drinkers should be always kept clean. For the first 2 weeks, they should be cleaned at least daily.

Recommended layout for 500 chicks

Radiant heater position and ground temperature



- radiant heater of 1450 Kcal capacity
- 5 drinkers (7 for hot climates)
- 10 feed trays
- 75-Watt bulb at 1.5 meter above floor level
- surround: 4m diameter – 0.6m high

Key points:
- Make sure that all the birds have access to at least 2 nipples.
- Place feed under the nipples and close to the automatic feeder to attract the chicks.
- Start placing the chicks in the warmest and brightest area.
- Make sure environmental conditions (temperature, ventilation, light) are uniform throughout the house.
- Check the functioning of the nipples prior to the arrival of the flock.

A practical system to check if chicks have found feed and water is assessing crop fill: take a sample of 30 to 40 chicks from different places in the rearing house and check if the crop is full, soft, and rounded. Start 2 hours after placement and assess crop fill several times during the first 24 hours. Target is:

- 8 h after placement: > 80 % full crops
- 12 h after placement: > 85 % full crops
- 24 h after placement: > 95 % full crops

If the target is not achieved, check brooding conditions, and take corrective actions. Early feeding is key for growth and development of gastrointestinal tract and other internal organs and for proper yolk absorption.

Keep in mind that during the first few days, the chicks must rely on the temperature that we maintain before their own thermoregulation starts to work properly. To ensure that the equipment and the litter are warm for chick arrival, we advise starting to raise the house temperature at least 36 hours before chick arrival so that the air temperature reaches 33 to 35°C when the chicks arrive. The concrete floor must be at 28°C and the litter at 30°C.

The best way to check if the house temperature is correct during the first days after arrival is to measure the cloacal temperature of the chicks (40°C). We recommend taking the temperature of at least 20 chicks throughout the house to get a good indication of the situation. Day old chicks cannot regulate their own body temperature, so they depend on ambient conditions. Be aware that chick body temperature reacts quickly after ambient conditions have been changed.

Find the correct set point for house air temperature by managing the body temperature of the chicks. Start checking the body temperature of the chicks every hour after placement. Keep checking body temperatures until the correct temperatures have been achieved and the situation is stabilized.

At day 5 the chicks will normally be able to keep up their own body temperature (within limits) and a rise in body temperature will automatically follow to about 41°C. From there on, set point for house air temperature can be gradually reduced to reach around 20°C at 5 weeks of age (e.g. 0.5°C per day). Temperature standards are given on the next page. But again, the observation of the flock is the best indicator of the real needs of the chicks.

Measuring litter temperature

Measuring chick body temperature

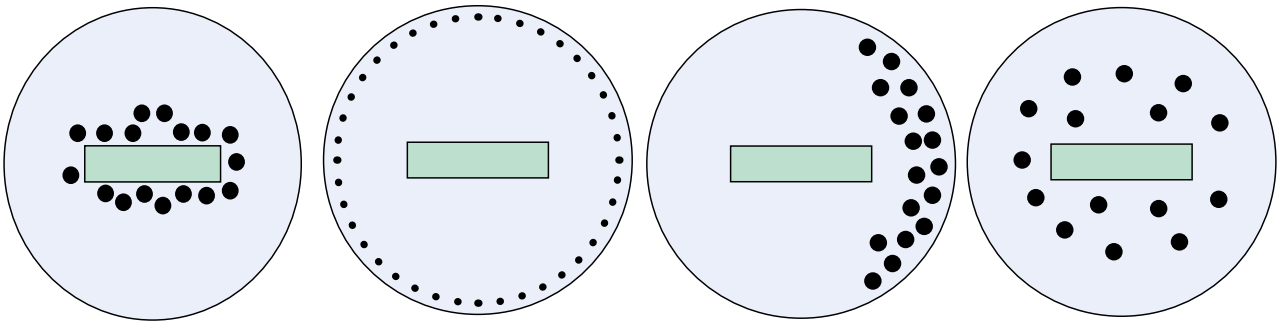
Standards for temperature and humidity

Age (days)	Brooding temperature		Room Temperature	Relative Humidity
	At the edge of the brooders	At 2m from the brooders		Optimum-Maximum in %
0 – 3	35°C	29 – 28°C	35 – 33°C	55 – 60 %
4 – 7	34°C	28 – 27°C	32 – 31°C	55 – 60 %
8 – 14	32°C	27 – 26°C	30 – 28°C	55 – 60 %
15 – 21	29°C	26 – 25°C	28 – 26°C	55 – 60 %
22 – 24		25 – 23°C	25 – 23°C	55 – 65 %
25 – 28		23 – 21°C	23 – 21°C	55 – 65 %
29 – 35		21 – 19°C	21 – 19°C	60 – 70 %
After 35		19 – 17°C	19 – 17°C	60 – 70 %

This table should be used as a guide, but temperatures can be adjusted according to the behavior and distribution of chicks:

- If the chicks crowd together under the brooder, the temperature is too low.
- If the chicks are close to the surround, inactive, lethargic and spreading away from the heat source, the temperature is too high.

Distribution behavior according to temperature



Too cold *Too warm* *Draught* *Ideal*

Key points:

- Chicks should be unloaded immediately after arriving. Avoid dehydration due to exposure to high temperatures especially when they stay too long in the chick transportation boxes.
- Observation of the flock is the best indicator of real needs!
- For the first week confine chicks to floor brooder areas and prevent air drafts.
- Temperature and relative humidity should be uniform throughout the building.
- Changes in temperature should be carried out gradually.
- Some ventilation is necessary during the first weeks to provide enough oxygen and to eliminate carbon dioxide, water vapor, ammonia as well as carbon monoxide from combustion. Maximum levels not to be exceeded are:
  - CO2: maximum 2500 ppm
  - CO: < 10 ppm
  - NH3: maximum 20 ppm

3.4 Lighting program

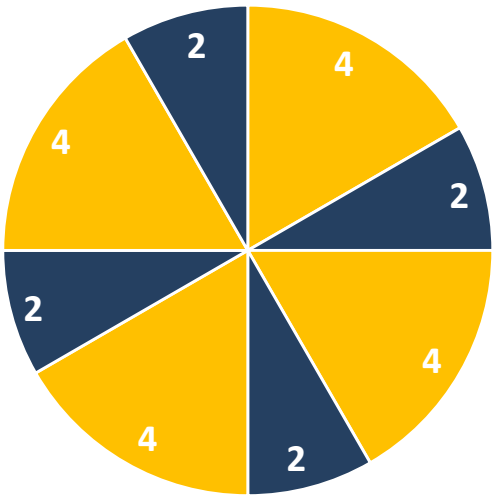
During the first few days, it is important to keep the chicks under a maximum light regime (22 to 23 hours) with a high intensity (30-40 lux) to encourage the intake of water and feed and the activity of the chicks. After the first few days the light intensity could be gradually reduced. Light intensity will also depend on bird behavior.

Lighting program in brooding according to age and rearing house system

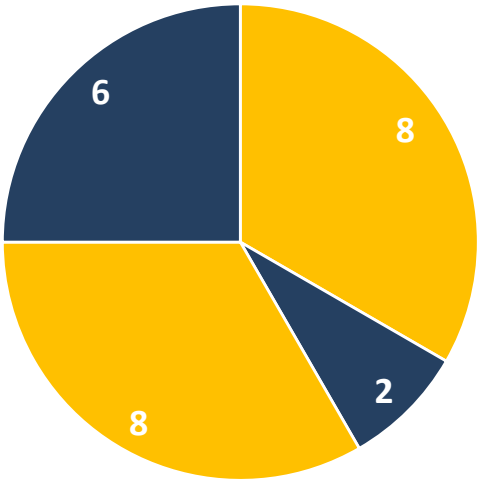
	Rearing in dark or semi-dark house		Rearing in hot climate (open houses)	
	Light duration	Light intensity	Light duration	Light intensity
1 – 3 days	22 hours	20 – 40 lux	24 - 23 hours	40 lux
4 – 7 days	20 hours	15 – 30 lux	22 hours	40 lux
8 – 14 days	19 hours	10 – 20 lux	20 hours	40 lux
15 – 21 days	18 hours	5 – 10 lux	19 hours	40 lux
22 – 28 days	17 hours	5 – 10 lux	18 hours	40 lux
29 – 35 days	16 hours	5 – 10 lux	17 hours	40 lux

Alternatively, after arrival of the chicks an intermittent program could be applied for the first 2 weeks. This program consists of 4 hours of light/2 hours of dark repeated 4 times to equal 24 hours for the first week (stage 1), followed by a transitional program on the second week (8 hours light/2 hours dark/8 hours light/6 hours dark) (stage 2) and then switch to the regular step-down program, which is 18 hours of light on the third week (stage 3). This program allows rest periods to chicks and synchronizes their activity, which has a positive effect on feed and water consumption, makes easier monitoring the flock behavior and contributes to reduction of early mortality. This program can only be implemented if it is compatible with local regulations.

Stage 1: Intermittent Lighting Program



Stage 2: Transitional Lighting Program



4 General management during the growing period

4 General management during the growing period

4.1 Building the potential

After a good start during the growing period, the objective is to ensure the full development of the (grand)parent stock flock so that they reach their potential for (re)production later in life.

The objectives during the growing period are:
- To achieve the recommended weight at 5% production.
- To establish a good feeding behavior pattern.
- To develop the digestive tract (crop and gizzard).
- To obtain a good uniformity of at least 80%.

These objectives can be achieved by:
- A correct stocking density and housing conditions.
- A lighting program adapted to the rearing conditions.
- A good standard of beak treatment (when local legislation allows the application of beak treatment).
- A good management of the feeding program and feeding techniques.

4.2 Housing and equipment

Recommended equipment requirements for the rearing period (6 - 17weeks)

		Floor 6 – 17 weeks	Cage 6 – 17 weeks
Ventilation	Minimum ventilation rate	0.7 m³/hour/kg	0.7 m³/hour/kg
	Required capacity of the system	4 m³/hour/kg	4 m³/hour/kg
Perches	Depending on the stocking density	5-10 cm / bird	
Stocking densities*	Birds/m² Birds/m2 (hot climate)	10 8	28 -
	cm²/ bird		350
Cage height			60 cm
Water supply	Birds/drinker	100	100
	Birds/nipple (hot climate)	75	
	Birds/nipple	9	9**
Feed supply***	cm through feeders/bird	8	6
	Birds/round feeder	24-39	

*Make sure that all the birds have access to at least 2 nipples
**If males are reared separated, increase floor/cage space by 25% for the males
***To calculate the feeder space availability when chain feeders are used, both sides of the trough should be accounted if these are accessible. When round feeders are used, calculate the pan circumference based on diameter to get at least 50% of (4cm) of the recommended feeder space for chain feeder (see table below that of equipment of starting period).

Drinking nipples should assure a water flow of 30 to 90 ml of water per minute. The required water flow rate depends on the presence of cups (60-90 ml/minute) or without cups (30-50 ml/minute).

Note: the water flow rate in nipple systems depends on the type of drinking nipple system and therefore the supplier should provide the system specific values.

We recommend using a feeding system which distributes feed rapidly throughout the house and enables the birds to finish all the feed distributed in the middle of each day. This encourages the birds' intake capacity and avoids fine particle accumulation. We consider the feed troughs with rapid chains as the best option, with the easiest feed intake control. If pan or tube feeders are used, they should be adapted specifically for this technique.

4.3 Feeding Program

The diet for the rearing period must be adapted to the actual evolution of the frame and bodyweight. Although males and females have a different body weight development, they are often reared together and therefore having the same feed composition. The following diets are identified for the different growth phases:

- Starter diet is recommended from one-day old to 4 weeks old. This can be extended up to 5 or 6 weeks to secure frame development in case the body weight is below the standard. Frame development occurs for the large part during the first 8 weeks of the rearing period.
- Grower diet is recommended from 4 weeks old to 10 weeks old and can be extended up to 11 or 12 weeks old, to secure growth. As the rearing period objective is also to develop the digestive tract and this grower diet is high in energy content, it should not be given after 12 weeks old. The risk being to reduce the development of the digestive tract and feed intake at the start of lay because of using feed with too high energy content.
- The distribution of a developer diet up to 16 weeks will help the development of the crop and gizzard capacity thanks to a lower energy level than grower feed, and slightly lower than the pre-lay or layer feed.
- To secure the development of the medullary bone which acts as a reservoir of calcium used for shell formation, we advise the use of a pre-lay feed for the two weeks before 2% production.

The detailed specifications for each of these diets are explained in a separate chapter on nutrition.

4.4 Feeding Technique

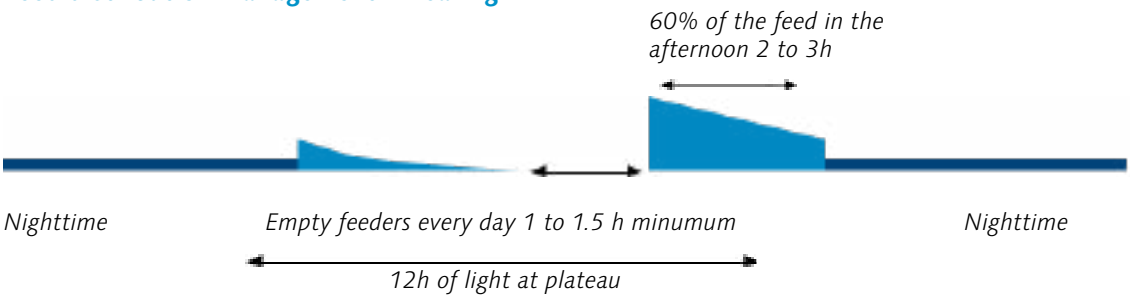
The feeding techniques used between 5 and 16 weeks are designed to:

- Avoid the build-up of fine particles.
- Encourage crop development through rapid feed intake.

Chickens are grain eaters by nature, with a strong preference for coarse particles. Fine particles are more difficult for birds to eat; therefore, they spend more energy for the same quantity consumed. The accumulation of fine particles in the feeding system leads to under-consumption. To avoid such situation and to ensure that the birds eat all the necessary elements of the diet, it is essential that the feeders are emptied every day from around week 5 of age onwards. This rule applies equally to the birds in rearing and during the (re)productive life.

Feed management in rearing has an impact on feed consumption later in production. The idea is to develop the digestive tract during the rearing phase and to prepare the birds to eat enough during the laying phase, especially immediately after transfer, when feed intake should increase sharply in just a few weeks. The crop is the bird's feed storage organ. It allows the bird to eat enough feed in the evening to satisfy its energy needs throughout the night. A rapid feed consumption during rearing leads to a better crop development. Therefore, feed consumption during the rearing period needs to be fast enough and eating speed will depend mainly on feeding times and feed texture. Since chickens naturally eat earlier in the morning and in the evening, it is important to take advantage of this natural behavior and get empty feeders in the middle of the day.

Feed distribution management in rearing



To encourage a rapid consumption, we recommend that the complete daily ration is given about 2 to 3 hours before "lights off". At "lights on", because the digestive system is empty, the birds will eat finer particles. If the feeding system does not allow the entire daily ration to be given in one distribution, distribute 60% of the daily ration in the early afternoon and the 40% in the morning at "lights on". This feeding routine can be started between 4 and 8 weeks according to the feeding equipment in use. The length of time, during which the feeders are empty, should be gradually increased, so that by around 10-12 weeks of age the feeders are empty for a minimum of 2 to 3 hours per day. It is however possible to give two distributions in the afternoon, provided that the feeding periods are kept short. It is recommended that the feed used during the rearing period is presented in the form of coarse particles, as this helps the overall development of the gizzard.

4.5 Insoluble Grit

We recommend the distribution of grit for the chickens already during the rearing period. The grit must be coarse and insoluble to develop the crop and gizzard. The effect of this action on the digestive tract will promote a good feed intake, which will be beneficial at start of lay. Grit can be provided in a round feeder or spread on the floor by hand. The birds will scratch the floor and look for the grit. This will also contribute to improve litter quality by aerating it. In addition, grit provides distraction in the flock, so it can reduce the aggression and improve feathering.

Supplying insoluble grit is beneficial for a gizzard development:

- From 3 to 10 weeks of age: 3g per bird per week (particle size 2 to 3mm).
- After 10 weeks: 4 to 5g per bird per week (particle size 3 to 5mm).

It is also possible, from 10 weeks onwards, to use 50% of the calcium in the diet supplied in coarse particle form (particle size between 2 and 4mm) to encourage gizzard development.

4.6 Monitoring development

Weekly measurement of growth is a must to check the actual development of the flock. Early detection of abnormal weight gain is of extreme importance to determine what corrective actions must be taken. Late attempts to correct low bodyweight are not efficient at improving body composition and frame size. In addition to this, monitoring of body weight is essential to calculate the appropriate quantity of feed to be issued, as requirements vary according to the energy level of the diet as well as the house temperature and the health status of the flock.

Besides the average body weight of the flock, it is also important to calculate its uniformity. The objective is to have a high uniformity to ensure an even response across the flock to management techniques, treatments and especially to light stimulation. If all the birds have a uniform development, they will react as one and it will be easier to manage the flock. Note: the water flow rate in nipple systems depends on the type of drinking nipple system and therefore the supplier should provide the system specific values.

Method of weighing control:

- Weighing time should be fixed, preferably in the afternoon.
- We advise carrying out individual weighing and using histogram type weighing sheets (see the chart on the next page) which shows immediately the weight distribution within the population.
- A sample of a minimum of 100 birds should be taken to obtain a good estimate of mean bodyweight and uniformity. However, if the flock is divided into separate pens, it is necessary to take a sample of 60 birds from each pen and then to calculate the overall mean.
- When rearing in cages, weigh all the birds from 5-6 cages chosen at random in different parts of the poultry house, to make up a sample.
- Weigh both the males and females, and record their weights separately, this will allow you to monitor the development of both sexes. As the size of the male flocks is lower to those of the females, you can take a smaller sample size for the males (about 15-20% of your recommended female sample size).

The most important factor in judging the quality of a flock is its uniformity. A batch is uniform when at least 80% of the weights lie within a range of ± 10% of the mean. Using modern weighing devices, it is also possible to obtain the coefficient of variation (CV), which is the ratio of standard deviation to the mean of the population expressed in %. A CV below 8% is good.

If uniformity/CV % is outside the target range, it is necessary to identify the causes and to check:

- Feeder space and position
- Speed of the feed chain
- Quality of beak treatment
- Vaccination status
- Disease and parasitism
- Housing density

Depending on the conclusions, management should be adapted to improve uniformity.

4.7 Example of a Body weight recording chart

Grams	No. Birds	10	15	20	25	Rearer
600						
20						Rearing
40						Actual
60						Mean WL
80						792
700	x x x x x					Target
20	x x x x x x x x					Weight
40	x x x x x x x x x x x x x x					790
60	x x x x x x x x x x x x x x x x x x x x					Grams
80	x x x x x x x x x x x x x x					Over/(under)
800	x x x x x x x x x x x x x x x x					2
20	x x x x x x x x x x x x x x x x					% evenness
40	x x x x x x x x x					. + or - 10 %
60	x x x x x					86,21
80	x x x x					. + or - 10 %
900	x x x					
20	x x x x					
40						St. Dev
60						53,65
80						cv %
1000						6,8

Time of Weighing a.m. / p.m. Weighed by:

Comments _____

_____

5 Lighting Programs

5 Lighting Programs for Parent Stock

5.1 Introduction

Lighting can make a big difference in each poultry house. Every type of poultry has its own needs when it comes to the optimal light climate. For layer breeders, lighting can be of great importance. Lighting can optimize breeder sight, which enables them to feel and eventually perform better. In this way, the chickens experience less stress, improve their feed conversion rate (FCR) and more. When the different aspects of light are on point, they are able to directly influence parent stock welfare and performances as well. More eggs, a higher hatchability, less stress, improved chick weight and other benefits can be the direct result. More research became available that's shows that an optimal light climate improves the parent stock's offspring's well-being and performances as well!

An optimal parent stock light climate responsibly improves overall farm performances:

- Plays a key role for layer breeders
- Optimizes sight for both males and females
- Increases well-being: improved behavior of both males and females, lower stress levels
- Benefits the parent stock's offspring
- Improves performances: more eggs laid in the nests, cleaner eggs, higher hatchability, etc.
- Improves over breeder farm performances in a responsible way

Young parent stock flocks are sensitive to changes in the lighting regime, and these will influence the age of sexual maturity for both males and females. In addition, feed consumption is greatly influenced by the duration of day length. During rearing, the main objectives of lighting programs are encouraging growth and controlling the birds' sexual maturity. Lighting programs should be adapted to rearing facilities (dark or open house systems), conditions of production, climate, and the egg weight profile of the breeders (bigger hatching eggs result in improved chick weight/size).

Two basic rules should be followed in every lighting program:

- Do not increase day length in rearing before the moment of light stimulation
- Do not decrease day length during production

Time of light stimulation should always be based on bodyweight, not on age. Premature light stimulation and/or too low bodyweight can lead to poor performance later in production (peak and persistency), as well as higher mortality and poor eggshell quality. Too early light stimulation will also negatively affect egg size, and in breeder flocks it is important to obtain a proper increase in egg size from start of lay to maximize % of hatching eggs of a suitable weight which will produce a good quality chick.

For the first weeks (rearing), a slow step-down lighting program is recommended to maximize growth, followed by a period of constant light duration (plateau). Speed of daylength reduction and hours of light at the plateau should be adapted to breed, growth performance, climate, expected sexual maturity and required egg weight.

When the parent stock flocks are reared in open system houses, control of sexual maturity is difficult to achieve. It is recommended to darken the poultry house and to use a lighting program that takes the natural day length at the moment of transfer into account. Golden rule: the total light duration at the plateau must never be shorter than the longest natural day length in the period between 6 weeks of age and the moment the birds are transferred to the laying house.

Lighting programs have different objectives:

In rearing:
- To promote early development and encourage feed intake and growth.
- To control the birds' sexual maturity, sexual stimulation takes place in the breeder's brains. Optimal sexual stimulation and increased fertility significantly influence the number of eggs laid and their hatchability. Lighting plays a key role here. It's important to use lighting with a broad light spectrum. A spectrum that contains all colors is a recommended, since every color has its own characteristics that influence the chicken in their own way.

During production:
- To encourage growth at start of lay.
- To counteract the harmful effects of decreases in natural day length.
- To stimulate bird behavior / sexual maturity.
- Stimulate egg uniformity and weight, the higher the egg weight uniformity, the better. This, combined with a high laying uniformity is surely beneficial for overall company results. By stimulating feed- and water intake and reducing stress improved performances can be realized. The different aspects of lighting all have their influence on this in their own way.
- Less stress, stress should always be avoided in parent stock houses since it significantly influences animal well-being and performances. Amongst others, stress could lead to a high FCR, high mortality and less eggs. A correct light climate significantly reduces parent stock stress in multiple ways.
- To stimulate laying eggs in nests / to reduce floor eggs. Floor eggs are lower quality eggs that require a significantly higher amount of work than regular eggs. They stand for lower revenues and higher costs. The less floor eggs, the better. Fortunately, lighting can help here. Amongst others, it is very important to have the right amount of light at the right place in the house. In this way, desired nesting laying behavior can be stimulated.

5.2 Recommended lighting program in dark houses

The following program should be used as an example and should be adapted to the specific circumstances of the farm and according to the performance results previously obtained.

Age (weeks)	Hours of light per day		Light Intensity (lux)	Stage	Remarks
	Brown Breeders	White Breeders			
1	16 (4L+2D)x4	16 (4L+2D)x4	20 – 40	Stage 1	Or 22 hours (D1 - D3) + 20 hours (D4 - D7)
2	16 (8L+2D+8L+6D)	16 (8L+2D+8L+6D)	10 - 20	Stage 2	When above, 19 hours
3	18	18	5 – 10	Stage 3	
4	17	17	5 – 10		
5	16	16	5 – 10		
6	15	15	5 – 10		
7	14	14	5 – 10		
8	13	13	5 – 10		
9	12	12	5 – 10		
10	12	12	5 – 10		
11	12	12	5 – 10		
12	12	12	5 – 10		
13	12	12	5 – 10		
14	12	12	5 – 10		
15	12	12	5 – 10		
16	12	12	5 – 10		
17	12	12	5 – 10		
18	12	12	5 – 10		
19	13	13	5 – 10		For Browns, Light stimulation if BW > 1450-1500 grams, and/or production > 5% For Whites, light stimulation if BW > 1300-1350 grams, and/or production > 5%
At 30% lay	14	14	5 – 10		
At 60% lay	15	15	5 – 10		Plateau for the Whites, to stick to 15 hours onwards.
At 90% lay	16	15	5 – 10		

*Stage 1, Intermittent lighting program as showed in chart
**Stage 2, transitional lighting program as showed in chart

Slow step-down

If you notice that bodyweights are staying behind target, you can choose for a slower step-down lighting program. This will allow the birds more time to eat which will result in better growth.
Slower step down can also be applied when you aim for higher hatching egg sizes straight from the beginning of production. Be aware that it will delay the onset of lay!

5.3 Lighting program in semi-dark or open-sided houses

Complete control of sexual maturity is difficult to achieve in this type of building because the seasonal fluctuations of day length interfere with sexual development. Sexual maturity previously observed in flocks coming from this type of rearing house, in the same season, should be considered.

Houses where the light intensity entering the building from outside exceeds 0.5 lux should be considered as semi-dark, and the lighting program should be designed for natural light exposure and follow the schedule for open-sided houses. To get effective photo stimulation and to avoid birds reaching maturity too early, the lighting schedule used should consider the natural day length when the flock is at 16 weeks of age. To avoid any unwanted increase in light duration before light stimulation, the minimum hours of light during the rearing period, should never be less than the longest natural day in the period between 6 and 16 weeks old.

It is very important to keep the following points in mind:

- Effective stimulation is always difficult when the natural day-length is near its longest.
- When the breeder flock is still in rearing and not in production, light stimulations is more effective when light is added at the end of the day
- When the breeder flock is starting to produce, light stimulation is most effective when it is gradually increased in both the evening and the morning as this will result in better spread of occupation of the nest boxes, resulting in a lower prevalence of floor and system eggs.

Example of a lighting program for open-sided houses according to day length at 18 weeks

Age	Duration of light at 16 weeks (hours)				
	10	11	12	13	≥14
1 – 3 days	23	23	23	23	23
4 – 7 days	22	22	22	22	22
8 – 14 days	20	20	20	20	20
15 – 21 days	18	18	18	18	18
22 – 28 days	16	16	16	16	16
29 – 35 days	14	14	14	14	15
36 – 42 days	12	13	13	13.30	14
43 – 49 days	11	12	12.30	13	14
Decreasing daylengths: from 49 days to light stimulation	10	Natural light	Natural light	Natural light	Natural light
Increasing daylengths: from 49 days to light stimulation	10	11	12	13	14

Transferring birds from a semi-dark rearing house to a windowed house can bring about advanced sexual maturity. Under these conditions, there is an increased risk of having underweight birds at the point of light stimulation. To reduce this risk, we recommend working with a higher light intensity in rearing (i.e. 40 lux) or gradually increasing the light intensity in the final weeks of rearing to get adapted to the conditions to be experienced in the production house.

Transferring the birds from an open or semi-dark house to a dark laying house slows down the sexual development of both the males and the females chicken and causes a delay in the onset of lay and sexual maturity. Under these conditions, it is necessary to keep a light duration and intensity equivalent to the day-length at the time of transfer, and to gradually adjust the light intensity after the transfer.

5.4 Light Intensity

Light intensity is an important factor during the first days of the rearing period, encouraging the chicks to explore their environment and quickly locate water and the feed. Next, light intensity can gradually be reduced to a level that in practice will depend on the:

- Light required to inspect the birds
- Degree of darkness of the building (light leaking in)
- Intensity to be used during the laying period

There is a strong relationship between light intensity, physical activity, mating behavior, pecking behavior and feather loss. High light intensity tends to increase the nervousness of the birds and it can result in increased mortality by vent pecking. This risk is higher when birds are kept at a (too) high stocking density. Using dim light during the production period will help to obtain better livability. Nowadays it is common to start off with high light intensity, as this helps the development of the breeders. By starting off with a high light intensity you have the opportunity to use dimming to counteract the onset of pecking/cannibalistic behavior later.

The light intensity required in production is relatively low, from 5 to 10 lux, and it is not necessary to increase it for effective light stimulation. However, a higher intensity at the start of production can help to stimulate feed intake, if needed. Achieving a good uniformity of light spread is also very important to minimize the risk of floor eggs in dark spots.

6 Male Management

6 Male Management

It is preferable to rear males and females together from one day old. This has given satisfactory results in terms of livability and production, whilst preventing stress due to social interactions that can occur when males are placed into the female flock, at a later stage. In some circumstances, especially for white breeders or when males are underweight, males may be kept separated during the first few weeks, and then spread evenly among the females before 4 weeks of age. If males are reared separately until the end of the rearing period, they should be mingled gradually with the females to minimize any possible problems derived from aggressiveness (see "Sexual Behavior").
We strongly recommend that males are also weighed regularly.

6.1 Beak treatment

A slight trimming of the beak can avoid pecking and injury to females. The age at which beak treatment is carried out must be in line with local regulations. Too severe beak trimming can have a negative impact on fertility as the male might have-difficulty to maintain position during mating.

6.2 Male percentages

The necessary percentage of males will depend on the housing and management system used in the production house. This can vary from about 3.5 % in artificial insemination up to 14% in some family cages. Here below we give a table with the recommended sex ratios. For the usual floor housing in lay, we recommend between 10% and a maximum 12% of males from one day old, so there is some safety margin to cover for selection during the rearing period.

Recommended mating ratio during the production period

Housing & management system	number males per 100 females
Artificial insemination	3.5-4.0
Family cages	10-14*
Floor housing / slatted housing	7-10**
Aviary housing	7-10**

*In smaller family cages (30 hens) the preferred number of males might be higher (4) to assure the fertility in case of an eventual cull/mortality.
** excellent fertility results have been obtained with numbers as low as 5 – 6 males per 100 females in aviary systems, this lower number will create a more peaceful environment for the breeders as there is less competition between the males. This is also resulting in better feather condition for the females, allowing them to be kept longer in a good condition.

At the start of lay, the percentage of males should be reduced to between 7% and 10% of first quality males. These males should have the following characteristics:

- Uniform bodyweight
- Good muscle tone and body condition
- Free of physical abnormalities (alert and active)
- Bright and red combs
- Strong, straight legs and toes
- Comb, wattles, and vent showing evidence of mating activity (only during the production period)
- Well feathered
- Good upright posture

The mating ratio during the production period should be reviewed weekly. Based on assessments of physical condition and bodyweight, any males considered to be non-working should be removed from the flock in line with these recommendations:

- Select males with dull combs.
- Take out (select) all males with footpad problems, bumble foot, curled toes, splayed legs, humpbacks, etc.
- Non-active males will often hide in the nests or resting on the higher perches.
- Active and reproductive males have a large, wet, and red cloaca and wet vent area.
- Productive males are always alert, well spread between the females and have red combs
- Extra males should be kept in a separate pen to be introduced as replacements in case of male mortality or culls. Manage them accordingly, red light sleeves/covers could keep them calm, it is also advised to install perches in these male pens, this will give them some escape options / provide them rest.

Carefully inspect the roosters for leg or toe problems

When natural mating takes place, males should develop dominance over the females. If the males mature too late, they will have a hard time to become dominant over the females and will be scared to mate with them. The males can be physically well developed but most often the females won't let them mate. When the males are not dominant over the females, the chance for successful mating is greatly reduced, resulting in too low fertility. It is crucial to keep an eye on the condition of the males during the entire rearing and laying periods. Bodyweights should be recorded on a weekly basis until they have reached 30 weeks of age and then monthly. Visit the flock frequent during different times of the day. Carefully monitor the sexual behavior of the flock and keep an eye on the good and even distribution of the males (especially during the most active mating period which is in the afternoon).

In family cages, it is critical to keep an eye on the male's quality and behavior, because the decline in fertility could be faster than in floor systems. Keep close monitoring on the fertility and do fertility checks every 2 weeks. When necessary, apply intra-spiking or spiking (with spiking you replace the existing males with a new flock (often younger) of males. Always keep a group of extra males in a pen (better if they are younger than the flock).

A proper balance between male : female ratio is key! More males is definitely not always resulting in improved fertility results, as too high male density can cause too many disturbances in the flock, resulting in reduced performance in egg numbers and fertility! Carefully monitor the behavior of the breeder flock multiple times a day. The overall feather condition score of both the females and the males can also be used as an indicator of a disbalance in male : female ratio. Surplus males must be removed quickly or a considerable loss in persistency of fertility will result.

6.3 Sexual behavior

In some circumstances, by the end of rearing, early mature males may encircle the females, which will prevent normal feeding and lead to reduced female growth and unevenness. If this happens, we recommend putting at least 30% of the males in a separate pen. If the females are still being encircled, take out more males. These males should be progressively returned to the flock, as production increases, based on observed behavior. Introduce a few males each day, distributing them evenly over the poultry house, preferably during the dark hours, to minimize the risk of aggressiveness.
During the rearing period we recommend a separate pen for males displaying aggressive behavior as they approach sexual maturity.

A surplus of males leads to over-mating, interrupted mating, and abnormal behavior. Over-mated flocks will exhibit reductions in fertility, hatchability, and egg numbers. In the early stages, after mating-up, it is quite normal to observe some displacement and wear of the feathers at the back of female's head and of the feathers on the back at the base of the tail. When this condition progresses to the removal of feathers, this is a sign of over-mating. If the mating ratio is not reduced, the condition will worsen with de-feathering of areas of the back and skin scratches occurring. This may lead to low welfare, deterioration in the condition of females and reduced egg production. Over-mated females may be seen "hiding" from the males beneath equipment, in nest boxes, or refuse to come down from the slatted area.

Excessive injuries and feather damage to the males because of fighting amongst males may also occur. In flocks with a too high male : female ratio the males tend to be more aggressive towards each other as there is more competition.

If fertility problems appear in a flock check:

- Bad physical conditions of the males and females
  - overweight or underweight
  - feather cover of both the males and females
  - color of the comb and cloaca
- Disease
- Nutritional deficiencies
- Sexual behavior of males and females
- Overall behavior of males and females

Keep an eye on feather damage, in both females and males, it can be an indicator of a disbalance between the male : female ratio.

6.4 Removal of sexing errors

To assure the correct genetic combination of (grand) parent stock and the corresponding commercial day-old chicks, it is vital to only keep the birds from the correct genetic lines in production. This means that all the sexing errors:

- For the grandparent stock flocks namely sisters of the males of lines A and C, as well as brothers of the females of lines B and D must be always culled, as any sexing error can have a huge impact on the color and feather sexing of the offspring.
- For the parent stock flocks all the sexing errors, namely sisters of the males (A x B) as well as the brothers of the females (C x D) must be eliminated, as also here any mistake can have big consequences on the sexing of day-old commercials (the inheritance of the feather and color sexing genes is disturbed.

These sexing errors are easily recognized during the hatching process because a special identification has been made for each sex, especially when grandparent stock day-old chicks are delivered. Hendrix Genetics does not dub the parent stock males from the lines "Rhode Island Red" as they are easy to recognize in a parent stock flock. Depending on which local regulations apply, the males from the white feathered (grand) parent lines can be dubbed to ensure recognition of possible sexing errors (males with intact combs should be taken out, as well as females with dubbed combs).

Important: If these sexing errors are kept in production, it may result in erratic offspring because of incorrect mating. The offspring could be difficult to sex (the case for both feather and color sexing), resulting in large amounts of sexing errors, low hatchability of females and /or strange sex ratios (because of mis-sexed day-old chicks). In addition, the commercial hens resulting from incorrect mating can have a genetic profile which differs from the expected one, mostly resulting in a lack of performance, different phenotype, different egg color, egg size, etc.).

Try to remove sexing errors as early as possible, keep accurate track of the sexing errors and report this to back to the breeding company.

Keep on looking for chickens with defects also in production, as certain deformities (especialliy leg and toe deformities) can develop over time..

7 Transfer

7 Transfer

7.1 Transfer to the laying house

Transfer is a stressful event for the birds, because of the handling and transport involved and because of the change of environment, from the rearing to the breeder laying farm. Therefore, transfer requires careful planning and management. Transfer should be done timely, certainly not later than 2 weeks before the expected egg production starts. The birds need time to recover from the stress related to the transfer, this recovery time is needed to prevent depression of the rapid ovarian development. In the ideal situation, birds are transferred at 16 weeks of age. This will enable them to be fully adapted to their new environment before the onset of lay.

A late transfer can result in the laying of floor eggs, as the hens have not had enough time to become accustomed to their new surroundings. When transferred, it is advised to feed the flock a pre-lay or a layer diet.
Please note, do not use pullet (or developer) diets, as the nutrient density of these diets is too low!

To ensure a smooth transition, drinking, feeding, and lighting systems should be similar each other between the rearing and production houses. The breeders should be reared in a housing system that matches with the housing system during the productive life. The birds should be properly trained during the rearing period to make use of the different tiers/levels (especially when the birds are kept in aviary systems). This will help them to find water, feed, and the nest boxes.

7.2 Preparation at the breeder rearing farm

Preparation of the transfer of the birds should already be done during the final stage at the rearing barn. The following points should be considered:

- Focus on bodyweight, the bodyweight of the breeders must always conform to the bodyweight standards of the breed (both for the males and the females). This should not just be according to the age of the birds but also according to the age of sexual maturity / the onset of lay. Please keep in the back of your mind that stress caused by the transfer of the birds can negatively impact the bodyweight by 10% to 15%, this is mostly related to moisture loss.
- The light intensity should be increased over a period of 2 to 4 weeks. The light intensity at the end of the rearing period should equal the light intensity level in the laying house.
- The temperature inside the rearing house at the end of rearing should be adjusted (usually to a lower level), over a period of 2 to 4 weeks. This will allow the birds to start off easier at the laying house.
- Important: the above-mentioned changes should be no less than 1 week before transfer!
- The final two weeks prior to transfer, it is recommended to limit the handling of the flock, routine uniformity and bodyweight checks need to be continued to make sure you can monitor the development of the flock. As this is such a critical period for the development of the birds, they must have had every opportunity to grow.
- Please consult your responsible veterinarian to schedule the best moment to vaccinate your flocks, it is advised that the final vaccinations are given at least one week before transfer, this will help to obtain a proper vaccine reaction.
- A too late or too long transfer will often lead to a delayed start of lay, higher mortality and the increased risk of laying floor eggs.
- Feed withdrawal before depopulating the rearing barn and transfer to the laying house should not exceed more than 6 hours, always adapt feed withdrawal to the duration of transport and the climatic conditions in the barn and during transport. Do not withdraw water until the depopulations starts.
- Recommended practice: insoluble grit can be provided to the flock in rearing, ideally during the entire rearing period, but at least 2 weeks prior to transfer. Towards the end of the rearing period the grit should be 3 to 5mm in size and provided at a rate of 4 g/bird/ week.

7.3 Preparation at the breeder laying farm

The breeder laying house should be well prepared prior to the arrival of the new flock. The following points should be considered:

- An appropriate biosecurity program should be in place to avoid transmission of disease.
- Full maintenance and all repairs must be completed prior to the arrival of the new flock.
- Flush the entire water system and provide fresh water the day before the arrival of the new flock. This is critical, as the key to a successful start of the incoming flock is the provision of water. The better the water quality, the less the depression in feed intake following transfer.
- When nipple lines are used, ensure the height is slightly above the back of the birds (during the first 7 days). Raise them afterwards to a level that ensures that the birds "comfortably need to stretch" to use the nipples. For the first 2-3 days, fill the bell drinkers to double the normal depth and lower them to a height of 20cm above floor level.
- The house should be dried prior to the arrival of the new breeder flock. Not only are wet houses very humid, (a condition which is depressing for the chickens), they are also cold – which is particularly noticeable during the colder months.
- The house should be preheated during the colder months. Please consider that the heating of an empty house can take up to 2 days. Start the heating well in time, especially during colder days.

7.4 Transfer

The best time to transfer a breeder flock is during the early morning. Disturbance to routines of drinking and eating is minimized if the birds are unloaded and housed by the time their day typically starts on the rearing farm. The transport vehicles and all the equipment used to transfer the birds must be clean and disinfected. The flock should be transferred within the same day as this causes less stress and avoids the issues of low temperatures in both the rearing and the breeder houses. Every effort should be made before and after the transfer to maintain water and feed intake according to the normal routine of the stock. Precautions should be taken to minimize undue exposure to wind and rain/sun during transfer procedure as these factors are very stressful.

Transfer is accompanied by changes in environment, temperature, humidity, and equipment. It is therefore a major source of stress and it should be carried out as rapidly as possible. Because of the stress to which the parent stock are subjected during and immediately after transfer, it is extremely important that transfer is completed before the appearance of the first eggs. We recommend scheduling the transfer at 16 weeks of age and ensuring that all breeders are housed in the production facilities by 119 days of age (17 weeks).

7.5 Lighting

The duration of lighting during lay should consider the program used during rearing. Exchanging detailed information on lighting program used in rearing, including not only total hours of light and light intensity used, but also time at lights on and lights off, is essential for a better adaptation of the breeder flock by adjusting time schedules to make them match.

In aviary systems, the breeders should be trained to come back in the system when the lights go out by using a 'light dimming' program: no birds should stay in the litter area when the lights are out to minimize floor/system eggs.

Water consumption
Chickens can become dehydrated during transfer. The water loss is between 0.3% and 0.5% per hour according to atmospheric conditions (4 g/hour at 20°C, more than 8 g above 30°C).
The drinking water devices must have been triggered and purged before the flock arrives to ensure they are working properly. The newly arrived breeder flock should drink before feeding. The absence of feed at transfer helps them to find the drinkers more easily. Wait for 3 to 4 hours before feed distribution and check that all the chickens drink properly. A daily check on water consumption should be routine, and daily recordings should be made to monitor the drinking behavior. When nipple drinkers are present in the breeder laying house, make sure that the chickens also have access to nipple drinkers in the rearing house. To stimulate drinking behavior, gently increase the pressure, so a drop of water is present underneath the nipple.

8 The (re)productive life

8 The (re)productive life

8.1 Arrival at the breeder laying farm

Unloading of the breeders is a delicate procedure, it should be done as quickly and gently as possible. The breeder laying house should provide the following to the birds:

- A dry house (+ its equipment) at a temperature of no less than 15°C, where 18°C is the optimum, especially in cold weather.
- To encourage water intake, drinking water must be clean and fresh when the new parent stock flock arrives.
- To improve the birds' appetite, it is better to use meal feeding instead of feeding ad-libitum.

The period of the first 48 hours after housing is a critical period, close supervision and observation are required to ensure the normal behavior of the entire flock. The following points should be noted:

- The birds should be released close to the drinkers and feeders.
- Water consumption – normal drinking habits within 6 hours after arrival.
- Feed Consumption – increasing appetite/intake.
- Temperature: should be in the range of 15°C to 18°C. Fresh air is a must, but it is also important that birds do not become chilled.
- The behavior of the flock: at first, they will be quiet, but they should gradually become more active and 'talkative' but not frenetic or hyperactive.
- Nest boxes must be closed until the first egg is seen. Open them almost 2 hours before the main house lights and keep the nests open until late afternoon.
- The light intensity must be higher compared to the rearing, make sure you can easily observe the birds and that the birds can easily navigate through their new environment. Starting production at a higher intensity will allow you to reduce more later in the productive life in case of aggressive pecking.
- Dim the light gradually at light off, this will trigger the birds to move up in the system.
- It is strongly recommended to move the remaining birds from the litter to the slats or on the system immediately after turning off the lights.
- If slats are incorporated in the house, make sure that you encourage the birds to perch and sleep on the slats during the night period. Make sure that when the lights have fully dimmed, no birds are present on the floor. It will need 3 to 7 days to take effect, but birds will perch naturally afterwards, and it will prevent many floor eggs.
- Special attention must be given to birds having difficulty finding the drinking/feeding points. Birds can often be found on the top level of aviary systems, on the scratching area or perches. Place these birds close to the drinkers and feeders.
- Use hardly any litter in the floor area, as this will attract the birds to stay on the floor.
- Close the surface underneath the aviaries, you can open the area underneath the system when the birds go on the system by themselves.
- At start of lay, floor eggs should be collected several times a day until the level becomes acceptable.
- Maintain the continuous monitoring of the birds' growth (both males and females) by measuring bodyweight.

During the first days, the farm workers should spend time with the breeders, observing their behavior and monitoring the water and feed consumption. This will also allow time for the birds to get used to their caretakers. Inspection of the flock should not be limited to daytime only! Listening to the birds after turning off the lights can be very useful: coughing or sneezing, also known as "snicking", because of a respiratory infection can readily be detected when the flock is resting. Additionally, you can observe if the birds are moving up in the system (in case of partially slatted floors or aviary systems).

8.2 Basic concept of growth

From transfer, birds continue their growth towards achieving their physical maturity at around 30 weeks of age, the bodyweight gain must be around 300 g for the females. After 30/35 weeks most bodyweight gain is fat, and its excess has a negative impact on the birds' laying performance, the males mating behavior and fertility and not to forget on feed conversion. A lack of bodyweight gain after transfer makes the breeders vulnerable and less robust against environmental variation like disease and heat. Flock uniformity must be followed up to avoid extremes of bodyweight as this will negatively impact laying performance.

From a nutritional point of view, the prelay period is characterized by an increase of the calcium concentration of the feed. The first objective of the higher calcium levels is to reinforce the mineralization of medullary bone and layer calcium storage, before the beginning of lay.

The second objective is to prevent demineralization of early sexually mature birds. With a classical developer feed, feed calcium concentration is not enough compensating the calcium exported for the formation of the eggshell. This leads to the decrease in the medullary bone calcium reserve. Breeder females without adequate calcium content on prelay will have poor eggshell quality during the later periods of lay.

Higher calcium levels in the prelay diet will prevent bone demineralization of breeder females that come into lay early. It will also reinforce the mineralization of medullary bone before transfer and will ensure a longer lasting eggshell quality.

The prelay diet constitutes a step, in terms of feed, between rearing and laying feed. It is strongly recommended to use a prelay diet to get the birds accustomed to the layer feed. If the prelay diet is not used, the risk for a too low feed consumption after transfer to the laying house is higher as the abrupt increase in calcium carbonate content from developer feed to layer feed can lead to a decrease in feed intake due to lower appetence.

During the prelay phase, the birds continue to grow. It is during this period that the lightest birds can improve and adjust their bodyweight. The birds that are early sexually mature could begin to lay. Both require a high nutritional feed to assist correct growth and production. Protein and amino-acids levels must be high at this time to meet the nutritional requirement. Without using an adapted feed, the uniformity of the flock could be jeopardized.

The period of the first 48 hours after housing is a critical period, close supervision and observation are required to ensure the normal behavior of the entire flock.

8.3 Housing and equipment

Recommended Equipment requirements for the production period

		Floor
Ventilation	Minimum ventilation rate	0.7 m³/hour/kg
	Required capacity	4 m³/hour/kg
Stocking densities	Birds / m² *	6 – 8
	Birds / m² (hot climate)	6
	cm²/ bird	
Water supply	Birds / drinker	100
	Birds/ drinker (hot climate)	70
	Birds / nipple	9
Feed supply **	Birds / round feeder	19 – 25
	cm of through feeders	10
Nest space	Hens / nest (individual)	5
	Hens / m² nest (collective)	120

* Stocking density can go up to 8 birds/m2 if the house is equipped with slats.
** To calculate feeder space availability when chain feeders are used, both sides of the trough should be taken into account. When round feeders are used, calculate pan circumference based on diameter to get at least 50% (5cm) of the recommended feeder space for the chain feeder.

Pan diameter (cm)	Birds / feeder (max)
30	19
40	25

8.4 Stocking Density

The control of this parameter in lay is as important as in the rearing. Flocks within enough comfort in the sense of total available, but also feeding and drinking space will express their genetic potential much easier.

Stocking density should be followed in accordance with local Animal Welfare legislation. However, if no slats are used, the density should not be higher than 7 birds per usable m², in slatted houses this should not exceed 9 birds per usable m². The use of an aviary system enables an increase in the stocking density up to 18 or even more birds per m² of the house floorspace.

In any of these cases it is important to consider enough easily accessible drinking, feeding and nest space per bird. Overcrowded flocks tend to have a higher incidence of suboptimal feed and water intake, pecking, cannibalism, suffocation, mortality, floor eggs and compromised performance.

8.5 Partitioning

We recommend partitioning the house to assemble pens of several thousand hens. Partitioning helps to create a better distribution of birds and contributes to easier flock management. Partitions should be opaque up to 60 cm to avoid smothering along the panels. The actual pen size must be adapted to local regulation.

Slats can be manufactured using different materials (plastic, wood, or metal). The slat level should be adapted according to building design and production duration. The slat height must be sufficient to store the manure for the whole production cycle. The height between the litter area and the slats should not exceed 90 cm, as birds will have difficulty accessing the slatted area. And a greater height will result in higher risk of floor eggs. The provision of perches is required to assist the birds to move from the litter to the slats/system. Perch rails are generally preferable to 'ladders', as breeder females may

choose to lay their eggs, or even to crowd and smother in the area under the ladders. It is advisable to place perches in the rearing house to train the birds to jump on slats after they have been transferred into the production house. A gradual slope from floor to slatted area can also be used. If the slope is too steep, it could lead to an increase in floor eggs and prevent the parent stock flock from having easy access to the feeding and drinking systems.

During the first week after transfer, we recommend moving the remaining birds from the litter to the slats immediately after turning off the lights, until birds get accustomed to moving onto the slats by themselves.

8.6 Feeding/Drinking

The breeder flock must have fresh, clean, potable water, readily available all time. The drinkers should be placed evenly over the whole house area, and the bottom of the round drinkers should be hanging on the height of the birds' back. It is important to install enough feeders and drinkers to avoid competition and chickens crowding near to them.

The height of drinkers and chain feeders should be arranged so that they can be easily seen, easily accessible and do not restrict the movement of the birds, as it could otherwise create a physical barrier between the birds and the nests (could results in floor-laying). They should be placed on the slats, drinkers preferably in front of the nests, as this will attract the birds to the nest boxes. Their distance from nests is also important: if they are too close it could cause the crowding of birds in front of the nests. By placing the drinkers and feeders on the slats you will encourage the birds to use the slats.

Make sure you always comply with local legislation, when nipple drinkers are used ensure 1 nipple per 10 birds (take the males into account). If bell drinkers are used, ensure 1 drinker for 100 birds in temperate climates and 1 drinker for 70 birds in hot climates. It may be convenient to have a water meter and a medication counter installed in the water supply system.

It is very important that the breeders find the same type of drinkers in the laying house as they were already accustomed to in the rearing house!

It is recommended to use a feeding system that distributes the feed rapidly throughout the house and enables the birds to finish all the feed daily distributed. It will continue to support the birds' intake capacity developed in rearing and lead to fast and continuous increase of feed intake from point of lay to peak of production.

Chain feeders are the best option since they allow the easiest feed intake control. They can be emptied easily and the build- up of fine feed particles is avoided. They should be able to deliver feed very quickly (18m/min). Assure 10 cm of linear space per bird.

Tube and pan feeders are more difficult to empty, and the feed depth must be regulated correctly. It is not advisable to use any system in which the feeders cannot be emptied, or which does not give an even distribution of feed throughout the whole building. When pans are used you can allow 25 birds per pan (diameter of 40 cm) and if their mutual distance allows enough access from all sides).

It is important to monitor the daily water and feed intake. Any strong deviations from the previous day's consumption might indicate a start of some disease or technical problem. When this is part of your regular flock inspection it will help you to avoid big surprises in the development of your flock. Take a close look on the eating behavior of the males, they should not experience any problems to eat or drink.

8.7 Perches

Perches improve the welfare by allowing the bird to express its natural behavior. Perches are useful to:

- Increase the usable surface per bird and decreasing floor density
- Train the bird to jump on the system
- Offer an escape to aggressed birds/overactive males, especially at high stocking densities

The recommended perch length per bird is a minimum of 10 cm. The first accessible level must be at 20 cm height. These values may be adjusted according to local regulations, in EU the minimum perch length is 15 cm for example. In partly slatted floor systems, the perches should be positioned on the slats to maintain good litter conditions. The distance between perches should be 40 cm and with a slope of 45°. To improve the use of perches, install them during the rearing period, before 4 weeks of age. Recommended perch space per bird in rearing is 5 to 10 cm, depending on stocking density.

Stocking density in relation to perch space

Stocking density (birds/m²)	Perch space (cm/bird)
6	5
7	6
8	8

Perch shape, left wrong design, right recommended design (more grip)

8.8 Nests

One comfortable individual nest should be available for 5-6 birds or 1m² of collective nest for up to 120 birds. In certain situations, when it is too crowded during peak periods in the nests it is advised to have 1m² of nest available for 100 birds. Nests should be distributed evenly in the laying house, preferably in the shade and easily accessible (one or two levels). They must be attractive and comfortable, draft proof, not too brightly lit, equipped with a perching area at the entrance, and a closing system for the night. Nests must always be clean and well maintained!

When individual nests are used at the start of lay, they can be mulched/strewed to encourage the birds to use them, and to minimize floor eggs.

A good practice is to install a dim light (0.3-0.5 lux) inside the nests, as this will allow the birds to find the nest before the normal day starts. This light should be turned on 1 hour before the general "lights on", for a standard 8 hours of night program. If this is not possible a dim light placed over the slats and close to the nest must be switched on 1.5h before lights on to avoid floor eggs.

Immediately after transfer it is essential to start training the birds to explore and use the nests. Walk slowly through the house to move them towards nests, collecting birds from the scratching area and the litter area, placing them on the slats, just before dusk. Automatic nests must be open at least 2 hours before the lights are on. The nests should be closed once a day after all the eggs have been laid. You can adapt this by monitoring the laying behavior of the flock. Regularly inspect the nests to check if they are clean. Also check for birds that are hiding inside the nests, too many females hiding in the nests can be a sign of a disbalance between the male : female ratio. When you come across males that are hiding inside the nests, take them out the nests and place them in your surplus pen as the chance is very low that they will be active males.

8.9 Heating

The breeder house temperatures should be kept between 18-22°C, though the birds will withstand the lower temperatures during winter and higher temperatures during summer. At lower temperatures a chicken increases feed intake as the maintenance requirements increases. On the other hand, at higher temperatures birds tend to decrease feed consumption due to a lower maintenance requirement and to dissipate the heat excess produced in the metabolism.

Throughout the winter season, temperatures in the rearing houses before and during transfer must be adjusted to those in the breeder houses. Moreover, to avoid temperature stress in wintertime, it is advisable to preheat the production houses up to 18°C before transferring point of lay breeders and to respect minimum ventilation (cf. ventilation part) requirements to avoid damage caused by $C0_2$/NH_3 levels. If necessary, use heaters.

8.10 Lighting system

The objective of the lighting program during the production period is:

- To encourage feed intake and growth at start of lay
- To counteract the harmful effects of decreases in natural day length
- To control the livability through the light intensity management

The lighting system in lay must be designed to ensure independent lighting control of the different areas. We suggest the creation of at least two zones, one lighting line above the nests and one lighting line above the scratching area. Three types of lighting lines are the optimum: one for the scratching area, one for the slatted area and one above the nests. All lighting lines must be dimmable and programmable. The dimming ability of the system will allow the control of behavior inside the building and avoid dark areas where birds may lay on the floor.
An independent programmable lighting row encourages birds to climb/move on to slats and not to sleep on the scratching area. This point is important to avoid floor eggs. Nest lights can be used with brown breeders to attract them into the nest before the general lighting is on. Lighting systems using bulbs of too low frequency will result in flickering light which will stress the birds. Warm color type (yellow-orange spectrum) must be used. In the event of negative bird behavior, the use of lampshades and red-light covers can help.
Achieving the best possible uniformity of light spread is essential. The bulbs should be covered with lampshades. Where lighting is provided by fluorescent tubes, they will need to be evenly distributed and of a warm color (maximum 3000°K) and of high frequency. In all cases, it is advisable to install dimmers that allow the light intensity to be adjusted.

LED lights are increasingly used in poultry houses due to their high light efficiency, low running costs, long-life span and wide wavelength range. Some key points to be considered when using LED lights are:

- LED lights used for the laying period should have the appropriate color spectrum, (maximum 3000°K)
- They are easily dimmed. Please make sure that the dimmers do not cause flickering!
- Select the right beam angle, which determines the size of the area to be covered by the light. As LED light is directional it tends to create shadows. Combine beam angles, placement and spacing to avoid uneven light distribution and dark areas.

Whatever the type of laying house (natural or artificial light), the golden rule is to never decrease daylength (interval between lights on and lights off) after the start of lay. The lighting program in production should be the continuation of the lighting program used during the rearing period. It is essential to make sure that the light duration at transfer is as long as the light duration the birds have already experienced in the rearing house just before transfer. It is recommended to make a light schedule before the new flock is placed. Determine the time to start the day (lights on) once the maximum daylength has been reached. After that, depending on the development, the feed intake and the bodyweight you can start to give extra hours of light:

- When the flock is not producing yet, add extra hours of light at the end of the day
- When the breeder flock has started to produce, add extra light gradually in the early morning and in the evening to spread the time of egg production (will reduce overcrowding of the nest boxes).

If the building is dark and the breeder flock has been reared in dark houses, a minimum light intensity from 5 to 10 lux is required for the production house. The nests should not be too bright. For laying houses with part floor / part slats, the litter area should be correctly lit to prevent floor eggs. To prevent the nests being too bright, it is possible to improve the distribution of light by using colored sticky tape on the sides of the fluorescent tubes (but LED lighting is advised).

It is advisable to use higher light intensity at the start of production to stimulate the birds' feed intake. Once the feed intake meets the desired level and the peak of production is achieved, the light intensity can be decreased.
There is a strong correlation between bird activity and feather loss during production. Too high light intensity can encourage pecking and result in increased mortality.

Floor eggs before "lights on" can be reduced by using night lights switched on an hour before general lights are on. This requires an additional row of lights, inside or above the nest, able to give 0.5 lux lighting to the birds.

Lights off

In partly slatted houses, lights must be switched off gradually to encourage the birds to move on the slats. Start switching off the lights above the litter area first, then the lights closer to the nests, and the slatted area last of all. In aviary systems it is important to be able to control the lighting in the different levels. In the evening the lights should be turned off gradually in the following stages:
- Start with the lights underneath the system
- Followed by the lights in the aisles
- Then the lights in the system, from bottom to the top

This will encourage the birds to move to the resting areas before the lights are completely turned off. In the mornings, the lights can be switched on at once. If you have a problem with many floor eggs, a dimmed light can be turned on one hour before the main lights are switched on. Combined with the lights that are already on in the nest could help to reduce the amount of floor eggs.

As both the onset of lay and the bodyweight play a major role in the determination of the egg weight profile during the entire laying period, it is important to use light stimulation according to the observed bodyweight of the flock, or based on the onset of lay. Light stimulation can be applied as soon as the flock has reached the level of egg production of 2% - 5%.

Below you will find the minimum bodyweight references (Bwtr) for both white and brown laying hens. Depending on the goal later in life (delay sexual maturity) or on the climate (hot season) we also show some advised light schedules.

Bwt Ref: the minimum bodyweight reference is:
- 1300-1350 g to for white egg female breeder 1450 - 1500 g for brown egg female breeders

Uniformity is an important parameter to consider. If bodyweight uniformity (±10%) is below 80% for brown and 85% for white, delay the light stimulation. The bodyweight reference can fluctuate over countries and egg size requirements.

8.11 Dark laying houses

When the breeder flock is transferred from a dark rearing house to a dark breeder house, control of sexual maturity is easier to achieve by using a suitable lighting program. The following lighting program can be used as a guide and can be adapted to the breed and the conditions at the farm.

Age and / or Bodyweight	Standard program brown egg layers (hours)	Standard program white egg layers (hours)
End of rearing to light stimulation	12	12
Light stimulation (at bodyweight reference or 5 % of lay)	13	13
At 30 % lay	14	14
At 60 % lay	15	15
At 90 % lay	16	15

*Bwt ref : bodyweight reference must be fixed according to country and egg size requirement

Control of day-length and light intensity during the laying period helps to achieve good production performance and to control abnormal behavior, therefore light-controlled houses are also recommended for the production period.

It is not recommended to move birds from a naturally lit rearing house to a dark laying house as this will slow down the sexual development of the birds and could cause a delay in the onset of lay.

Midnight lighting
Where local regulations permit it, midnight lighting (1hr 30min to 2hr in the middle of the dark period with the feeders running) is often used to encourage feed intake and growth at the beginning of production. If necessary, it can be introduced after transfer and then be gradually withdrawn, when birds reach their adult body weight.

Midnight lighting is also useful during the hot season, to reduce the negative impact of high temperatures, by allowing the birds to eat during the cooler hours of the night. It can be used during the rearing phase to promote growth, but caution should be taken when introduced between 10 to 16 weeks of age, as it could interfere with sexual maturity.
However, this is a very efficient management tool especially at the onset of lay.

In addition to this, midnight lighting helps to maintain a better eggshell quality by allowing the birds to ingest calcium at the end of shell formation. This has a beneficial impact on shell quality and hence on hatchability.

The regular lighting program (time of "lights-on" and "lights-off") should not be changed when the mid night light is added. Midnight lighting may be used throughout the flock's life if necessary, but it can be also removed if not needed (body weight target achieved, hot period is over etc.). When midnight light is withdrawn, the reduction should be gradual, in short steps, at a maximum rate of 30 minutes per week, to avoid a negative impact on daily feed intake.

8.12 Ventilation

An important priority is the provision of fresh air. If the air inside the poultry house is stuffy, humid, smelly or laden with dust, then the rate of air change is too low. The minimum air exchange rate is 0.7m³ / hour / kg live bird. A free-range house maybe ventilated automatically, naturally, or by a combination of both systems. Besides supplying fresh air to the poultry house, the following points must be taken into consideration:

- Removal of excess moisture helps to maintain a good litter quality and healthy birds.
- Removal of dust from the environment helps to prevent disease. There is a strong association between dust particles and disease, as disease organisms tend to bind to dust particles.
- Maintain a sufficient oxygen supply.
- Removal of gasses such as ammonia. In addition to the specific problem of 'ammonia blindness', these gasses have a generally stressful and depressive effect on the birds.

8.13 Air Circulation

When rate of air change is low, it is important that air is circulated within the house for the following reasons:

- Fresh air should be distributed to all parts of the house.
- If the warm air from higher levels in the building is mixed with lower levels air, the birds will enjoy a more balanced temperature.
- Mixing air allows greater removal of moisture from the litter: keeping the litter dry.
- During hot weather, air moving over the birds improves their comfort helping to mitigate the effect of temperature being above the optimum.
- Avoid direct drafts on the birds.

There are different ways to make air circulate within the house, one of the least expensive is to purchase stir fans.

Poor air quality affects not only the birds' environment but also affects the birds' respiratory system, which can have a negative impact on the birds' health: reducing productivity and increasing mortality.

Air Quality Levels

Traits	Recommended level
Ammonia (NH^3)	20 ppm max
Carbon dioxide (CO^2)	2500 ppm max

Frequent problems associated with improper ventilation

Poor	Excessive	Uneven
E. coli	E. coli	E. coli
Respiratory diseases	Respiratory diseases	Respiratory diseases
Feed intake	Feed intake	Feed intake
Ammonia Blindness	Floor eggs	Floor eggs
Poor internal and external egg quality	Nervousness	Nervousness
Poor production		Poor production
	Crowding	Crowding
Litter quality		Litter Quality

8.14 Outside Fencing

Perimeter fencing is needed to protect birds from foxes, domestic pets, feral cats, mink, other predators and to reinforce security and biosecurity. A typical fencing example could be a wire type mesh construction, of 2 meters high with an overhang of 30 cm, placed at an angle of 45° to the vertical outside of the fence. The bottom of the fence would be approximately 50 cm underground to act as an anti-tunneling barrier. Alternatively, commercially available safety electric fencing can be used. In addition to reduce entry by foxes or similar predators, electric wiring could be placed on the top of the fence.

8.15 Electric fence

If allowed by Animal Welfare legislation, an electric wire around the outside of the litter area and along the partitions can be used to discourage floor eggs and the risk of smothering. It should be fixed at 5 cm from the wall and 12 cm above the litter. Monitor the behavior of your birds when they encounter the electric wire and use a voltage as low as possible.

8.16 Hospital pens

It is recommended that the poultry house includes 1 or 2 small pens which can be used for treating sick or injured hens that have a good chance to recover. It could also be used for keeping and treating broody hens.

8.17 Litter Management

Litter enables the birds to perform the natural functions of scratching and dust bathing. There is no doubt that the presence of litter enables the birds to be more relaxed. Slatted areas cover an enclosure, to which the birds are denied access, for storage or manure. This separation of manure from the litter makes the task of maintaining the litter in good condition much less onerous, particularly during wet and cold weather. The litter adjoining the slatted area should be well lit, to deter floor egg laying. It is also recommended to only put a minimal amount of litter down initially to also deter floor egg laying at the onset of lay.
The objective of litter management is to maintain a dry, friable, and almost odorless material, which is attractive to the birds for scratching, and dust bathing. The type and quality of the litter are important for the hens and the house climate.

Different materials which may be used:
- Sand or gravel up to 8 mm granule size
- Wood shavings
- Wheat, spelt, rye, straw
- Bark mulch
- Coarse wood chips
- Chopped paper

There are two materials, which are popular – soft wood (white) shavings and chopped straw. Sawdust is not a suitable material, as once moistened it compacts and becomes immovable, and consequently does not release moisture to the atmosphere. Litter material shouldn't be contaminated or stored on site from flock to flock of birds. All materials should be dry and uncontaminated when spread in the poultry house. Straw should be chemically treated to ensure freedom from molds, in particular aspergillus species.
If the system allows it, it is recommended to remove frequently accumulated litter/manure. this prevents floor eggs and improves environment. Always avoid wet and caked litter. Try to remove it from the barn or break it into smaller fragments to enable the birds to scratch it further open again.

Dry, good quality, litter enables the birds to perform the natural functions of dust bathing.

Litter Management points of attention:

- Keep the litter dry. Well managed ventilation and good gut health contribute to dry litter.
- The litter water content should be about 25 to 30%. When too wet: litter gets caked and causes higher level of ammonia. When too dry: will result in increased emission of dust.
- Litter should be friable and 'moveable'. The birds help to maintain this condition by scratching and dust bathing. Providing a small daily 'scratch feed' of whole grain, preferably good quality wheat or insoluble grit may encourage scratching.
- Water pressure in drinker supply lines should meet supplier's specification to avoid leakage.
- Drinkers should not be overfilled. Hanging plastic drinkers of the 'bell' type should contain no more than 1.5 cm depth of water. Furthermore, these drinkers should be suspended at such a height as to minimize the problem of spillage resulting when birds collide with them. The drinker height is ideal if the birds can just reach to drink and are able to walk underneath the drinkers.
- Where nipple drinkers are provided, they should be suspended so that the birds have to reach up to drink. They should also be provided with (large) drip cups to reduce spillage directly from the nipples onto the litter.
- Litter depth should be 5 to 10cm depending on the type of flooring.
- Additional litter should be added on top of the existing litter so that moisture content is kept low. The requirement for additional litter is very low during the summer but high during cold, wet weather.
- Wet patches resulting from water spillage should be promptly removed and additional litter provided.
- During cold and/or wet weather, it is important to regularly work the litter with a fork to break up accumulating droppings and to 'open up' any compacted litter. Usually some fresh material will be added at this time.

9 Beak Treatment

9 Beak treatment

9.1 Introduction

This treatment is normally carried out to prevent feather pecking and cannibalism. Poor beak treatment often leads to unevenness and, in some birds, causes difficulties with feeding and drinking. Well treated birds hardly suffer and future suffering due to pecking behavior can be prevented. In addition to technical recommendations any codes and local regulations concerned with animal welfare should always be followed.

Different methods for beak treatment are used, for example cauterization by hot blade or infra-red treatment. The infra-red treatment is the preferred method as this will have the lowest negative impact on the wellbeing of the chicks and their development. Cauterization by hot blade is a delicate operation, which should only be performed by specially trained personnel. Beak treatment by hot blade is a stressful operation: it is not recommended to beak treat birds if the flock is not in good health or if it is suffering from vaccine reactions. In the rearing house, adding vitamin K to the drinking water 48 hours prior to beak treatment is helpful to prevent hemorrhages.

Beak treatment is generally only performed in females, under good housing and management conditions, males should preferably not be beak treated. If males are beak treated it should be preferably performed gently and at an early age, from day old (hatchery) to 10 days. The beak is a key organ for proper mating: when the rooster grabs the hen by the back of the neck with his beak. Too sharp, too short, or uneven male beaks could have a negative impact on fertility.

The decision about the age at which beak treatment takes place depends mostly on the housing system and local regulations:

- Always check the latest local regulation on approved beak treatment practices.
- In dark houses, when the intensity of the light is low, beaks should be treated at one day old or at 7-10 days.
- For production in open-sided houses, where there is exposure to high natural light intensity, one single beak treatment at one day old or a light tipping at 10 days may not prevent pecking completely. If done too severely at that age, it will lead to a reduction in growth rate and uniformity. Under these conditions, beak treatment could be carried out twice - a light tipping at 10 days and then a second operation between 8 and 10 weeks of age, where local regulations allow it.

9.2 Beak treatment at one day old

The preferred method used for beak treatment at one-day old is the infrared beak treatment system (IRBT) in the hatchery. It is a convenient system with low costs and, depending on housing conditions, it may not be necessary to carry out a second beak treatment.

As the beak of a chick treated at one-day old is still sensitive, it is very important to use sideways activated nipples (360°) or nipple drinkers with cups and supplementary starting mini drinkers for the first few days, to ensure an easy access to drinking water in the rearing farm. Lowering the pressure in the nipples will also make it easier for the chicks to drink. The infrared treated part of the beak will fall off within 10 and 24 days of age.

Infrared beak treated day-old chick

Infrared beak treated chick at 3 weeks of age

9.3 Beak treatment at approximately 10 days

Early precision beak treatment at 7 – 10 days, when carried out properly, will have a minor effect on bodyweight development. In open-sided houses, where a second beak treatment at later age is scheduled and when local animal welfare regulations allow it, the early beak treatment should be performed less severely.

Method:

- Carefully choose the correct diameter hole on the beak treatment machine.
- Hold the chick in one hand, with the thumb behind the head, holding the head firmly in position resting the beak on the forefinger.
- Tilt the chick's beak upwards at an angle of 15° above horizontal and cauterize the reinforced side edges of the beak, to avoid unequal re-growth of the 2 mandibles.
- Cauterization contact time should be between 2 and 2.5 seconds.
- Check the temperature of the blade (600 - 650 °C) for each operator and machine, every hour.

Attention points

Before beak treatment:

- Do not beak treat birds if the flock is not in good health or if it is suffering from vaccine reactions.
- Add vitamin K to the drinking water 48 hours prior to treatment and afterwards to prevent hemorrhages.
- Check the equipment and make sure that the trimming blade is at the right temperature to cauterize but not too high to form a blister on the beak later. If the temperature is too low, bleeding can occur.

During beak treatment:

- The operator should be seated comfortably so that each beak is cut in the same manner.
- Do not rush the process. Going too quickly (number of birds/minute) could lead to a higher chance of errors and poor uniformity.
- Change blades when required.
- Make sure the birds' tongues do not get burned.

After beak treatment:

- Increase the water level in the drinkers and lower the pressure in the pipes.
- Avoid the feeders from becoming empty for one week.
- Use sideways activated nipples (360°) or nipple drinkers with cups.
- Use supplementary mini drinkers in the rearing farm for the first few days.

9.4 Beak treatment between 6 and 10 weeks of age

Late beak trimming, where local regulations allow it, is an aggressive operation and will temporarily have a negative impact in feed consumption and growth.

Within this age range, beak treatment at an earlier age will be easier for the operators but there is a risk of affecting the frame development at a crucial period, while a later beak treatment is more stressful for the breeder chicks but most of the skeletal growth of the chick is already finished. Looking from the animal welfare point of view, it is strongly advised to only apply beak treatment during the first 10 days of the life of the chick.

Ask yourself the Question if severe bak-trimming is needed

10 Bird behavior

10 Bird behavior

10.1 Introduction

Individual or flock behavior can be the result of individual factors, often it is a combination of multiple factors. In general, a laying hen can cope with moderate stress, such as rises or falls in temperature, transfer from the rearing barn to the laying facilities, or minor and gradual changes in the diet. It is important to recognize any significant change in the behavior of the flock, as the changes in behavior are good indicators of troubles within the flock. The sooner a problem is detected, the easier it can be to overcome the problem and limit its' impact. The most important behavioral characteristics to recognize are feather pecking and crowding.

10.2 Pecking

Feather pecking can become a major welfare problem in parent stock: severe feather pecking can result in severe feather damage, resulting in denuded body areas. These denuded body areas are more vulnerable for tissue pecking, wounding and, in more severe cases, mortality due to cannibalism or infected wounds. We should not forget that the feather cover also protects the females from scratches of the males during mating. Overall, in layer parent stock, the better the feathering, the better the chance for successful mating.

Next to feather pecking, pecking around the cloaca (also called vent pecking) can be one important cause of mortality. Vent pecking is often observed early in the laying period and towards the end of the laying period. Vent pecking is observed in both cage housings as in cage-free housing. In cage -free it mostly occurs when nests are too bright, or when the hens are producing floor or system eggs. Chickens are very curious by nature, and they can be triggered by the cloaca/egg production to think, "hey what's that". The wounds that are the result of the pecking, can trigger the birds again to peck at it, as it looks different/new to them. Good and timely management interventions can prevent excessive pecking behavior. Keep in mind that next to the economic losses of higher mortality, there are also economic losses related to feather cover as the loss of feather cover will lead in most cases to increased heat loss and consequently to higher feed consumption.

There are different kinds of pecking, in the eggs sector a distinguish is made between gentle pecking, which is considered as normal behavior or normal social interactions between laying hens, and severe pecking, which is abnormal behavior.

- Gentle pecking is defined as careful pecks, not resulting in feathers being pulled out and usually without reaction from the recipient bird. This is a form of social and explorative behavior. As brown egg layers are more curious compared to white egg layers, more of these social interactions between brown egg layers compared to white egg layers.
- Severe/injurious pecking is defined as forceful pecks, feathers are often being pulled out and you clearly can observe that the recipient hen is moving away, or she cringes. This form of severe/injurious pecking is clearly a form of aggressive behavior. This form of pecking often starts at the back, at the basis of the tail feathers. It also observed to start at the top of their heads and at their necks. When present at the neck, it is often misinterpret as being molting of the neck and neglected. You can distinguish molting versus pecking by looking closely to the feather loss, if you can observe true damage, it is most likely to be the result of pecking. Severe pecking can already start during the rearing period, it is known that flocks that had to deal with feather pecking in the rearing period, are more likely to develop pecking during the productive life.

There can be stressful circumstances, which can result in this aggressive pecking behavior. You can often hear typical pain squawks of the birds that are aggressively being pecked. It is extremely useful to take the time to listen to and to look at your flock. As this can help you in identifying changes in behavior sooner, allowing you to take more timely interventions. By forcing yourself to execute daily inspection rounds you will train yourself to listen to your flock, and to identify "what your flock is telling you". Any abnormalities in behavior, movements, sounds, presence in the system (for cage-free), are indicators of a serious stress that is affecting your flock.

The most common causes of pecking are listed below:

- Parasitic infection: external (red mites, poultry lice) or worm infestations (Ascaridia, Capillaria)
- Enteritis and diarrhea
- Inadequate ventilation, leading to high levels of humidity, dust or ammonia
- Drafts
- Non respect of density and equipment specifications
- Insufficient floor space, stress due to overcrowding
- Limited access to drinkers and feeders (insufficient number/ poor distribution)
- Difficulty to access nests, resulting in birds laying floor eggs that could results in pecking of exposed vents
- Shortage of water or feed
- Empty drinkers / feeders
- Water or feed unpalatable
- Too low pressure / leakage
- Improper ground connection of feeder and/or water equipment
- Poor beak treatment
- Feed not suitable
- Sodium deficiency
- Amino acids deficiency
- Lack of insoluble fiber
- Sudden change of feed particle size or feed ingredients
- Excessive energy level, leading to a reduction in bird's feeding time
- Mistakes in the feed composition – like incorrect salt inclusion
- Light intensity too bright
- Light source too powerful
- Direct light from fluorescent bulbs (especially) or tubes, depending on the type.
- Entry of direct sunlight into the poultry house
- Flickering lightbulbs
- Too sudden increases in the duration of light
- Nests illuminated too bright– birds' vents targeted during egg laying

Keep a close eye on the feathering of both males and females

As pecking is difficult to control once it has started, the objective is to be ahead of the problem to prevent an outbreak. If it does occur (bearing in mind that it is indicative of abnormal behavior) the objective should be to identify the problem promptly and remedy the cause as quickly as possible.

If a pecking outbreak occurs, you need to react quickly:

- Try to decrease the light intensity. Take caution as the % of floor eggs could increase, and feed intake could be decreased.
- When the lighting system allows, make use of the red LED light spectrum. Otherwise, you can paint the light bulbs in red or place red light covers over your TL's.
- Add salt into the water (0.5 - 1 kg / 1000 l).
- Add extra vitamins / minerals / amino acids in water.
- Add extra fiber sources within the house, like alfalfa or grain hulls.
- Add enrichments within the house (pecking blocks, fiber bales, plastic bottles, plastic toys, Compact Discs, etc.). Make sure that the enrichments are compliant to local legislation and they are not harmful to the hens.
- Try to isolate the birds that have been severely pecked (place them in an infirmary, sick pen), by removing them from the flock the remaining birds will be less distracted by the different behavior of the affected chickens.
- Natural calming products for poultry, like Pheromone blocks, could be used to "naturally" calm the birds.

Preventive actions that can be taken to avoid pecking

Equipment

It is advised to install a housing system that is creating different zones: zone to rest, a zone to lay eggs, a zone for dust-bathing and foraging, zones for eating and drinking. This is easier in cage-free housing systems compared to cage housing, but enrichments in cage housing (nest compartments, perches, scratching areas) can limit the impact of pecking. These different zones will also allow the pecked hens to find a place to escape. Never overpopulate the house, not in rearing, not in production. Allowing the birds sufficient space will give the birds less chances for negative counteractions, and there will be less competition for feeder and drinker space.

When wintergardens are provided to the flock, try to make them attractive by installing drinkers, and to create lots of opportunities for dustbathing. Dustbathing is a social activity, it encourages positive social interactions, it stimulates a healthy feather cover, and it can help the birds to get rid of lice and mites. For free-range or organic flocks with outdoor access: provide plenty of opportunities for the birds to shelter. Planting shrubs and trees will make the range more attractive, installing outdoor shelters will also provide the birds with a safe feeling. Try not to make the range attractive for predators as this can scare the birds off from using the range intensively. Installing an electricity wire at the outside of the outer fence can scare off foxes, coyotes, racoons, cats, dogs, and any other unwanted visitors.

During recent years, more information became available on the effects of lighting. LED lighting is strongly preferred. Daylight that enters the barn does not need to be a trigger for the flock to develop pecking. Many successful flocks have been reared and kept in production with natural daylight entering the barn. It is very important that the natural daylight is evenly spread when it enters the barn, it should not create big contrasts in regions that are very bright or that show a lot of shadow. Even light distribution is also important for all artificial light sources used, do not underestimate the impact of light on the behavior of chickens! If you'd like to be able to make use of the option to dim the lights in case of severe pecking, then it is advised to start off with bright lighting. This will allow you to use light dimming as an intervention method. The bright light will not harm the birds if no feather pecking occurs. Using the red color spectrum can help to lower the incidence of severe pecking, the red light will hide the differences in areas with or without feathers as well as the wounds. When you install new LED lighting, consider installing the LED's where you can easily switch on the red color spectrum.

Make sure nests are attractive, and they are available in sufficient quantities. Always avoid too crowded nests. Hens need to have the time and space to feel comfortable when producing an egg. Competition for nest space should be avoided. Well-designed attractive and clean nests, in sufficient availability, can reduce the incidence of floor or system eggs. Don't forget, hens producing eggs outside the nests are more prone to vent pecking.

Climate

A healthy, fresh, and well-balanced barn climate stimulates chick, and adult parent stock health in general. Ventilation is key as it can provide fresh air and stimulate a healthy climate (proper ventilation will reduce dust and ammonia levels). Always avoid draught, as this will have a negative impact on the barn climate. There is a higher chance to develop severe pecking under tropical, hot, and humid conditions. Laying hens and parent stock are better able to cope to colder, but dry climates, compared to hot and humid. Investing in good functioning climate control equipment will pay itself back over-time. When the chickens have access to litter, do keep an eye on your litter quality. Keep it dry and loose, remove caked litter as soon as possible, as it can negatively impact the climate inside the barn quickly.

Health Management

A good biosecurity plan is absolute key for all chicken farmers, whether it is rearing, parent stock or production. Good biosecurity will result in a lower risk of pathogens entering the barns and affecting the flock. Main message: keep it clean! Remove dead birds as soon as possible, regularly check the system, the nests, or the cages for the presence of dead birds. Gut health is key: most flocks that show feather pecking or cannibalistic behavior have troubles related to gut health. Adding acidifiers to the drinking water can promote gut health. Providing alfalfa, grass or hay can also have a positive impact on gut health. Always consult your nutritionist and poultry veterinarian to come up with a plan that is designed for your operations. Regularly check the acidity levels of the drinking water.
It is known that worms have an impact on general bird health, including the development of feather pecking / cannibalism. Monitor the worm infection status of your flocks regularly, deworm always in consultation with your poultry veterinarian, as too frequent deworming can also activate feather pecking / cannibalism (it something can kill worms, it is most likely to also impact the microbiota /gut health of the chickens). The presence of both (red) mites and lice are directly linked to feather pecking and cannibalistic behavior. They cause stress to the birds, and this stress can result in feather pecking / cannibalism. Have a mite / lice eradication program in place, again: prevention is often the cheapest and most effective method.
It is advised to install a separate pen for injured/wounded birds, this will allow them the rest needed for recovery, and they won't get the attention from the more curious birds. An infirmary is strongly advised for parent stock flocks. When you make use of an infirmary, the chickens have a better chance to survive and recover. It is also easier to treat the chickens.

Feed Management

Feeding techniques can be used to distract the birds from pecking each other. Supplying additional grain several times a day will keep the flock active, as something exciting is happening. Supplying coarse grains / coarse feed particles is promoting overall gut health, they take more time to digest resulting in a more "satisfied" feeling for the chickens. Adding grit, or oyster shell, will promote bird activity, and stimulated general health (including bone health) In case of cannibalism, extra salt can be temporarily (for a period of 1 week) added to the drinking water (0.5 - 1 Kg of salt / 1000 liter of drinking water). The diets provided to the flocks should be well balanced: protein, fat, carbohydrates, minerals, and vitamins should all be present in the sufficient proportions. Fibers and coarse particle sizes have shown to stimulate general gut health, as mentioned earlier, chickens with a healthy gut have a lower chance to develop severe feather pecking or cannibalistic behavior. For a complete overview of all the recommendations we kindly refer to our nutrition management guide.
The empty feeder technique is strongly advised, especially when birds with intact beaks are kept. The empty feeder technique will guarantee that there is no accumulation of the very fine particles, and it will prevent selective eating. The empty feeder technique stimulates also crop development and feed intake during the rearing period. For a full description of the empty feeder technique, we kindly refer to our nutrition management guide.
Please remember that chickens cannot deal well with dietary disruptions, introduce dietary changes gradually as too big changes will cause stress to the chickens.

Overall Management

Make sure that the birds are used to human interactions and noises. This habituation process should already start during the rearing process. Visit your flock frequently, so they know who you are. When you have technical visitors to your farm, make sure they wear farm coveralls, in a color they are used to (when they are used to blue coverall, and suddenly someone wearing a red coverall enters the barn, can cause panic/stress to the chickens. Installing a radio / radio boxes can help to train the chickens to get used to different sounds and can help in hiding background sounds.
For Parent Stock, make sure the male to female ratio is well balanced already since the housing in the production barn. Be aware that spiking, replacing older males by younger males, can result in stress for the hens.
There are many different options to distract the birds, often referred as enrichments. Think of pecking stones, pecking blocks, plastic bottles, big boxes, footballs, CDs, straw ropes, big plastic toys (that they cannot ingest). These are just a few of many enrichments that can come at low costs.

10.3 Prolapse

Several factors can adversely affect the egg production of a flock in which prolapse plays a prevailing role. Prolapse which causes reduced welfare of the hens, reduced productivity in laying hens and can be considered as a serious sickness. Prolapse in laying hens is a condition in which the lower part of a hen's oviduct turns inside out and protrudes through the vent. When a hen lays an egg, the lower part of the oviduct is momentarily everted through the cloaca. Usually, the hen can retract the oviduct after the egg has been laid. Sometimes the oviduct does not retract immediately once the egg has been laid. When a part of the oviduct is remaining outside the vent, it results in prolapse. Prolapse will result in discomfort for the hen and is often associated with a lot of pain, especially when hens are not able to get rid of the egg. A prolapse can trigger other birds to start pecking at the protruding oviduct. The pecking often triggers cannibalism, with fatal consequences in most cases. Most hens affected by prolapse also have troubles with defecating as the cloaca is being blocked, this is also associated with huge discomfort of the laying hens. Prolapse is a very serious condition that is treatable if caught early and is likely to recur, it usually causes permanent damage to the laying hen. Synonyms for prolapse include prolapse vent, oviduct blow-out or cloacal prolapse.

Causes

There are several factors related to prolapse. The major factors are hormonal disturbances, intestinal infection, overweight in birds, age at onset of lay, too early light stimulation, unbalanced diets, and the production of double yolk eggs.

Hormonal disturbances

Disturbances in the hormonal status of laying hen can result in the occurrence of prolapse. Low plasma estradiol levels have been found to be associated with the occurrence of prolapse in laying hens. Reduced plasma estradiol levels decrease the prostaglandin synthetase activity, which causes decreased prostaglandin level of the oviduct. Prostaglandin plays an important role in the muscular activity of the oviduct. Too low prostaglandin levels negatively affect the smooth muscular functioning of the oviduct, often resulting in prolapse. It should not be forgotten that the hormonal regulation in laying hens is heavily affected by photo stimulation (light stimulation). The impact of the rearing period should not be forgotten, and therefore the rearing program should be considered when investigating a flock with a significant prevalence of prolapse.

Behavior

Vent pecking (cannibalism of the cloaca) can be considered as both a cause and a consequence to prolapse in laying hens. owl. Vent pecking is one of the most widespread and severe forms of cannibalism in laying hens. Most laying hens die quiet quickly once vent pecking has started. The moist and glistering texture of the protruding uterus/oviduct attracts curious laying hens. Hens that have been beak-trimmed can still badly injure their follow laying hens, the protruding uterus/oviduct is soft, and will easily start bleeding, triggering more hens to start pecking. As mentioned in the pecking section, flocks that produce significant amounts of system and floor eggs, or when nests are too bright, have a higher chance to develop cloaca/vent pecking. Prolapse occurs in all housing systems, cannibalism can be more present in cage housing as there are more interactions between the laying hens and less room to escape from the injurious pecks.

Body size

Body weight, body size, or frame are related to the occurrence of prolapse. Underweight hens (i.e., poorly developed hens that have a small body frame, but also in overweight (obese) hens have a higher chance to develop prolapse. In these birds the uterus may be slow to retract, allowing fellow laying hens to start pecking at it. When the uterus is traumatized / irritated, the laying hen has more difficulty in retracting the uterus. Overweight birds have the tendency to lay bigger eggs, big egg size is negatively associated with the development of prolapse, i.e., the bigger the eggs, the higher the chance to develop prolapse. Underweight birds are often underdeveloped, an underdeveloped pelvic girdle is associated with higher risk to develop prolapse. Monitoring of body weight, and steering on body wight during the rearing period, and during the first months in the production barn are key when it comes to good flock management. Good uniformity in body weight, and body weight development can be obtained by providing the breeder flock sufficient space to grow, not only in available floor space, but also feeder and drinker space, competition should be always avoided.

Age of the birds

The highest development of prolapse is most likely to occur around peak production. To flatten off the continuous increase in egg size as the hens get older, a lower demand will be asked from the laying hens' metabolism, reducing the chance to develop prolapse.

Double yolk eggs

As a result of the excessive size of double yolk eggs, a lot of pressure is being placed on the uterus, and the cloacal muscles. When they are stretched too much, there is an increased chance to develop prolapse, as it becomes harder for the hen to retract the uterus. It is expected that the incidence of prolapse in laying hens can be reduced via breeding by actively selecting against the production of double yolk eggs.

Unbalanced diets

The main parameters in feed formulations which help to prevent prolapse, are energy, protein together with calcium and phosphorus levels. Pre-lay management is essential to prepare the flock for a good start of egg production. Contact your nutritionists and feed suppliers to take a close look at the pre-lay diet formulation, and make sure that the laying hens have time to adapt and prepare themselves.
Calcium plays an important role, not only for eggshell formation and strong and healthy bones, but also for good functioning muscles. Weak muscles have a higher chance to result in prolapse, as in general it takes longer to retract the oviduct back into the hen's body. A proper functioning calcium absorption / extraction mechanism is there for key, phosphorous plays an important role in maintain this mechanism.
An increased accumulation of fat in the abdominal region can result in prolapse. The presence of too much fat can narrow the egg passage, increasing the pressure that is needed by the hen to lay the egg. This increased pressure can stretch the muscles too much. A balanced diet is therefore key, as an overall too high fat content can easily result in the accumulation of abdominal fat. This is also true for a too high energy content (often related to too high fat, or too high carbohydrate content).

When feeding very high levels of protein, the chance to develop big eggs is increased, also that of double yolk eggs. Stimulating egg size via the diet should be not too much of a concern when it is being done gradually.
The role of fiber should not be underestimated in relation to laying hen behavior, fiber can have a very positive impact d thereby catching their attention to the exposed oviduct when eggs are being laid. Light stimulation (photo-stimulation by adding extra hours of light) should always be done based on achieved body weights, never just on age of the birds. Weekly monitoring of bodyweight in the rearing period is absolute key when growing breeder chicks! One major effect of light is altering the age of sexual maturity of the breeder females (the moment the hens start to produce their first egg). It is not the intensity of light that causes the difference but it's the change in day length that alters the age that the first eggs are laid. The bodyweight development during rearing will tell you a lot of information about the development of the breeder flock (both males and females). It is known that breeder females that are exposed to increasing day length before the reproductive tract has fully matured are more likely to suffer from prolapse, because the reproductive tract may not be fully matured when they start to lay. When breeders reach sexual maturity too early, the result will be excessive numbers of small eggs and an increased incidence of prolapse (to small frame, not fully developed reproductive tract). Sudden increases in light duration can result in jumbo eggs (very large eggs), also these can cause prolapse to occur.
Take a close look at the breeder recommendations for light duration, and light intensity.

Disease

Disease related to prolapse are enteritis, constipation, egg drop syndrome (EDS), Infectious Bronchitis (IB) but also Marek's disease and the presence of ecto- and endoparasites (lice and mites causing irritation and discomfort of the vent). EDS and IB cause weakening of the oviduct and immunodepression. Marek's disease causes enlarged liver, kidneys, spleen and thickened intestine, which can increase the pressure on the oviduct. The best possible protection against disease is to have good functioning vaccination and biosecurity plans in place.

Tips

- An early indicator of the occurrence of prolapse is the presence of eggs containing blood-streaks, keep an eye on these when sorting your eggs at the egg belt.
- Visit the flock frequently, listen to sounds of cannibalistic pecking, look for signs of vent pecking, and try to isolate injured birds, and treat them, when possible, with wound spray.
- Monitor nest box occupation, are there sufficient and comfortable nest available, and are they attractive to the birds? Please note that nests should also not be too attractive, to avoid them being inside the nests all day. In breeder flocks they often make use of closed nest management in the late afternoon, to avoid the birds spending too much time inside the nests.
- Do you observe any competition around the feeders or drinkers? Always avoid competition around feeder and drinker space, as this will trigger negative behavior.
- Closely monitor bodyweight and bodyweight development during rearing. Avoid birds from getting underweight or overweight via management.
- Light stimulation should always be done on body weight development and uniformity of the breeder flock.
- Avoid sudden light stimulation.
- Balanced diets are key, introduce dietary changes gradually, and according to the flock it's needs.

Monitor nest box occupation and answer the following question: are there sufficient and comfortable nest available?

10.4 Broodiness

Broodiness can appear in certain flocks in cases of stress or when they are generally underweight. Nutrient deficiency, heat stress and any factors related to poor growth can lead to broodiness. Laying eggs on the floor can also result in broodiness. Preventing floor eggs and frequent egg collections will limit the amount of broodiness (chapter: Preventing floor eggs).

Broodiness can be identified by behavior patterns such as staying in the nest, fluffed feathers, clucking and aggression. Therefore, we advise closing nests at the end of the afternoon but a few hours before "lights off". Nests should not be closed until 4 hours before "lights off" to avoid the loss of late laid eggs. To minimize the interruption to laying, rapid action will be needed to correct the problem.

Broodiness and lay link duration

Time broody (days)	Pause in lay (days)
1	7
2	9
3	12
4	18

According to B. Sauveur (I.N.R.A)

We advise isolating broody birds from the moment they appear (in the evening). Place them in a spacious pen, on a concrete or slatted floor without a nest. The density in the pen must not be greater than 6 per m^2. The birds must have feed and water permanently. At the end of 4 days, those which respond (widening of pelvic bones) can be placed back with the flock. It is thought that supplying aspirin or paracetamol to the broody hens can help to overcome broodiness.

10.5 Smothering/crowding

Non cage housed brown birds sometimes tend to crowd together. This natural behavior can be triggered by different situations:

- Panic reaction - when birds are frightened, they try to avoid danger.
- Attraction - when they are attracted by something, birds are curious and naturally want to find feed and discover their environment.
- Sleeping behavior.

Smothering may occur during lay in different parts of the poultry house and often the reason is not clear. However, in flocks that are in production, it is most observed around the peak of production, as it seems to be related to stress situations. Identifying the time when smothering occurs and the areas in the poultry house where birds tend to gather will give some hints to find the reason of such behavior.

Although unpredictable, smothering is more frequently observed in these situations:

- In the evening at "lights off".
- At rest, after egg laying (noon).
- Along partitions, due to curiosity (e.g. presence of the stockperson in the house).
- Following a change in feeding times, in feed composition or due to lack of feeding or drinking equipment.
- When flocks are restricted in their feed intake, or when feed intake is low.
- When direct sunlight is getting in the poultry house.
- Inadequate ventilation, uneven in-house temperature and drafts

To control the risk of smothering:

- Minimize the number of corners (e.g. with feeders).
- Ensure an even light distribution within the house. Install light traps/deflectors.
- It is advised to use LED lighting, if your barn is still equipped with TL lighting, try to replace them by LEDs. Todays' LED lights often come along with different color spectra. Good results with bird behavior, and distribution over the barn, have been obtained by using a warm white LED lighting color scheme.
- Construct partitions with wire mesh, birds crowding against a mesh partition are still able to breathe
- Use wire mesh covered triangles to eliminate corners.
- If crowding occurs during the evening, for example close to sunset, check that sunlight does not enter the house through the pop holes. This is almost certain to attract too many birds into a small area. Installing deflectors in front of the pop holes may solve this issue.
- Visit the birds at the end of the day or when lights go off to check behavior, especially in the first few days after delivery.
- Install music in the houses so the birds react less to unexpected and sudden noises.
- Carry out a feed distribution one hour before lights go off. It will evenly distribute birds throughout the building. The extra heat produced during digestion will avoid crowding before night.
- The lighting program must be adapted to natural day length. Try to avoid switching off the lights before sunset, especially during long days. This should be considered at the time of flock placement.
- Ensure that available perch space is adequate.
- Adapt the ventilation to obtain a uniform environment in the house and to avoid drafts.
- Avoid any feed restriction at the critical periods.
- Change the feeding times to introduce change to the behavior of the birds whilst not disturbing them too much.
- Give scratching material (e.g. grain/grit) in the afternoon to keep birds occupied.
- White Plastic bags, suspended from the ceiling, well above bird level (not allowing the chickens to peck at them) in the corners can prevent from smothers in those areas.

10.6 Enrichments

Introducing environmental enrichments to the flock can have a beneficial impact on the health and wellbeing of the birds. Make sure you use these enrichments correctly, and make sure they are safe to use. You can rotate the use of enrichments during the birds' lifetime, this will prevent the birds of being bored with them and directing their behavior towards the other birds. There are many examples of enrichments that can be used, below we have stated some commonly seen enrichments:

- Pecking blocks/stones
- Alfalfa / luzerne bale, straw bales
- Compact discs
- Ropes
- Cardboard boxes (like television boxes)
- Plastic bottles filled with stones

11 Preventing floor and system eggs

11 Preventing floor and system eggs

11.1 Floor eggs

11.1.1 Introduction

Prevention of floor eggs is a key factor for flock success. Avoiding this behavior requires a lot of attention at the beginning of lay. In this section, we define floor eggs as all eggs laid out of the nest such as floor, slats, and system eggs. The three main points are:

- The nest must be more attractive and comfortable than other parts of the hen house.
- Access to the nest must be easy for birds.
- There must be enough nest boxes in the house.

11.1.2 Light

Light management is one of the main factors in the prevention of floor eggs. If nest box lights are installed to make not too bright. Nest boxes to open 2 hours before the main lights come on to avoid overcrowding. Avoid putting feeder on during the most active times the birds are likely to be using the nest as this distracts them and blocks access to the nest.
Light must be well spread in the laying house and shadow areas need to be avoided. Birds naturally lay in darkened areas. This can be prevented by a simple action such as replacing broken bulbs and adding light to the shadow areas.
When possible, a progressive "lights off" process should be done. Lights underneath the system should be turned off first, followed by the lateral light; this will encourage birds to go close to the nest and to sleep on slats and in the system, then finally, the central light and the lights in the system should be switched off. According to breed and lighting program, a variable percentage of birds will lay before "lights on" and the propensity to lay on the floor is higher for these birds. Night lights in the nest encourage these early birds to go into the nests for laying, before the general lights come on.
Where legislation allows it, a short light period during the night (for example 1h30 of light, 3 hours after "lights off"), will delay the lay of one part of the flock and reduce the competition for the nest. This will be more efficient if the number of birds per nest is high, allowing all hens an easy access to the nests. In some situations, adding one extra hour of light in the morning could solve a floor egg problem.

11.1.3 General management advice

The rearing system should be as similar as possible to the egg production system, this to avoid the risk of increased number of floor eggs. Installation of perches in the rearing house before 4 weeks of age is recommended. Light intensity should not be too high, because high intensity increases the sensitivity to dark areas in the laying house. Early transfer is strongly recommended to avoid the onset of lay in the rearing house, which can encourage the birds to lay on the floor in the laying house.
Any corners caused by equipment or building design are potential areas for eggs to be laid. Therefore, limiting access to corners prevents floor eggs. It has been observed that keeping the birds on the slats or in the aviary system for too long may increase the incidence of floor eggs. The floor scratching area should be accessible when the flock has discovered the upper area (nest, feeder, drinker).
At the beginning of lay, frequent floor egg collection should be done several times per day. At the onset of lay the minimum is every hour. An egg on the floor will encourage other birds to lay in the same place. Ensure all the birds sleep on the slatted area or in the aviary system. Observing where floor eggs are laid can help to explain the reason for the behavior. This information can be very useful to help understand the problem and to develop a solution.
Grit distribution on the floor discourages floor eggs by eliminating the building of potential nests in the litter. The installation of a deflection barrier between the nest boxes helps the birds to be evenly distributed, thereby decreasing the pressure in particular nest boxes. This also helps to prevent the overcrowding of nests located near to partitions.
Frequently remove the manure and litter in the litter area to prevent the floor of being too comfortable to serve as a nesting area. Especially for white birds it is important to remove the litter soon enough, as they have the tendency to go and lay on the litter.
Within the local welfare constraints, a good quality, adjustable and approved electric fence could be installed. Used from the very start and until 26 weeks – 28 weeks of age. It is advised to install it on the internal perimeter wall.

11.1.4 Behavior

Just before laying (approximately 30 minutes), birds express a specific behavior called "pre-laying behavior" which consists of 3 phases:

- Active nest searching
- Choice of nest
- Nest creation

Birds should not be disturbed while they are searching for a nest as they will stop searching. Disturbances cause them to lay where they are at the time, increasing floor egg numbers. For instance, feed distribution or an egg belt running can also disturb the process of searching for a nest. Therefore, if floor eggs are a problem, the best is to avoid disturbing the birds with feed distribution, or egg collection, during the lay.

11.1.5 Ventilation

Nests must be comfortable, to encourage birds to lay there. During winter, prevention of direct cold drafts around the nest is recommended, while during summer, nests should be well ventilated. Specific ventilation adjustments should be done to increase airflow on the floor or lateral areas. The purpose of ventilation is to create a comfortable area close to and in the nest, more comfortable than the other part of the laying house. Ventilation should be adjusted according to the season.

11.1.6 Equipment

The position of the equipment and the stocking density can affect floor eggs.

Feeder drinker	Feeders should not be too close to the nest boxes, to prevent the accumulation of birds in front of the nests. Drinkers need to be put close to the nest boxes to attract the birds to the nest boxes.
	Take care of feeder and drinker height (no creation of physical barrier between bird and nest)
	Enough feeders and drinkers to avoid competition and stagnation near to them
Nest	Clean and attractive (without broken eggs, manure, etc.)
	Adequate number (a maximum of 120 birds / m² communal nest or 5-6 hens/single nest)
	Nest access management: close the nest a few hours before 'lights off' open the nest before 'lights on'
Slats	Not too high, installation of ramp / ladder: easy access from scratching area to slats
	Slat slope not too steep: comfortable area, facilitate nest access

Installation of ramps allows the birds to move up and down, making it easier to visit the nests, and sleeping on the slats.

11.2 System eggs

Eggs laid on the system can be a common problem in certain aviary systems.

To avoid it we recommend:

- To promote birds perching as high as possible during the night, this will avoid crowding in front of the nest box in the morning.
- High perching can be promoted by using a longer dimming period but not longer than 30 minutes.
- The light intensity in the systems close to the light intensity in the rest of the house helps to create an environment that is not comfortable to lay eggs.
- Avoid those lights in the system that also light the nest boxes.
- It is essential to promote that the birds use the perches and the plateau, so they can move up and down in the system, or between the systems.
- Vertical movement can be stimulated by limiting access to water or feed on certain levels. When this is practiced it is at the utmost importance to check if all birds eat and drink sufficiently.
- Plan the increase of the light duration correctly; provide the extra hours of light in the evening when the birds are not yet in production and add them in the morning as soon as the birds have started to lay. This will lead to a better spread in the occupation of the nest boxes.

When eggs are produced on the top level, this is in most cases because the birds are afraid to move down. Placement of extra perches can help to promote vertical movement and to avoid mislaid eggs on the top level. No feeding on the upper level for the first feed distribution in the morning may also help to avoid the lay in this area.

In many occasions eggs are produced on the middle level of the system; the reason for this is feed and water access at the middle level. Closing the drinker line in the middle level during the morning can promote the bird's movement to the drinker line in front of the nest.

Recording of floor and system eggs and have an egg collection scheme in place can help to understand what happens after changing the feed, water, or light management.

In aviary systems, light management is key to steer flock behavior and preventing floor and system eggs.

12 Nutrition

12 Nutrition

12.1 Feeding during the rearing period

Basic feeding principles for chicks
- Do not change the feed if birds do not reach the standard body weight.
- Promote early growth, skeleton, and organ development by providing feed in crumble form for starter diet for at least 3 weeks, and preferably up to 5 weeks of age.
- Use a uniform and good coarse mash feed for grower, developer, and pre-lay feed.
- Promote the development of the digestive tract and the birds' feed intake capacity by feeding management (fiber, coarse calcium and grit).

During the first few weeks of life, it is advised to provide young chicks the feed in a crumb form, so they can increase their feed intake and have a more homogenous feed intake. During the period 10 - 17 weeks, under-consumption is often the result of a poor particle size. It is important to develop the digestive system by using diets at the end of rearing with an energy concentration lower than or equal to that of the first layer phase diet.

12.1.1 Protein requirement

The amino acid requirements are to a large extent dependent on the feed conversion ratio and, therefore on age. Any delay in growth during the first few weeks will be reflected in a reduced bodyweight at 17 weeks and in later performance. It is, therefore, important to use a starter diet for the first 4 or 5 weeks, which has a high energy and protein content. Any amino acid deficiency will result in a reduction in growth rate and an increase in the FCR. In hot climates, the amino acids and minerals concentrations should be slightly higher than in temperate climates.

12.1.2 Energy requirement

The main difference in feed between cage and alternative housing is the energy requirements. Birds in alternative production systems are more active and, in case they have access to the range, they are confronted by temperature variations. Depending on the housing system, the temperature and the birds' feathering, feed consumption can be increased by 3 to 20%. Although the energy requirement is increasing, amino acid requirement is not. Therefor it is important to increase the energy level of an alternative production feed compared to a cage production feed, while maintaining the same requirements for protein and amino acids.

12.1.3 Feed presentation

Feed consumption is determined to a large extent by the form of feed presentation and the stage to which the digestive tract has developed. During the first few weeks of life, young chickens are incapable of regulating their energy intake according to the energy concentration of the diet. Young chickens can increase their feed intake when fed crumbles. The table below shows the effect of energy level and presentation method on the bodyweight of chicks at 5 weeks of age.

Table : Energy level and feed presentation on bodyweight of chicks in rearing

Presentation Dietary Energy Level	Mash Bodyweight at 5 weeks	Crumbs Bodyweight at 5 Weeks
3100 kcal	375 g	412 g
2790 kcal	345 g	405 g

(Newcombe, 1985)

Presenting starter feed in crumb form makes it easier for the chicken to eat it, makes the feed intake more homogenous as all particles should be equal, reduces the time taken in eating, and encourages growth. This benefit of feeding crumbs will only be obtained when the birds have access to good quality crumbs in the feeders. A poor-quality crumb can lead to a build-up of fine particles in the feeders and therefore have the opposite effect. We recommend using a mash diet from 5 weeks, to avoid the risk of under- consumption at the beginning of the sexual maturity if the change is made later.

12.1.4 Development of the digestive system

A larger crop and gizzard will increase the feed intake capacity of the chicken. Gastrointestinal development can be stimulated in the second part of the rearing period by providing coarse particles in the feed. This can be done by including coarse insoluble fibers, larger particles of slowly soluble limestone, and/or providing insoluble grit. If a high fiber diet is difficult to achieve lignocellulose can be used, which provides the correct form of fiber in powder form. Limestone granules can be provided from 10 weeks of age onwards. From this age 50% of the calcium can be supplied as coarse, slow soluble, calcium carbonate with a particle size of 2 to 4mm. Grit can be provided from 3 weeks of age onwards. Between 3 and 10 weeks of age, we recommend 3g per chick per week with particle size 2 to 3mm. After 10 weeks this can be increased to 4 to 5g per chick per week with particle size 3 to 5mm.

12.1.5 Pre-lay feed

Medullary bone is developed in long bone before the first ovulation. The total calcium contained in this medullary is around 1.5 to 2 grams. A pre-layer feed with a higher calcium level compared to a developer feed is needed to establish this bone reserve. It must be used from approximately 10-14 days before the first egg till 2% production. Its characteristics are similar to the layer 1, but with a level of calcium of 2.1 - 2.5%.

A prelay diet will facilitate feed consumption after transfer. Layer diets contain high amounts of coarse calcium carbonate particles and therefore differs strongly compared to the rearing diets. The prelay diet minimizes the negative transition effect and increased layer feed palatability.

Placing a sufficient amount of feeders will help the birds to find feed easily and support their growth

12.1.6 Feed specifications during the rearing period

The suggested feed specifications during rearing are mentioned in the table below. Depending on the body weight developmentof the breeder flock, the start of a new feed phase can be delayed.

Table: Nutrient requirements during the rearing period

	Diet units	Starter 0 - 5 weeks 1 - 35 days	Grower 6 - 10 weeks 36 - 70 days	Developer 11 - 16 weeks 71 - 112 days	Pre-lay 17 weeks to 2% lay
Minimum Metabolisable energy	Kcal/kg	2950-2975	2850-2875	2700-2750	2700-2750
	MJ/kg	12.3-12.4	11.9-12.0	11.3-11.5	11.3-11.5
Crude Protein	%	20.50	19.00	16.40	16.80
Lysine	%	1.16	0.98	0.77	0.81
Methionine	%	0.52	0.45	0.37	0.40
Methionine + Cysteine	%	0.93	0.86	0.68	0.66
Threonine	%	0.80	0.66	0.54	0.58
Tryptophan	%	0.21	0.20	0.18	0.18
Valine	%	0.99	0.84	0.65	0.69
Isoleucine	%	0.89	0.76	0.59	0.62
Arginine	%	1.08	0.92	0.76	0.81
Apparent faecal digestible amino acids					
Dig. Lysine	%	1.00	0.85	0.66	0.71
Dig. Methionine	%	0.48	0.41	0.34	0.38
Dig. Meth. + Cysteine	%	0.84	0.74	0.61	0.59
Dig. Threonine.	%	0.69	0.59	0.46	0.49
Dig. Tryptophan	%	0.19	0.17	0.15	0.16
Dig. Valine	%	0.85	0.74	0.56	0.58
Dig. Isoleucine	%	0.78	0.65	0.51	0.59
Dig. Arginine	%	0.95	0.87	0.69	0.75
Major minerals					
Calcium	%	1.05 - 1.10	0.90 - 1.10	1.00 - 1.20	2.10 - 2.50[1]
Available Phosphorus	%	0.45 - 0.50	0.45 - 0.50	0.42 - 0.47	0.45 - 0.50
Retainable Phosphorus	%	0.38 - 0.42	0.38 - 0.42	0.36 - 0.40	0.38 - 0.42
Chloride	%	0.15 - 0.25	0.15 - 0.25	0.14 - 0.24	0.14 - 0.24
Sodium	%	0.18 - 0.21	0.16 - 0.21	0.16 - 0.20	0.16 - 0.20

[1] Supply 50% of the calcium in granular form (2-4mm diameter)

12.2 Feeding program during the production period

12.2.1 Feeding management

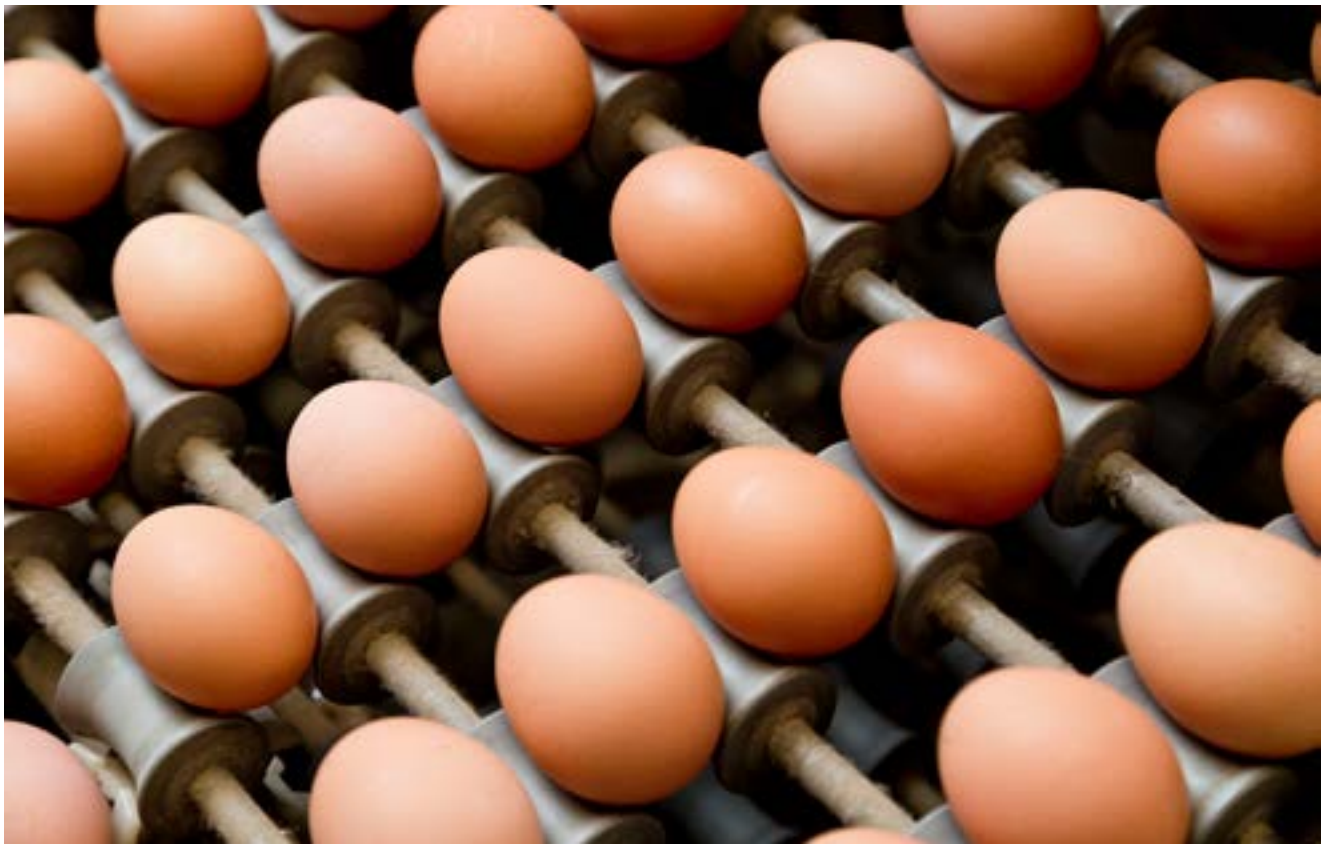
Feeding management during production should follow several simple rules:

- Preferably the birds should eat a greater part of their daily ration (60%) during the second half of the day. The fast accumulation of calcium in the eggshell starts at this time and the birds can effectively utilize the calcium from the feed to form a good eggshell.
- The last feed distribution, 1 - 2 hours before "lights off" also encourages the birds to get to the house from the range and further onto the system (slatted area and perches) and to sleep there. The amount of feed distributed must be sufficient to cover the increased consumption during the next morning.
- Birds are very sensitive to feed presentation and the introduction of new raw materials. For this reason, we recommend a limited number of feed changes and a stepwise introduction of unknown or new harvested raw materials.
- The amino acid requirement depends on the productivity of the flocks and the uniformity of productivity. Our amino acid recommendations are based on an average productivity of 59.5g egg mass per day. At 50 weeks, the daily egg mass produced is around 58g. Many birds can produce more than 60g of egg mass over a period of 50 – 65 weeks. Therefore, we recommend changing to a next feed phase if daily egg mass is decreasing.

The amount of feed distributed must be sufficient to cover the increased consumption during the next morning: the birds will be hungry after the night period and will easily finish the less attractive fine particles. As the feed is not distributed in the early morning, the hens have time to find a nest and lay the eggs without being disturbed by a new feeding round. The feeding system may stay empty for one or two hours. This will create enough appetite in the birds to start the intensive feed consumption in the afternoon when you want the birds to eat the most.

12.2.2 Shell quality

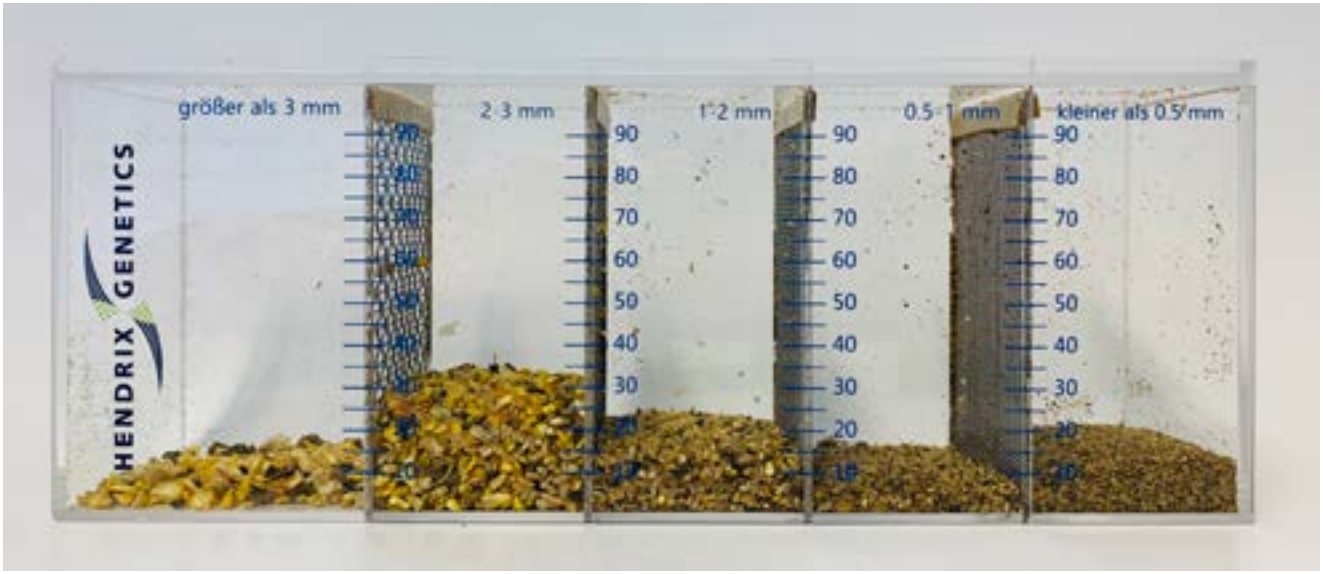
Shell weight increases while the absorption rate decreases with age throughout lay. For that reason, we advise increasing the calcium concentration in the diet from 50 weeks of age.



12.2.3 Effect of granulometry

Feed consumption is highly dependent upon granulometry. Chickens have a marked preference for coarse grains. During lay we recommend the following particle sizes:

- Particles below 0.5 mm: 10 % maximum.
- Particles above 3.2 mm: 10 % maximum.
- At least 80% of the particles should be between 0.5 and 3.2 mm.



12.2.4 Genetic progress and nutritional consequences

Genetic progress has a considerable influence on dietary amino acid concentrations. Over the last 50 years, measured at a consistent age, production has increased by more than 40%, while feed consumption has been reduced by about 10%. Therefore, the daily amino acid requirements need to be adjusted according to the daily egg mass and to the feed consumption.

12.2.5 Conclusion

The feed density (g/liter) seems to be the limiting factor in ingestion regulation. The use of insoluble fiber increases gizzard size, it improves nutrient digestibility and limits feather pecking by reducing the need to ingest feathers. The feed presentation influences feed consumption and consequently nutrient consumption.

It follows that 3 factors must be controlled and a balance between these 3 criteria must be sought to realize the full genetic potential at the lowest cost. The factors are:

1. the physical form of the feed
2. the insoluble fiber content
3. the nutrient density

12.3 Feed formulation

12.3.1 Nutrient Recommendations

The amino acid concentration of the diets depends on:
1. The potential of egg mass produced, which determines the daily requirements.
2. The daily feed consumption which determines the amino acid concentration.

Feed specifications during the production period

The suggested feed specifications during production are mentioned in the tables on the next pages. Depending on the egg mass produced, the start of a new feed phase can be delayed. In the meantime, in case necessary calcium can be increased over time to obtain a good eggshell quality. Please make sure the changes between the different phases are gradual changes.

Layer 1

This feed must be used from start of production till 55 weeks of age, or when daily egg mass starts to decline. It is advised to formulate for higher energy levels (+ 75-100 kcal per kg feed) in the production phase compared to the developer phase. Layer 1 must meet the requirements for the amino acids and energy levels required for further growth and production at a time where the feed consumption is still low. Please keep in mind that the bird's growth is still not finished at start of production and continues till 35 weeks of age. When looking to the protein levels, the requirement for growth is added next to the requirement for egg production. At the onset of lay, feed consumption is lower because the birds have not yet reached their adult bodyweight and the digestive system is not yet prepared and trained to such high levels of feed intake, while feed consumption needs to increase by 40% in that short period of time.

At the onset of lay, it is desirable to encourage nutrient consumption to obtain quickly eggs of marketable size. For this, a feed enriched in fat allows to improve the presentation of the diet which results in an increase in feed consumption. Oils rich in polyunsaturated fatty acids, or mainly linoleic acid, are responsible for a large increase in egg weight. From a practical point of view, the dilution effect of raw materials which are rich in insoluble fiber and of low density can be compensated by the addition of fat. Feed granulometry also affects nutrient consumption, too fine feed particles lead to a reduction in feed consumption.

When considering the persistency in lay, the individual variation within the flock and the egg weight curves, it can be stated that the bird's amino acid requirement does not fall throughout the laying period. In an economic context, it may be worth reducing the safety margins slightly. However, the best results, in terms of productivity and feed conversion ratio, are achieved when the amino acid intake level is maintained. Any amino acid imbalance, no matter the type, results in a reduction in performance. 2/3 Of this reduction is due to a reduced rate of lay, the remaining 1/3 is the result of a decrease in the mean egg weight. Therefore, it is not possible to reduce the egg weight towards the end of lay by reducing the amino acid concentration without sacrificing the rate of lay.

Layer 2

Depending on the daily egg mass produced, this feed must be used from 55 till 80 weeks, or until the end of lay. It is advised to formulate for lower energy levels (-25 kcal per kg feed) in layer 2 compared to layer 1. As laying hens have daily requirements for amino-acids and minerals, it is important that the percentage of nutrients must be defined according to the feed consumption and the production results observed. The feed consumption is highly determined by the energy requirements and the climate observed by the birds.

Recommendations for amino acids expressed as total and digestible amino acids during production in White and Brown layers and given for alternative feed intake levels: Layer 1

Layer 1 - From 2% lay to 55 weeks	mg/h/d	unit per kg feed	100	105	110	115	120	125
Energy Cage Housing		kcal			2800-2900			
Energy Alternative Housing		kcal			2800-2950			
Protein Minimum		%	17.6	17.2	16.8	16.4	16.0	15.6
Total amino acids								
Lysine	980	%	0.98	0.93	0.89	0.85	0.82	0.78
Methionine	510	%	0.51	0.49	0.46	0.44	0.43	0.41
Methionine + Cysteine	860	%	0.86	0.82	0.78	0.75	0.72	0.69
Threonine	665	%	0.67	0.63	0.60	0.58	0.55	0.53
Tryptophan	230	%	0.23	0.22	0.21	0.20	0.19	0.18
Valine	845	%	0.85	0.80	0.77	0.73	0.70	0.68
Isoleucine	770	%	0.77	0.73	0.70	0.67	0.64	0.62
Arginine	1000	%	1.00	0.95	0.91	0.87	0.83	0.80
Digestible amino acids								
Lysine	850	%	0.85	0.81	0.77	0.74	0.71	0.68
Methionine	470	%	0.47	0.45	0.43	0.41	0.39	0.38
Methionine + Cystine	740	%	0.74	0.70	0.67	0.64	0.62	0.59
Threonine	595	%	0.60	0.57	0.54	0.52	0.50	0.48
Tryptophan	190	%	0.19	0.18	0.17	0.17	0.16	0.15
Valine	750	%	0.75	0.71	0.68	0.65	0.63	0.60
Isoleucine	680	%	0.68	0.65	0.62	0.59	0.57	0.54
Arginine	885	%	0.89	0.84	0.80	0.77	0.74	0.71
Minerals								
Available phosphorus min	450	%	0.45	0.43	0.41	0.39	0.38	0.36
Available phosphorus max	480	%	0.48	0.46	0.44	0.42	0.40	0.38
Retainable phosphorus min	380	%	0.38	0.36	0.35	0.33	0.32	0.30
Retainable phosphorus max	410	%	0.41	0.39	0.37	0.36	0.34	0.33
Total calcium min1	3900	%	3.90	3.71	3.55	3.39	3.25	3.12
Total calcium max1	4100	%	4.10	3.90	3.73	3.57	3.42	3.28
Sodium minimum	180	%	0.18	0.17	0.16	0.16	0.15	0.14
Chlorine minimum	170	%	0.17	0.17	0.17	0.17	0.17	0.17
Chlorine maximum	260	%	0.26	0.26	0.26	0.26	0.26	0.26

1 in case necessary calcium can be increased over time to obtain a good eggshell quality

Layer 1 respected a daily egg mass of 59.5 gram

Recommendations for amino acids expressed as total and digestible amino acids during production in White and Brown layers and given for alternative feed intake levels: Layer 2

Layer 2 - From 55 to 80 weeks	mg/h/d	unit per kg feed	105	110	115	120	125	130
Energy Cage Housing		kcal			2775-2875			
Energy Alternative Housing		kcal			2775-2925			
Protein Minimum		%	16.1	15.7	15.3	14.9	14.5	14.5
Total amino acids								
Lysine	935	%	0.89	0.85	0.81	0.78	0.75	0.72
Methionine	490	%	0.47	0.45	0.43	0.41	0.39	0.38
Methionine + Cystine	830	%	0.79	0.75	0.72	0.69	0.66	0.64
Threonine	635	%	0.60	0.58	0.55	0.53	0.51	0.49
Tryptophan	220	%	0.21	0.20	0.19	0.18	0.18	0.17
Valine	808	%	0.77	0.73	0.70	0.67	0.65	0.62
Isoleucine	735	%	0.70	0.67	0.64	0.61	0.59	0.57
Arginine	963	%	0.92	0.88	0.84	0.80	0.77	0.74
Digestible amino acids								
Lysine	815	%	0.78	0.74	0.71	0.68	0.65	0.63
Methionine	450	%	0.43	0.41	0.39	0.38	0.36	0.35
Methionine + Cystine	710	%	0.68	0.65	0.62	0.59	0.57	0.55
Threonine	570	%	0.54	0.52	0.50	0.48	0.46	0.44
Tryptophan	180	%	0.17	0.16	0.16	0.15	0.14	0.14
Valine	715	%	0.68	0.65	0.62	0.60	0.57	0.55
Isoleucine	650	%	0.62	0.59	0.57	0.54	0.52	0.50
Arginine	850	%	0.81	0.77	0.74	0.71	0.68	0.65
Minerals								
Available phosphorus min	400	%	0.38	0.36	0.35	0.33	0.32	0.31
Available phosphorus max	420	%	0.40	0.38	0.37	0.35	0.34	0.32
Retainable phosphorus min	340	%	0.32	0.31	0.30	0.28	0.27	0.26
Retainable phosphorus max	360	%	0.34	0.33	0.31	0.30	0.29	0.28
Total calcium min1	4200	%	4.00	3.82	3.65	3.50	3.36	3.23
Total calcium max1	4500	%	4.29	4.09	3.91	3.75	3.60	3.46
Sodium minimum	180	%	0.17	0.16	0.16	0.15	0.14	0.14
Chlorine minimum	170	%	0.17	0.17	0.17	0.17	0.17	0.17
Chlorine maximum	260	%	0.26	0.26	0.26	0.26	0.26	0.26

1 in case necessary calcium can be increased over time to obtain a good eggshell quality

Layer 1 respected a daily egg mass of 59.5 gram
Layer 2 respected a daily egg mass of 57

Insoluble grit
Grit stimulates the gizzard muscle development in rearing, stimulates digestion and improves feed intake capacity. If the birds eat litter and feathers, but have no access to grit, physical damage of the intestinal tract may occur. It is recommended to supply 3g of insoluble grit per hen once a month of the particle size between 4 and 6mm.

12.3.2 Calcium nutrition and particle size

Nowadays, the time taken to produce the egg is close to 24 hours which enables us to achieve very high rates of production with eggs being laid early in the morning. Calcification of the eggshell takes about 12 hours, being completed on average 2h – 2h 30 minutes before oviposition. Eggshell quality depends to a large extent on the quantity of calcium absorbed in the digestive tract during the night, which is influenced by the form and solubility in which calcium carbonate is supplied.

There is a difference between brown and white birds in the moment when calcium deposition for eggshell formation takes place. A high percentage of brown birds stop calcification at "lights on" or just after, while white layers finish their shell after "lights on". Therefore, we recommend using 70% coarse limestone for brown birds and 50% coarse limestone for white birds.

12.3.3 Calcium absorption

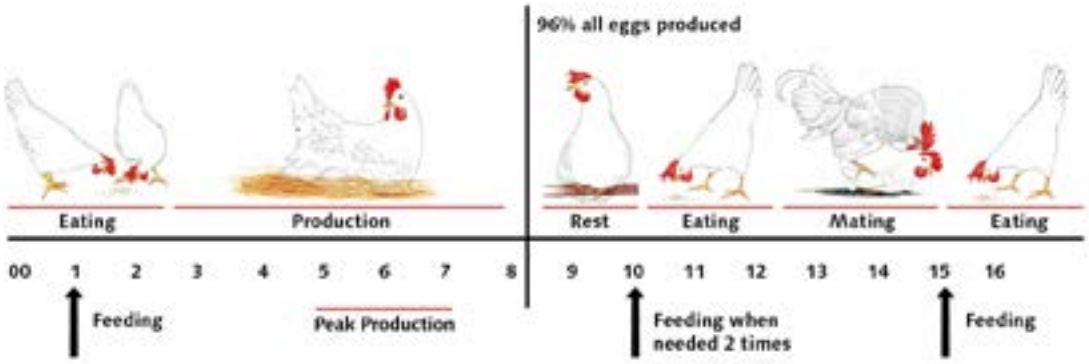
Regular gizzard contractions deliver calcium through the intestine. The availability of calcium via the feed at the end of the night period is improved by using a coarse calcium source with a low solubility. When the absorbable quantity of calcium is insufficient, bone reserves are used. Birds which are forced to use their bone reserves produce eggs of poorer shell quality. Calcium deposition is slow during the first 5 hours after it enters the shell gland. After that and for approximately 10 hours, the rate of shell deposition is rapid and linear. Calcium absorption varies from approximately 30% to over 80% between periods without calcification and the period of shell formation. For this reason, all increases in the quantity of calcium available at the end of the night lead to an improvement in shell quality.

12.3.4 Feed distribution Parent Stock

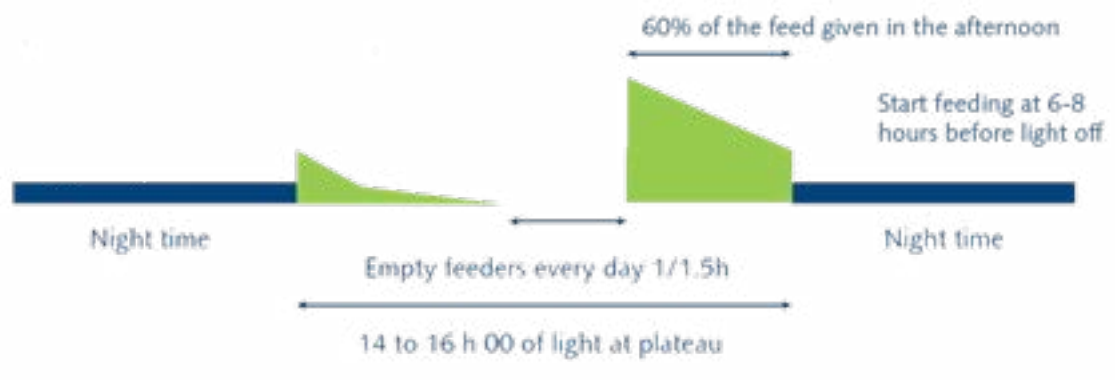
The activity patterns of Parent Stock flocks contain next to eating, egg production and resting some other activities, as shown in Figure 11. Mating is an important activity in the afternoon, it is recommended to plan the feeding times as following:

- In the morning.
- Quite some time before the mating period.
- Shortly after the mating period.

Daily activity pattern of Parent Stock flocks



When birds are not eating enough the classic response is to increase the number of feed distributions. However, this practice encourages selective eating and does not solve the feed intake problem. To avoid selection, the feeder needs to be empty once a day from week 5 onwards and once a week before 5 weeks of age. It is recommended to have empty feeders by the beginning of the afternoon. Too early feed distribution during the laying period increases dirty eggs and floor eggs. For eggshell quality reasons and in line with the natural behavioral pattern, a minimum of 60% of the feed needs to be distributed in the afternoon. The feed program needs to be adapted depending on the observation on the flock, and the type of feed distribution equipment.



The impact of light and temperature
Just after transfer, the light intensity needs to be high. This encourages hens to discover their new environment (location of the drinkers, feeders, perches, and nests). Light intensity will also stimulate the feed consumption. Dimming the lights can serve as a tool to reduce feed consumption. When local legislation allows it, a maximum of two hours of light (night flash) could be given to the hens 3 hours after the lights are turned off. During the night flash, one distribution of feed is provided. This technique can be very useful during hot seasons to encourage the birds to eat enough feed and to prevent them consuming less nutrients than they require at that moment. Reducing the temperature by 1 or 2 °C can also be used as a tool to stimulate the birds' feed consumption.

12.3.5 Fiber

Birds have a specific requirement for fiber during egg production. It has been shown that birds that are deficient in fiber ingest feathers as a fiber source. A good supply of fiber improves feathering, decreases mortality, and improves both gut health and digestion, which will result in drier manure quality. Characteristics of good fiber sources for layers are insoluble fiber of a coarse structure. Cellulose, hemicellulose and especially lignin are classified as insoluble fiber. These fibers are not digested or fermented in the gastrointestinal tract, and therefore serve as filling material that stimulate gastrointestinal movements without increasing the viscosity of the intestinal contact. If fiber particles are small (finely ground), the effect on gastrointestinal movements is minimal, therefore coarse fiber is recommended. Inclusion rates of 2.5% of crude fiber are low in fiber, while 6% of crude fiber is high in fiber. For free range or aviary birds, fiber content between 3.5 and 6% is recommended. For cage birds, 2.5% of fiber is sufficient. The inclusion of 6-7% of crude fiber (for example by increasing the level of oat hulls) gives good results in terms of production parameters and livability.

Fiber should be provided directly in the building. The use of a coarse fiber such as straw, alfalfa (Lucerne), wood shavings, rice/oat husk, silage, etc. is recommended. These materials must be available in the building through round feeders or directly as a bale on the scratching area. Birds must always have a free access to fiber sources. We advise not spreading fiber directly on the floor. To prevent floor eggs, fiber supply must be introduced after the peak of production when the birds are well trained to use the nest.

Livability is positively influenced by fibers because it increases the feeling of satiety in birds, which in turn results in quieter birds, by eliminating need for feather ingestion (pecking and cannibalism). A good feather cover in parent stock flocks is key for proper mating behavior and consequently fertilization results. Diluting the feed helps to maintain a good energy balance in older birds and to prevent fatty livers.

12.4 Feed structure and mixing

12.4.1 Mash diets

During the rearing and laying period, a good textured diet will allow the birds to increase their feed consumption, their production and their growth. In hot climates, a good textured feed can reduce the under-consumption experienced during the warmest season. That's why, we advise having at least 75 to 80% of the particles between 0.5 and 3.2mm. This type of diet is in fact easier and cheaper to produce. The attractiveness of the diet improves markedly if the fine particles are sticking together. That can be achieved by the addition of 1.5 to 2.5% vegetable oil.

Feed presentation affects the bird's appetite for feed and so the feed intake level. The suggested particle sizes are mentioned in the table below.

Particle Size	Starter and Grower	Developer, Pre-lay and Layer
< 0.5 mm	Max 10%	Max 10%
0,5 - 1 mm	Max 15%	Max 15%
1,0 - 3,2 mm	Min 75%	Min 70%
> 3,2 mm	Max 0%	Max 5%

At least 75% (starter and grower diets) and 70% (Developer, pre-lay, and layer diets) of the feed particles should fall within the range of 1 to 3.2mm. In case that this standard cannot be achieved, it is preferred to feed the birds good quality crumbs or pellets.

Importance of the feed particle size
Mixing difficulties, inappropriate particle size and separation problems have been resolved by milling the raw materials relatively fine. However, diets, which are too finely ground, often seriously reduce feed intake. Low consumption has been avoided by using diets presented as crumbs or pellets. In effect, the ease of eating and the reduction in feeding time, due to pelleting, leads to an increase in the number of feeds taken by the birds and in their growth. Please note that birds are grain eaters and their feed consumption depend on feed presentation.

12.4.2 Pelleted or crumbled diets

In theory, presenting a diet in crumb or pellet form will result in higher feed consumption. That presupposes that the feeding systems in operation and the raw materials used are providing the laying hen with a good quality pellet or crumb.

Apart from the increased costs of manufacturing, very often, the difficulties in obtaining a good quality crumb are responsible for under-consumption and some technical problems because of:
- The breaking down of the crumb in the feed distribution system.
- The build-up of fine feed particles in the feeders.
- More shell quality problems related to the difficulties in using a granular limestone.
- More feather pecking due to a shorter feeding time and lack of structure.

To develop a good digestive system, it is necessary to have coarsely milled feed. With the intention of keeping good shell quality, we suggest:
- Use granular limestone if the diameter of the diet is adapted.
- Add some of the limestone after pelleting.
- Distribute 3 to 4g per bird of granular limestone (2 to 4mm) in the poultry house each afternoon.

12.4.3 Mixing

Trace elements and vitamins should be correctly mixed before being added to the raw materials. Heat treated for extra feed safety can have a negative effect on premix stability and consequently decrease nutrient availability. Therefore, the use of an increased level of vitamins with excellent stability and an additional antioxidant is highly recommended.

Suggested premix composition for parent stock in rearing and he productive life

Added trace elements	Unit	Rearing period		Laying Period	
		standard feed	heat treated feed	standard feed	heat treated feed
Added trace elements in mg per kg of diet					
Manganese Mn)	mg	85	85	100	100
Zinc (Zn)	mg	80	80	80	80
Iron (Fe)	mg	60	60	60	60
Iodine (I)	mg	1	1	2	2
Copper (Cu)	mg	10	10	10	10
Selenium (Se)	mg	0.3	0.3	0.4	0.4
Added vitamins in IU or mg per kg diet					
Vitamin A[1]	IU	13000	15000	12000	13600
Vitamn D3[2]	IU	3200	3500	3500	3750
Vitamin E	mg	100	105	100	105
Vitamin K3	mg	3	5	3	5
Vitamin B1 (Thianine)	mg	3	5	3	5
Vitamin B2 (Riboflavin)	mg	12	12	12	12
Vitamin B6 (Pyridoxine)	mg	5	6	6	7
Vitamin B12	mg	0.03	0.04	0.04	0.05
Nicotinic Acid (Niacin)	mg	60	66	50	55
Pantothenic acid	mg	15	17	15	17
Folic Acid	mg	3	3.4	3	3.4
Biotin	mg	0.3	0.3	0.4	0.4
Choline	mg	750	750	1000	1000
Antioxidant added					

1 Vitamin A: Legal limits needs to be observed: chickens up to 14 days max. 20.000 IU/kg feed (DM 88%) and chickens older than 14 days max. 10.000 IU/kg feed (DM 88%). Reference regulations (EU) 2015/724.
2 Vitamin D3: legal limits need to be observed: chickens max 3.200 IU/kg feed (DM 88%). Reference (EU) 2019/849.
3 Vitamin E can be increased up to 100 mg/kg under heat stress conditions.
4 Vitamin E can be partly replaced by polyphenols with an antioxidant effect.
5 Vitamin C can be added up to 150 mg/kg under heat stress conditions.

12.4.4 Toxicity of some minerals

Some minerals can have a toxic effect when present in high levels, the maximum admissible levels for different minerals are listed in the table below.

Mineral	Toxicity level
Chlorine	5000 ppm
Copper	300 ppm
Iodine	300 ppm
Iron	1000 ppm
Magnesium	3000 ppm
Manganese	2000 ppm
Potassium	20000 ppm
Selenium	10 ppm
Sodium	5000 ppm
Vanadium	10 ppm (due to contamination from rock phosphates)
Zinc	1000 ppm

12.4.5 Mycotoxins

Mycotoxins are natural substances produced by molds and fungi, which are common in almost all farm environments. Mycotoxins can survive in many places and on many different types of feed sources. Laying hens are susceptible to mycotoxins for various reasons. The longer production cycle makes them ideal candidates for chronic mycotoxicosis. This can be further influenced by the increased use of feed by-products in layer diets, as by-products can contain up to three times more mycotoxins than grains.
Common signs of mycotoxicosis in poultry include:

- Reduced feed consumption
- Poor growth rates
- Reduced egg production
- Reduced feed conversion efficiency
- Increased susceptibility to diseases
- Increased mortality
- Poor eggshell quality
- Reduced fertility
- Leg problems
- Carcass condemnation

Egg size increases with the age of the flock, but management can influence egg size as well. Important points to be considered are the following:

- Bodyweight at onset of lay: average egg weight is largely determined by the hen's weight on coming into lay. Breeder females which are too heavy at the onset of lay will lay larger eggs throughout the lifetime of the flock.
- Oil content in feed: high oil levels in the diet leads to increased feed intake and a larger egg size. Consider limiting feed oil content or replacing it by saturated fats.
- Amino acids: reducing the amino acid level in the laying diet will have an impact on decreasing the egg weight but will also lead to a reduction in rate of lay. We therefore advise against any big change in amino acid levels during lay.
- Energy intake: if necessary, from 45 weeks of age, a slight reduction of about 50 Kcal in energy level could be considered to stabilize egg weight, as long as changes in feed composition do not lead to under-consumption.
- Temperature: house temperatures which are too low cause over-consumption and consequently increases egg weight and should be avoided.
- Feathering: the better the feathering, the easier to manage the egg size profiles of your birds. Birds with good feather cover are better able to control their body temperature and therefore their feed intake.

13 The care for hatching eggs

13 The care for hatching eggs

13.1 Introduction

Superior day-old chick quality starts with the very base material: the hatching egg. To obtain high numbers of fertile eggs, the conditions in the breeder house should be optimal.

The roosters and the breeder females should be in good condition to encourage successful mating between well-developed birds, as this will result in high numbers of fertile eggs and strong embryos. Not only mating behavior contributes to good quality hatching eggs, also the reproductive system needs to function well. If not, this can lead to increased number of defect eggs (misshapen, weak shells). The performance of a hatchery is highly dependent on maintaining good hatching egg quality at all levels, starting with the nests, all the way up to the setters and hatchers.

The common goal is to produce clean, dry, viable hatching eggs, with the potential to hatch first quality day-old chicks. Hatchability and day-old chick data are extremely important references for optimizing incubation management. The age of the flock, number of storage days and incubation program are typically included in the analysis and optimization of hatchery results, but very often, insufficient ¬attention is paid to the quality of the hatching eggs. It is crucial that egg quality is not taken for granted when optimizing your hatchery performance. To ensure optimum egg quality, it is essential that you always measure the incoming egg quality. This will tell you a lot about the performance of the breeder flock, but also about their management. In the hatchery world it is very important to openly communicate on all levels! Feedback to parent stock suppliers, suppliers of hatchery equipment and breeding companies is crucial to improve your results.

13.2 Collection of eggs

Nests must be always kept clean. Manure and broken eggs should be removed frequently. In littered type nests, the nesting material must be clean and free of mold and be renewed regularly. In automatic nests, plastic bottoms or pads must be cleaned periodically. Nests should be equipped with a closing or ejection system to prevent birds from staying in at night and soiling the nest.

It is advised to collect eggs at least once a day. We also advise to increase this in extreme hot or cold weather. Egg collecting devices such as baskets, plastic trays and belts must have holes to allow organic contamination debris to fall away from the eggshell surface and to avoid contamination of other eggs. These devices should be cleaned and disinfected before use. Cardboard trays must better not be re-used (biosecurity). Prior to handling eggs, hands should be washed and then disinfected with a sanitizing solution. Hands should be re-sanitized frequently during egg collecting time and whenever returning from other tasks.

13.3 Floor eggs

Floor eggs should be collected quickly after lay, selecting clean eggs only as first quality eggs. Dirty eggs must be eliminated under all circumstances, and they should not be stored near to clean table eggs. The number of floor eggs can be reduced by following good management procedures (see "Floor eggs" in the Control of Behavior section).

Good quality hatching eggs start with clean nests

13.4 Hatching egg quality

Egg quality has been highly affected by genetic selection, for production traits like growth, feed ¬conversion, number of eggs, egg size profile, breaking strength and eggshell quality. Breeding companies pay also attention to egg parameters that are related to hatchability and chick quality, Hatch out of eggs Set, Hatch out of Fertile and day-old chick quality (black navels, chick defects, etc.) are among the traits that breeding companies are selecting for. Despite decades of genetic selection, variation in hatching egg quality still occurs between and within breeder flocks. Monitoring and recording egg quality parameters will help to manage the breeder flock and will contribute in better understanding the fertility and hatching performance. When specific protocols for ¬optimizing incubation results are in place, it is essential to include hatching egg quality in the analyses and routine evaluation. A short description of internal and external hatching egg para¬meters is given below.

The Egg shape

The very first thing you'll look at when handling and grading hatching eggs is the shape. A good quality hatching egg has a blunt side containing a small air cell and a clearly recognizable sharp end. Too many abnormal or misshapen eggs could be signs of different causes: an immature shell gland, a young (or old) parent stock flock, disease, stress and overcrowding in the flock.

The Egg shell

The shells of first quality hatching eggs are smooth, without wrinkles, ridges or small lumps of calcified material (pimples/ sandy eggs). The egg color should be uniform within a batch, brown eggs should be covered in a nice gloss. It is well known that young flocks produce eggs with thicker shells, as the parent stock flock ages, the shell becomes thinner and the incidence of abnormal shells and cracked shells increases. The diet plays an important role in maintaining good quality eggshells, insufficient calcium or vitamin D3 content in the feed will result in thin eggshells. Drinking water with high salt content or high levels of chlorine can also cause shell-quality problems. Pale eggs (when talking about brown eggs) are often an indicator that the flock is suffering from a disease (Infectious Bronchitis, New Castle Disease, Egg Drop Syndrome).

The Yolk

It is well known that the size of the egg yolk increases with age, as the flock is getting older. The larger yolks have a direct impact on the yolk : albumen ratio, as this will increase. In good quality hatching eggs, the yolks have a uniform color without any presence of blood or meat spots. When you come across mottled yolks, this could be indicators for stress in the parent stock flock.

The Albumen

Good quality hatching eggs contain a higher proportion of thick, viscous albumen (egg white) with less thin albumen. As the flock is aging, the volume of the thick egg albumen reduces. Egg storage will also negatively influence the proportion of the thick albumen versus the thin albumen, as storage will reduce the volume of the thick albumen. Good quality albumen is translucent with a greenish or yellow cast indicating the presence of riboflavin. As with the yolks, the presence of meat or blood spots point to stress or overcrowding in the parent stock flock.

13.5 Egg washing

Washing of hatching eggs is not recommended, as it will negatively impact hatchability. Removing dust and feathers with a soft brush or airflow can be done to prevent dirt from traveling along with the eggs into the incubators.

13.6 Storage of eggs

An appropriate egg storage room is required for the storage of eggs. It should be well insulated and equipped with a cooling and heating system with a humidifier to maintain a constant temperature and humidity. Walls and roofs should be kept free of dust and floors tiled for easy cleaning and frequent fumigation. Drafts should be avoided, and mice always kept out of the egg storage room.

Storing conditions should be set to avoid water condensation on the shell's surface ("egg sweating"), which creates favorable conditions for microbial growth. This phenomenon occurs when stored eggs are transferred to a warmer environment and the dew point is reached. To avoid temperature fluctuations and egg sweating during transport, truck and farm egg storage room temperatures should be equal.

Eggs should always be handled with care to avoid mechanical shocks at loading, during transport and unloading. If an egg storage room is not available on the farm, eggs must be collected from the breeder farms to the hatchery more frequent.

Recommended climate condition during egg storage

Storage duration	Temperature (°C/°F)	Relative humidity* (%)	Egg orientation
0-3 days	18-21 / 64–70	75 – 85	Blunt end up
4-7 days	15-17 / 59–63	75 – 85	Blunt end up
8-10 days	12-14 / 54-57	80 – 85	Blunt end up
More than 10 days	12-14 / 54-57	80 – 85	Preferably small end up or turning the eggs an uneven time per day

* The recommended relative humidity range for eggs stored on paper trays is 50 – 75%; the risk for dehydration is much smaller on paper trays and the occurrence of floppy trays due to too high relative humidity should be avoided.

Egg handling is part of a process which already starts at the nests in the breeder farm, directly from the moment that a hatching egg is being produced. To ensure optimal egg handling you should follow at least the following 6 crucial steps:

- Keep the nests always clean, extra care for nest hygiene should be given at least 1 time per week.
- Wash and disinfect hands before each egg collection.
- Collect eggs from the nest at least 4 times per day in case of manual litter nests and at least 2 times per day from automatic roll away nests under the condition that temperature on the egg transport belt is 20 – 22 °C / 68 – 72 °F. At lower and higher temperatures, the frequency of egg collection should be increased.
- Avoid shocks and jolting in handling to prevent damage to the fragile embryonic structure and hairline cracks in the shell.
- Carefully sort the dirty and cracked eggs from the clean eggs and keep them separate as soon as possible. Also keep floor eggs separate.
- Provide optimal hatching egg storage circumstances (temperature and relative humidity). Aim at eggs uniformly cooling down from 41 °C / 106 °F (the hen's body temperature and thus the egg temperature at oviposition) to between 22 and 25 °C / 72 and 77 °F in approximately 6 hours. Too fast and too slow cooling down should be avoided. Therefore, maintain a temperature of 20 – 22 °C / 68.0 – 72 °F in the egg collection room.
- Keep the hatching eggs dry, always prevent egg condensation (egg sweating). Place hatching eggs on well-designed egg trays (paper or plastic) or setter trays with sharp end down. Avoid the use of floppy trays and do not over stack.
- Place the egg trays in egg containers or boxes after all the eggs have cooled down to 22 - 25 °C / 72 - 77 °F. Place setter trays in farm trolleys and allow eggs to cool down gradually before placement in the egg storage room.
- Monitor the climate conditions daily and record them.
- Always handle the eggs with care, do not forget that there is already an embryo inside!

A golden rule in the hatchery world: never place eggs containing cracks, or floor eggs in the incubators!
Eggs with cracks say welcome bacteria! Best is to discard these eggs from the incubation process since they don't hatch anyway. If they hatch, the day-old chicks are likely to die within the first few days of life. Make good records to inform the breeder farm when the percentage of eggs with cracks get too high. The same holds for floor eggs. It makes no sense to incubate dirty floor eggs. Incubating floor eggs results in poor hatchability, and chicks are likely to die at the farm and can infect the other chicks as well.

These nests are ovecrowded,more nests should be added

Downgraded Egg Chart Brown Eggs

GOOD EGG
Normal (oval) shape with one end larger than the other and tapers towards the small end. The shell is smooth, without pimples, rough areas, wrinkles or ridges. There are no cracks, windows or flat sides.

CRACKED EGG
Shell has mild to severe cracks (hairline crack, star crack or body check), is broken or has albumen/yolk leaking.

WHITE BANDED EGG
Shell contains a white band which resultrs from two eggs coming into contact in the shell gland.

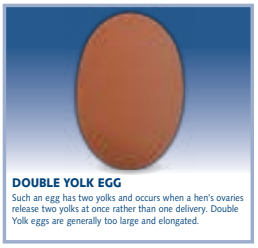
SPECKLED EGG
Small brown spots on the shell.

PIMPLED EGG
Shell has rough areas or pimples of calcified material and is not smooth. The level of roughness may range from a few pimples to a severe level, with the shell sometimes feeling like sandpaper on touch.

DIRTY EGG
Shell is not broken but has dirt or foreign material, such as faeces adhering to its surface. It has prominent, or moderate stains, which may be localized or scattered, covering about 3% to 6% respectively of the shell surface.

MISSHAPED EGG
Such an egg does not have the oval shape of a normal egg and the shell is not smooth. Such eggs include those with flat sides or body checks, and those usually too large or too small.

SLAB-SIDED EGG
The egg is flattened on one side, which is the side where it made contact with the first egg in the pouch. It is wrinkled and misshapen.



DOUBLE YOLK EGG
Such an egg has two yolks and occurs when a hen's ovaries release two yolks at once rather than one delivery. Double Yolk eggs are generally too large and elongated.

COLOUR SPECTRUM EXAMPLE EGG
There is a spectrum of acceptable and unacceptable colouring of a brown egg shell. Eggs with shells the shade of the example egg (above) or lighter should be culled. If unsure, refer to the Colour Spectrum Chart Brown Eggs.

DOWNGRADED EGG: Any egg that fails to meet the minimum standards must be removed. This chart outlines some major reasons for downgrading eggs. There are reasons other than these shown.

HENDRIX GENETICS

Downgraded Egg Chart White Eggs

GOOD EGG
Normal (oval) shape with one end larger than the other and tapers towards the small end. The shell is smooth, without pimples, rough areas, wrinkles or ridges. There are no cracks, windows or flat sides.

CRACKED EGG
Shell has mild to severe cracks (hairline crack, star crack or body check), is broken or has albumen/yolk leaking.

STAINED EGG
Shell has foreign material such as blood or faeces and stains or discolourations that are readily visible.

WRINKLED EGG
Shell has ridges or wrinkles on surface. This may range from a few tiny wrinkles to severe wrinkles that completely cover the egg.

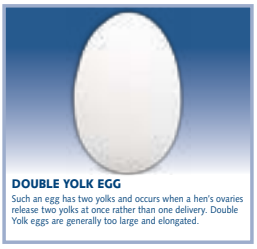
PIMPLED EGG
Shell has rough areas or pimples of calcified material and is not smooth. The level of roughness may range from a few pimples to a severe level, with the shell sometimes feeling like sandpaper on touch.

ROUND EGG
The shape of such egg is not oval but rather appears round like a ball or sphere. The two ends are so close to the same shape it is difficult to determine which is the large end and which is the small end.

DIRTY EGG
Shell is not broken but has dirt or foreign material, such as faeces adhering to its surface. It has prominent, or moderate stains, which may be localized or scattered, covering about 3% to 6% respectively of the shell surface.

MISSHAPED EGG
Such an egg does not have the oval shape of a normal egg and the shell is not smooth. Such eggs include those with flat sides or body checks, and those usually too large or too small.

SLAB-SIDED EGG
The egg is flattened on one side, which is the side where it made contact with the first egg in the pouch. It is wrinkled and misshapen.



DOUBLE YOLK EGG
Such an egg has two yolks and occurs when a hen's ovaries release two yolks at once rather than one delivery. Double Yolk eggs are generally too large and elongated.

DOWNGRADED EGG: Any egg that fails to meet the minimum standards must be removed. This chart outlines some major reasons for downgrading eggs. There are reasons other than these shown.

HENDRIX GENETICS

14 Health

14 Health

14.1 Introduction

Your breeders will only perform if they are healthy. Sick or injured birds have less desire to drink and eat, whilst having a higher energy demand because of the activated defense system. In this chapter we will discuss some of the main pests and diseases that can affect the health of your flock. And we will discuss some of the most common vaccination procedures.

14.2 Disease signals

When birds are affected with a disease, it often manifests itself in disease symptoms. Make sure that you monitor your birds and their behavior from the first day they arrive in your barns. This will help you to understand the healthy birds' behavior and will enable you to detect the early warnings when something is wrong with your flock. Looking for symptoms and trying to categorize them will help you and your vet to set an accurate diagnosis. If you keep good track of your flock via recording their production data, and the daily parameters, the flock will give you some early warnings. When you observe a sudden drop in water and feed intake, or in egg production your alarm bells must ring. Ask your representative for the data record sheets.

14.3 Pens for sick hens

It is recommended that the poultry house includes 1 or 2 small pens, or compartments, which can be used for treating sick or injured malesor females that have a good chance to recover. These pens can also be used for keeping and treating your broody hens, it is advised to keep the broody hens separate from the sick or injured birds.

Take sufficient time to inspect your breeder flocks, and look for any abnormalities in their behavior

14.4 Internal parasites

The most common internal parasites in laying hens include coccidia, Capillaria worms, round worms (Ascaridia), caecal worms (Heterakis), tapeworms (Raillietina) and Histomonas ("black head").

14.4.1 Worm infestations

Worm infestations can be responsible for low weight intake, bad uniformity, egg quality trouble, increased pecking and even death in the case of heavy infestation. The birds get often infested by the ingestion of parasite eggs from the environment. The diagnose of worm infestation can be made by opening up a few birds every few weeks or by the examination of droppings for worm eggs.

As treatment against worms, the layer industry most commonly uses piperazine and anti-worm compounds from the family of the benzimidazole drugs such as levamisole or albendazole. Control of worm infestations involves not only treating birds against worms, but also proper cleaning and disinfection, adequate husbandry, and proper coccidiosis control. Early administration of drugs against round worms might contribute to maintain under control other parasites like Histomonas.

In free range systems, to prevent worm problems, grass enclosure should be used in rotation and may be treated with products able to destroy parasite eggs (calcium cyanamide, ferrous sulphate).

14.4.2 Coccidiosis

One of the most widely spread and most harmful diseases in the poultry industry. Coccidiosis is caused by several types of Eimeria. This single-cell gut parasite is common in poultry and causes very minor to severe harm to the birds' gut. The moderate infections can result in subclinical disease, while mass infection can lead to clinical symptoms such as diarrhea and even death. Coccidia easily spread as oocysts, and they are extremely hard to destroy with disinfectants. When the chicks have access to droppings, outbreaks of coccidiosis could potentially occur.

Coccidiosis may be responsible for enteritis and mortality. Sub-clinical infection will damage feed conversion and uniformity. Regardless of the type of operation, it is important to ensure immunity against coccidiosis, which can be accomplished by using one of two common methods. Where legal, breeders reared on the floor may be treated with anticoccidial drugs for 8-12 weeks to allow for a gradual acquisition of immunity. Commonly used drugs for this purpose include (not exclusively) amprolium and salinomycin. Anticoccidia during rearing should create immunity and thus avoid infection during lay. They should not be given after 14 weeks of age at the latest.

Perhaps the best approach to control coccidiosis in breeders reared on the floor is vaccination. The breeder chicks can be vaccinated by spray at the hatchery, by spray on the feed in the rearing house or via drinking water in the rearing house, with one of the various commercially available vaccines. It is important to use a commercial product that will contain at least E. acervulina, E. maxima, E. tenella and E. necatrix.

When coccidiosis vaccines are used it is critical not to medicate the flock with any drug that coccidia would be sensitive to, in order to allow at least 2 complete coccidial cycles. To enable this, the chickens must be in contact with litter. Infestation pressure in the houses can be reduced by using disinfectant that destroys oocysts. Pay attention to the area surrounding the houses for free range birds. Good hygiene and good litter quality are essential for limiting the spread of coccidiosis.

14.5 Mites

External parasites frequently seen in poultry houses include the red mite or roost mite (Dermanyssus), the Northern fowl mite (Ornythonyssus) and the bed bug. Poultry lice are frequent in backyard flocks but are rare in commercial operations. The northern fowl mite completes its entire life cycle on birds, whereas the red mite feeds on the birds during the night. Mites are external parasites that must be controlled to avoid drops in egg production, dermatitis around the vent, restless birds, increased mortality and farm employee discomfort. Some mites are known to carry other disease agents and can induce anemia if the infestation is severe and thus must be controlled. Mites are more common in cage or slat systems than in aviary systems where the birds can get dust baths and get rid of the mites. Mites may be responsible for nervousness, feather pecking (due to stress), a drop of production, anemia, blood spots on the eggs, increase of floor eggs (birds don't want to go in the infested nests) and even for mortality. Red mites often hide in dark and inaccessible places such as nests and the crossbars of slats of perches.

Mite management must be extensive and start from the empty period when the houses can be treated with insecticides. The best form of prevention for mite infestation is biosecurity. Infested flocks should never be visited before visiting mite-free flocks. mites can be mechanically carried from farm to farm in clothes, footwear, on people, equipment, egg boxes, etc. Such parasites usually thrive in sexually mature flocks and thus most treatments become necessary while the infested flocks are in production. A variety of products can be used for mite control, including pyrethroids, organophosphates, carbamates, mineral-based products, vegetable oils, citrus concentrated extracts and other products. Some of these products can be administered by dry (dust) spray, or as a wet spray. Prior to using any of these products it is critical to determine whether they are approved for use in hens in production! Also check whether the personnel applying the products requires personal protective equipment.

Some products are less effective if applied dry but quite effective when applied wet directly on the birds, which requires considerably more time than the application of dry products. The most important for treatment is to reach the places where the mites are hiding. Treating birds against mites is frequently expensive and it may be necessary to treat an infested flock more than once. After the affected flock is removed, thorough cleaning and disinfection and chemical treatment of the premises and equipment is necessary. The best approach is to exercise adequate biosecurity and never to transit from infested flocks to clean flocks, or to share equipment and egg boxes between infested and clean premises. Prevention treatments must be done before getting heavy contamination, as these are more difficult to manage and responsible for economic losses.

14.6 Colibaccillosis / E. coli in Poultry

E. coli is a very common disease in adult laying hens, characterized by moderate to severe losses of birds in top condition. Production is mainly maintained and birds with clear sick symptoms are rare. E. coli infections are known under different names: colibacillosis, E. coli peritonitis, E. coli Sepsis, E. coli mortality, E. coli arthritis.

E. coli can cause problems as a primary agent or as a secondary pathogen. To act as a primary pathogen, the infection pressure must be high or other complicating factors must be present. In alternative housing systems, high levels of ammonia can damage the epithelium of the respiratory tract, thus opening the way for airborne E. coli mortality. In combination with high levels of dust, the E. coli, attached to dust, can colonize the air sacs and the lungs. Both in cage systems and alternative housing systems, contaminated drinking water can be a source of E. coli. Also, in both systems, ventilation stress can be a reason for E. coli mortality. Ventilation stress is caused by draught (the fast movement of too cold air). Draught occurs mainly in spring and autumn, when the differences between day and night temperatures are significant. At the end of the afternoon/beginning of the evening, the outside temperature drops fast. Most ventilation systems are temperature regulated; the inside temperature is still high, so the system pulls in this cold air with force, until the set temperature is reached.

E. coli mortality can be secondary to viral respiratory infections like infectious bronchitis (IB) and avian rhinotracheitis (ART), secondary to bacterial infections like ornithobacterium rhinotracheale (ORT) infections and secondary to parasitic infections like red mite infections. E. coli mortality can also be secondary to pecking. E. coli can also penetrate via an ascending route (via the reproductive tract), or possibly from the intestinal tract, a mechanism that has not yet been confirmed. Vaccination against E. coli can be a method of control and is commonly done by using live vaccines by spray or in the drinking water twice during rearing, once at hatch and once a few weeks later.

The primary cause of peritonitis is not always E coli. Also, egg yolk peritonitis can be observed in your flock. With both types of peritonitis, you find birds with a pale comb with blue points. Birds with egg yolk peritonitis usually not die acute. On postmortem, these birds are dehydrated and display pericarditis, perihepatitis and peritonitis with a lot of debris, which can be recognized as solid egg yolk.

E. coli peritonitis is acute mortality. The general flock looks healthy and is performing well. The only problem is increased mortality, and it can be quite difficult to see the signs. The follicles are always hyperemic; sometimes this is the only visible pathological sign. Sometimes the only traces of fibrin are seen between the follicles.

An important difference between the two is the smell. Egg yolk peritonitis birds, when they are fresh, smell like boiled eggs, while E. coli peritonitis birds have a very bad, rotten smell.

Egg yolk peritonitis occurs in young flocks, at the start of production, when the flock shows a very fast increase in lay percentage. In this situation, part of the follicles "miss" the oviduct and land free in the abdomen, with egg yolk peritonitis as result. Nervous flocks can also show some egg yolk peritonitis as a form of internal trauma. To conclude, egg yolk peritonitis can also be a complication of viral infections targeting the ovaries, like IB, ART and ND.

E. coli mortality is difficult to treat. Antibiotic treatments are often effective, during the treatment, but once you stop and the underlying primary cause is still present, the mortality comes back. Besides, the use of antibiotics is not always possible due to the withdrawal time of the products used. Drinking water sanitation, with H202/per acetic acids combinations, with organic acids or with chlorine are also widely used.

For more information on poultry diseases,
please check the "disease one pagers" on our website

www.hendrix-genetics.com/layinghens

15 Vaccination

15 Vaccination

15.1 Introduction

Vaccination is the process in which the animals are infected with a dead or much weakened pathogen. It is done in a controlled way to build up the defense against infections, e.g., to make the birds themselves less susceptible to poultry pathogens. Parent stock can be vaccinated to make their offspring less susceptible for disease (providing them with maternal immunity via the yolk). Poultry can be vaccinated to make them less susceptible for contamination with human pathogens, i.e., Salmonella species.

Each vaccination will produce a reaction in the birds' defense mechanism, as a result your birds will be slightly stressed or sick for a few days post vaccination. In case of improper vaccination, the birds can be in severe pain, and this will severely hinder the birds' development.

Always keep in mind that a very intensive vaccination scheme puts a lot of pressure on the birds and her development. More vaccinations do not necessarily offer more guarantees. Hindering growth in the first 5 weeks of life can have serious and negative consequences later in life, all the way up to the production period. Always make sure there is adequate time in between repetitive vaccinations, as a repeat vaccination can severely reduce the immunity that a chicken has already built up to a particular virus for a short time, and the vaccination will not take well because of the chicks existing immunity.

Vaccination programs should always be tailor made, taking into account the following questions:

- What is the local disease situation, e.g. which diseases are present in the area?
- What is the location of the farm, what's the distance to neighboring farms and what type of birds are housed on the neighboring farms?
- Which diseases are present on the farm itself (endemic diseases)?
- Does it hold parent stock or final product?
- Is it a multi-age or a single-age farm?
- Are the chickens fit and healthy?

You must make a risk assessment:

- What is the risk of infection?
- What are the costs of infection and how do they relate to the costs of vaccination?
- What's the damage done by vaccination compared to the expected benefits of vaccination?
- Is protection needed during rearing and/or during lay and/or should the offspring be protected by vaccination?
- Should you use live or killed vaccines?
- What is the most suitable/practical route of administration of the vaccine? Consider the principle of priming and boosting. Consider the minimum time distance between two vaccinations targeting the same organ system.

When you vaccinate it is important to monitor the vaccine take. Was the vaccine administered at the right time, in the right way? You can monitor the endemic diseases on a farm. Which pathogens are present and what is their behavior / dynamics?

You can use regularly taken serum samples for diagnostic reasons. Can observed clinical signs be linked to a rise in antibody titer for a certain pathogen? You can monitor the specific pathogen free status of a farm, consult your local veterinarian to set up a monitoring scheme.

An individual becomes "immunized" or resistant to a specific disease after inoculation with a specific vaccine, or after exposure to a disease agent in the field. Vaccination programs should be designed to "immunize" flocks against diseases with an economic impact; and against disease agents that could potentially compromise food safety. The entire disease control program relies on sound and well-designed vaccination programs and adequate biosecurity, husbandry, and nutrition. At the same time, vaccinations should be administered at times or ages when their detrimental impact is minimal, and at times when the best possible benefit can be obtained from them.

Most vaccination programs are intended to immunize chickens against diseases that affect the immune system; cause tumors in chickens; affect the respiratory, urinary, or reproductive tracts; affect the nervous system; induce disease in the intestinal tract; or represent a food safety concern. Fortunately, there are vaccines and vaccination methods available to protect chickens against most of these groups of conditions. Prior to using any vaccines, ensure that their use is legal and that it will not disqualify specialty flocks because of the type of preservatives contained in the vaccines.

15.2 Types of vaccines

There are many types of vaccines available for commercial poultry. It is important to become familiar with their basic characteristics related to their potential for protection, safety, ease of administration, relative cost, reactivity, compatibility with other vaccines, etc. This is a list of some of the most important types of vaccines:

- Live virus vaccines
- Recombinant virus vaccines
- Live bacterial vaccines
- Inactivated bacterial vaccines (bacterins)
- Gene modified and deletion mutant live bacterial vaccines
- Autogenous inactivated bacterial vaccines
- Autogenous inactivated viral vaccines
- Live coccidiosis vaccines
- Live Mycoplasma vaccines
- Inactivated Mycoplasma vaccines (bacterins)
- Recombinant Mycoplasma vaccines
- Competitive exclusion products

15.3 Vaccination methods

It is important to understand the characteristics of each vaccine and to use each product according to the manufacturer's recommendations. Vaccines are designed and approved for individual or mass application methods.

Individual vaccination methods include:
- Eye-drop
- Beak dipping or intranasal
- Subcutaneous injection
- Intramuscular injection
- Transcutaneous injection (wing web)
- Vent brush application

Mass vaccination methods include:
- In ovo injection
- Drinking water vaccination
- Spray vaccination

15.3.1 Eye drop

Eye-drop vaccination is commonly used to protect chickens against respiratory viruses, Mycoplasma and occasionally against infectious bursal disease. Eye-drop vaccination is most suitable for delivery of live vaccines against diseases or agents such as (but not exclusively) Newcastle disease, infectious bronchitis, infectious laryngotracheitis, and Mycoplasma gallisepticum. Eye drop vaccination is likely the most effective and safest method for respiratory viruses. Direct contact of the vaccine with the mucosa of the eye will result in stimulation of the Harderian gland and a strong local immune response.

Despite being highly effective, eye drop vaccination is labor intensive and time consuming and thus it is usually limited to application of vaccines that must be administered via the ocular route and by no other method, such as some (but not all) live MG vaccines and live attenuated vaccines against ILT.

15.3.2 Beak dipping or Intranasal

Intranasal and beak dipping application of vaccines has the same objectives as the ocular route. Intranasal application is popular in some countries, but beak dipping is rarely used. The vaccine is administered by depositing a drop (usually 30 ul or 0.03 ml) of reconstituted vaccine directly on the eye or into the nostrils. The advantage of eye drop application is that if applied properly, every bird receives a similar dose of vaccine and is thus likely to be immunized (protected) against the disease, as opposed to mass application methods, which unavoidably result in suboptimal coverage since not every bird receives an equally immunizing dose.

Because beak dipping vaccination requires individual handling of birds, biosecurity is most important, and the vaccination crews must follow strict biosecurity procedures so as not to bring infectious diseases to the flock being vaccinated. For the beak dipping method to be successful, both nostrils must be immersed in the vaccine. This method is suitable only for chicks up to 7 days of age and is used for immunization against NDV or IBDV. It is used in areas or farms where even vaccine uptake is not possible using the drinking water or spray methods, or with the objective of minimizing vaccine reactions.

15.3.3 Subcutaneous and intramuscular injection

Injection via the intramuscular and subcutaneous routes is reserved primarily for inactivated vaccines and bacterins. The vaccination equipment should be sterile, and the needles used should be of the proper caliber and length for the age of the bird and also for the type of product being injected. The needles should be replaced with sterile needles at least every 500 injections to prevent injections with bent or blunt needles, and to avoid transmission of some diseases from infected to non-infected chickens. Most inactivated (killed) vaccines are administered at approximately 12-14 weeks of age. Should it be necessary to vaccinate younger chickens with inactivated products it should be kept in mind that handling and administration of inactivated vaccines or bacterins between 6 and 11 weeks of age might delay or alter the development of the chickens. Inactivated viral vaccines are usually available in a water-in-oil (WO) or water-in-oil-in-water (WOW) emulsion, which are typically not very reactive. Thus, such products can be injected with confidence intramuscularly or subcutaneously, provided the injection is done in the proper area and without depositing any of the vaccine product in the cavity or directly into the internal organs. Inactivated products containing Mycoplasmas and/or bacteria such as Salmonella may be quite reactive, and every effort should be made to minimize the local vaccine reactions that can be derived from the injections. For subcutaneous injections, it is especially important to avoid the thymus by injecting the vaccine in the middle line (avoiding the sides of the neck), and by not injecting too close to the head or the base of the

neck. For intramuscular injections (in the breast muscle), every effort should be made to avoid injecting the product into the abdominal cavity. Vaccinations in the thigh may contribute to reduced adverse reactions but care must be exercised to minimize injuries resulting in lameness.

15.3.4 Transcutaneous injection (wing web)

Transcutaneous (wing web) application is used almost exclusively to vaccinate chickens against poxvirus (POX). For convenience, manufacturers of vaccines have added other agents such as chicken infectious anemia virus (CAV) and avian encephalomyelitis virus (AE) to POX vaccines and thus it is possible to vaccinate chickens simultaneously against AE, POX and CAV in one injection. The latter (CAV) is only necessary in layer breeders, but AE and POX are routinely used in commercial layers. In addition, there are recombinant vaccines with a poxvirus as a vector carrying genes that express proteins from ILTV. Thus, such products can also be administered by wing web application.

Latest innovations in hatchery equipment technology combine vaccination and infra-red beak trimming

15.3.5 Drinking water (oral) vaccination

Water vaccination can also be accomplished using a water pump to "inject" or "force" the vaccine into the water lines, which is a popular and very effective method of mass application using the drinking water for delivery of live vaccines. Water pump vaccination requires a closed water system (nipple drinker lines) and can be used successfully for delivery of vaccines against diseases or disease agents such as IBDV or CIAV. As with other methods involving water delivery, this one requires that the birds be thirsty prior to delivering the vaccine to them. Wherever possible, the drinker lines are raised high enough so as to prevent drinking by the birds in the 2-3 hours prior to vaccination. Water vaccination requires flushing the drinker lines with fresh water to minimize the number of unwanted residues. Commercial products can be used to clean the drinker lines thoroughly prior to vaccination. Even after the use of commercial products, it is recommended to flush the lines with clean fresh water before vaccinating the flock. This is particularly important in operations that have hard water, or in operations that have used antibacterial drugs or other products that may have formed a film in the drinker lines. Prior to vaccination, it is important to water-starve the chickens to be vaccinated so that most will consume vaccine upon its administration. Check the drinkers or nipple drinkers to ensure they are clean and operational and shut down all water sanitizing systems. Allow the chicken to become thirsty by interrupting access to water. The amount of time required for the chickens to become thirsty will depend on their age, environmental temperature, feed formulation, etc. The goal should be for all chickens to consume the vaccine in a matter of 60 minutes. Vaccination via the drinking water should be used in birds one week old or older because water consumption in younger chickens might be too irregular.

A few essential steps for water vaccination are listed as follows:

- Clean and flush the water lines.
- Turn off the water sanitation system.
- Ensure proper functioning of the drinker system.
- Water-starve the chickens enough for them to consume the vaccine in less than one hour.
- Verify that the vaccine to be administered has been stored according to the manufacturer's recommendations; that it is still viable (before expiry); and maintain a record of the type of vaccine, serial (lot) number, number of doses per vial and number of vials used, as well as the expiry date.
- Reconstitute the vaccine in an aseptic manner and verify that the number of vials used matches the number of doses to be given. The amount of vaccine to be consumed in volume should be equivalent to approximately 1/7 the total water consumed the previous day.
- Use a commercially produced vaccine stabilizer or powdered skim milk to help protect the vaccine viruses. Closely follow the recommendations of the manufacturer of the vaccine stabilizer. If skimmed milk is used, approximately 2.5 g of well dissolved skim milk per liter of water plus vaccine is enough to protect the vaccine from any residual chemicals or minerals in the drinking water. Keep the reconstituted vaccine cool and away from exposure to the sunlight.
- Deliver the vaccine into the drinkers and drinker lines. To ensure a complete fill out of the drinker lines (pipes) add a visual aid such as commercial blue dye and let the vaccine be flushed to the end of the lines until blue dye is seen at the end of the lines. At this time close the end of the water lines and allow the birds to drink. If the vaccine is delivered into open water systems, it is important to walk slowly through the house to stimulate water consumption and to help distribute the birds in the house.
- Check at least 100 birds throughout the barn to verify that they have consumed the vaccine. If enough dye was used, it should be easy to observe a blue coloring of the tongue, head feathers and occasionally the crop, which is visible through the skin. Vaccine coverage of at least 90% should be a realistic goal.

15.3.6 Vaccination through a medicator

Vaccination through a medicator is one of the methods of vaccination with live virus vaccines which is least recommended, although it is a suitable method for administration of drugs, vitamins, etc. Coccidiosis vaccination using a medicator should be avoided because the Eimeria oocysts will tend to settle and the actual dose of oocysts per bird will vary greatly, and so giving very poor results.

15.3.7 Spray Vaccination

Spray vaccination is used primarily for immunization against respiratory viruses such as Newcastle disease virus (NDV) and infectious bronchitis virus (IBV). However, it should be noted that spray vaccination should involve the less invasive forms or strains of viruses, such as the B1B1 strain of Newcastle, or H120 of infectious bronchitis. In general, the more invasive the virus, the better the protection against disease but the harsher the vaccine reactions, especially in flocks infected with MG or some strains of MS. Coccidiosis vaccines are sometimes sprayed on the feed of layer breeders in some areas. Some live Mycoplasma gallisepticum vaccines (but not all) can be sprayed directly on chickens in the field. Each type of equipment intended for spray vaccinations may be different and the operator must be thoroughly familiar with each piece of equipment and its spray patterns, pressure, and particle size. For example, pressurized sprayers are excellent to deliver vaccine to the respiratory tract but because of the small particle size that they produce, the vaccine will tend to remain suspended in the air or it may be sucked towards the house fans if they are not turned off prior to vaccinating the birds. With some types of sprayers, the equipment must be located not more than 50 cm over those birds to be vaccinated. This method is therefore not practical for mass application over chickens on the ground. Rather, sprayers intended for horticultural use or pesticide application in the horticultural industry have proved very popular and effective for application of live respiratory vaccines in the field. The particle size will range between 100 and 300 ums, which is suitable for most respiratory viruses. In general, spray vaccination is used for protection against respiratory viruses and Mycoplasma in the rearing period; and for protection against respiratory viruses in hens in production.

Several essential considerations for spray vaccination are listed as follows:

- Prior to choosing spray vaccination to immunize chickens against respiratory viral diseases, consider all possible options. Be aware that spray vaccination against Newcastle disease and Infectious Bronchitis generally provides better protection than water vaccination, but vaccine reactions can be harsh, particularly in Mycoplasma-positive chickens. Spray vaccination against Infectious Laryngotracheitis should be avoided and must never be done in chickens in production. Only vaccinate healthy chickens.
- For adult flocks, verify the flock antibody titers prior to vaccination. If antibody titers are low, vaccine reactions may be harsh.
- Ensure that the vaccination equipment has been thoroughly cleaned, disinfected, and rinsed to remove all traces of vaccine and disinfectant.
- Drive the birds (if reared on the floor) to an area of the barn where they can be vaccinated without them flying or moving freely away from the vaccination equipment.
- Calculate the total number of doses and the total volume of diluent (distilled deionized water) required to vaccine all chickens. The water used should not be chlorinated and should have a pH of 5,5 to 7,0.
- Turn off the lights, brooders and ventilation system while ensuring the birds do not overheat or suffocate. The flock should be relatively calm when spraying the vaccine on them.
- Reconstitute the vaccine aseptically and in the shade, and only immediately prior to vaccinating the flock.
- Use appropriate personal protective equipment (PPE), including protective mask and goggles.
- Adjust the spray nozzle to a proper droplet size. Coarse sprays (>80-120 microns) are recommended for priming vaccinations and also, for invasive vaccines. Fine sprays (50-60 microns) are recommended for boost vaccinations in older chickens, but only after they have been primed with similar viruses.
- MG-infected chickens tend to react too severely to spray vaccinations, particularly if the droplet size is too small.
- Use distilled water to dilute the vaccine (the amount should be adjusted to every situation). If a pressurized spray apparatus is used, it should be kept in mind that this type of equipment delivers droplets with a diameter range of 50-1000 microns, and thus only part of the vaccine will be inhaled. Thus, it is necessary to spray the vaccine at a distance not larger than 50cm from the chickens. This type of equipment typically requires a relatively large volume per chicken house (15-20 liters). For situations where a controlled-droplet application apparatus is used, the droplet size is considerably more uniform (~50-150 microns). Although the droplet size is more uniform with this type of equipment, some of the droplets are too small and may remain in suspension for quite some time after the vaccine is sprayed. This may represent a problem because a vaccine that stays in suspension a long time may decrease in virus titer before it is inhaled and much of the vaccine ends up on house and equipment surfaces but not in the chickens. In addition, if much of the vaccine remains in suspension (in the form of a mist), re-activating the ventilation system will draw the vaccine out of the house through the exhaust fans.
- Only spray-vaccinate healthy birds. Avoid spraying birds that are infected with MG.
- Adjust the nozzle to obtain the desired droplet size.
- Wear a mask and goggles for personal protection when spray vaccinating. Make sure the sprayer to be used is clean and has no residual disinfectant. The vaccine containers of the spray apparatus should be rinsed with distilled water prior to and after every use.
- Use only one dose per bird or less.
- Reconstitute the vaccine only immediately prior to use.
- Close up the house including curtains and doors and shut the ventilation system and dim the lights while the birds are being vaccinated and if possible, for 20-30 minutes postvaccination (provided the air quality and temperature allow for a

temporary shut down without compromising the flock integrity). If the flock is in a high temperature area, vaccinate birds at night or early in the morning. Make sure the ventilation system is not running at the time the vaccine is being applied or that it runs at a minimum power. Dim the lights to a minimum to settle the birds.

- Spray the birds evenly and thoroughly at least twice and ensure that all calculated doses are used evenly. The heads and upper body of the sprayed birds should appear wet after vaccination.
- Make a point of not leaving the farm without making sure the ventilation system and the lights have been re-engaged.
- Ventilation should be restored approximately 20 minutes after the initiation of the vaccination process.
- Rinse, clean, disinfect and re-rinse the vaccination equipment before leaving the farm.
- Destroy all residual vaccine and vaccine vials by incineration. Follow local regulations regarding adequate disposal of vaccines, vaccine vials and biological materials.

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Credits

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Photography
Main Photographer: Hendrix Genetics B.V.
Additional: Merck Animal Health (pictures at pages 101, 103, 110)

Appendix: conversion table

1 mtr.	= 3,282 feet	1 foot	= 0,305 mtr.
1 sq. mtr.	= 10,76 sq. feet	1 sq. foot	= 0,093 sq. mtr.
1 cub. mtr.	= 35,316 cub. feet	1 cub. foot	= 0,028317 cub. m.
1 cm.	= 0,394 inches	1 inch	= 2,54 cm.
1 sq. cm.	= 0,155 sq. inch	1 sq. inch	= 6,45 sq.cm.
1 kg.	= 2,205 lbs.	1 lb.	= 0,454 kg.
1 g.	= 0,035 ozs.	1 oz.	= 28,35 g.
1 ltr.	= 0,22 gallons	1 gallon	= 4,54 ltr.

1 bird per square metre	= 10,76 square feet per bird
3 birds per square metre	= 3,59 square feet per bird
4 birds per square metre	= 2,69 square feet per bird
5 birds per square metre	= 2,15 square feet per bird
7 birds per square metre	= 1,54 square feet per bird
11 birds per square metre	= 0,98 square feet per bird
13 birds per square metre	= 0,83 square feet per bird
1 cubic meter/kilogram/hour	= 16,016 cubic feet/lb./hour
1 cubic foot/lb./hour	= 0,0624 cubic meter/kilogram/ hour

F °	= 9/5 °C+32	°C	= 5/9 (°F-32)		
45 °C	= 113 °F	22 °C	= 72 °F	10 °C	= 50 °F
40 °C	= 104 °F	20 °C	= 68 °F	8 °C	= 46 °F
35 °C	= 95 °F	18 °C	= 64 °F	6 °C	= 43 °F
30 °C	= 86 °F	16 °C	= 61 °F	4 °C	= 39 °F
27 °C	= 81 °F	14 °C	= 57 °F	2 °C	= 36 °F
24 °C	= 75 °F	12 °C	= 54 °F	0 °C	= 32 °F

1 Joule per second = 1 Watt = Volt x Ampere 1 KJ =1000J
1 MJ = 1000KJ
1 MJ = 239 Kcal
1 Kcal = 4.2 KJ
1 KWh = 3.6MJ - 860 Kcal
1 BTU = 1055J

Appendix: daylength according to the Northern Hemisphere latitude

Lat	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	12:07	12:07	12:06	12:06	12:06	12:07	12:07	12:06	12:06	12:06	12:06	12:07
5	11:50	11:54	12:01	12:09	12:17	12:23	12:24	12:19	12:12	12:04	11:56	11:51
10	11:33	11:42	11:56	12:13	12:28	12:40	12:41	12:33	12:18	12:01	11:46	11:35
15	11:15	11:29	11:50	12:16	12:40	12:57	13:00	12:47	12:24	11:59	11:35	11:18
20	10:57	11:16	11:45	12:20	12:52	13:15	13:19	13:01	12:30	11:57	11:23	11:00
25	10:37	11:02	11:39	12:24	13:05	13:35	13:39	13:17	12:37	11:54	11:12	10:41
30	10:15	10:46	11:33	12:29	13:20	13:57	14:02	13:34	12:45	11:52	10:59	10:21
35	9:51	10:29	11:26	12:34	13:36	14:21	14:28	13:53	12:54	11:49	10:44	9:58
40	9:23	10:10	11:18	12:40	13:54	14:49	14:57	14:15	13:03	11:46	10:28	9:32
45	8:50	9:48	11:09	12:47	14:16	15:23	15:33	14:41	13:15	11:42	10:09	9:01
50	8:10	9:20	10:58	12:55	14:42	16:04	16:17	15:13	13:28	11:38	9:47	8:24
55	7:17	8:46	10:45	13:05	15:15	16:59	17:16	15:53	13:46	11:33	9:18	7:35
60	6:03	8:00	10:29	13:18	16:00	18:18	18:42	16:49	14:08	11:26	8:41	6:27
65	3:54	6:54	10:06	13:37	17:05	20:42	21:36	18:14	14:39	11:18	7:48	4:36

Appendix: daylength according to the Southern Hemisphere latitude

Lat	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	12:07	12:06	12:06	12:06	12:06	12:07	12:07	12:07	12:06	12:06	12:06	12:07
5	12:24	12:19	12:12	12:04	11:56	11:51	11:50	11:54	12:01	12:09	12:17	12:23
10	12:41	12:33	12:18	12:01	11:46	11:35	11:33	11:42	11:56	12:13	12:28	12:40
15	13:00	12:47	12:24	11:59	11:35	11:18	11:15	11:29	11:50	12:16	12:40	12:57
20	13:19	13:01	12:30	11:57	11:23	11:00	10:57	11:16	11:45	12:20	12:52	13:15
25	13:39	13:17	12:37	11:54	11:12	10:41	10:37	11:02	11:39	12:24	13:05	13:35
30	14:02	13:34	12:45	11:52	10:59	10:21	10:15	10:46	11:33	12:29	13:20	13:57
35	14:28	13:53	12:54	11:49	10:44	9:58	9:51	10:29	11:26	12:34	13:36	14:21
40	14:57	14:15	13:03	11:46	10:28	9:32	9:23	10:10	11:18	12:40	13:54	14:49
45	15:33	14:41	13:15	11:42	10:09	9:01	8:50	9:48	11:09	12:47	14:16	15:23
50	16:17	15:13	13:28	11:38	9:47	8:24	8:10	9:20	10:58	12:55	14:42	16:04
55	17:16	15:53	13:46	11:33	9:18	7:35	7:17	8:46	10:45	13:05	15:15	16:59
60	18:42	16:49	14:08	11:26	8:41	6:27	6:03	8:00	10:29	13:18	16:00	18:18
65	21:36	18:14	14:39	11:18	7:48	4:36	3:54	6:54	10:06	13:37	17:05	20:42

Visitor registration						If "NO" always consult the location manager before entering!				
Date	Name visitor	License plate	Arrival time	Departure time	Appointment for visit	72h free of contact with poultry?*	48h free of contact with pigs, veal, calves. fur animals? **	Date of contact	Name company visited	Signature visitor
30/01/2018	Piet Jansen	12-ABC-34	10:20	12:05	Health inspection	Yes / No	Yes / No	12/06/19	HG	P. Jansen
						Yes / No				
						Yes / No				
						Yes / No				
						Yes / No				
						Yes / No				

*Have you had contact with poultry / birds in the previous 72 hours? If so, always consult the location manager before entering. Fill out date and address of this poultry contact.

**Have you had contact with pigs / veal calves / fur producing animals in the previous 72 hours? If yes, consult the manager before entering. Fill out date and address of this contact.

Notes:

HENDRIX GENETICS