Innovation Breeds Success

ISA BROWN

COMMERCIAL PRODUCT GUIDE

NORTH AMERICAN VERSION

THE STORY OF ISA

In 1975, the Ministry of Agriculture in France were determined to develop a poultry sector which would be able to compete internationally.

Led by Alain Audubert, an independent appraisal of the poultry breeding sector in France concluded that future international success should be based on excellence, innovation and research.

This philosophy became the guiding scientific principle behind the “Institut de Sélection Animale” (ISA) which was formed by the merger of the poultry stock of two organizations, Studler S.A. and I.N.R.A. Magneraud (INRA-M).

A commitment to excellence in breeding, innovative research techniques and constant improvements in pursuit of the perfect expression of the breeds genetic potential lies behind the success of the ISA Brown.

As a result, by the mid 1980s, the ISA Brown had become a global brand and worldwide leader in the world brown egg market. This position has remained ever since.

THE ISA BROWN TODAY

The ISA Brown is recognized globally for its exceptional feed conversion, which makes it one of the most efficient, proven and profitable brown egg layers in the world.

Producing high numbers of first quality eggs, per hen housed, the ISA Brown is a reliable and versatile layer with excellent feed conversion which adapts well to differing climates and housing systems.

Optimal egg size, strong shells and great laying persistency also make the ISA Brown perfectly suitable for longer laying cycles.

- A reliable and economic winner
- Proven worldwide
- High production and excellent persistency
- The efficient brown egg layer
- Market leader in egg numbers

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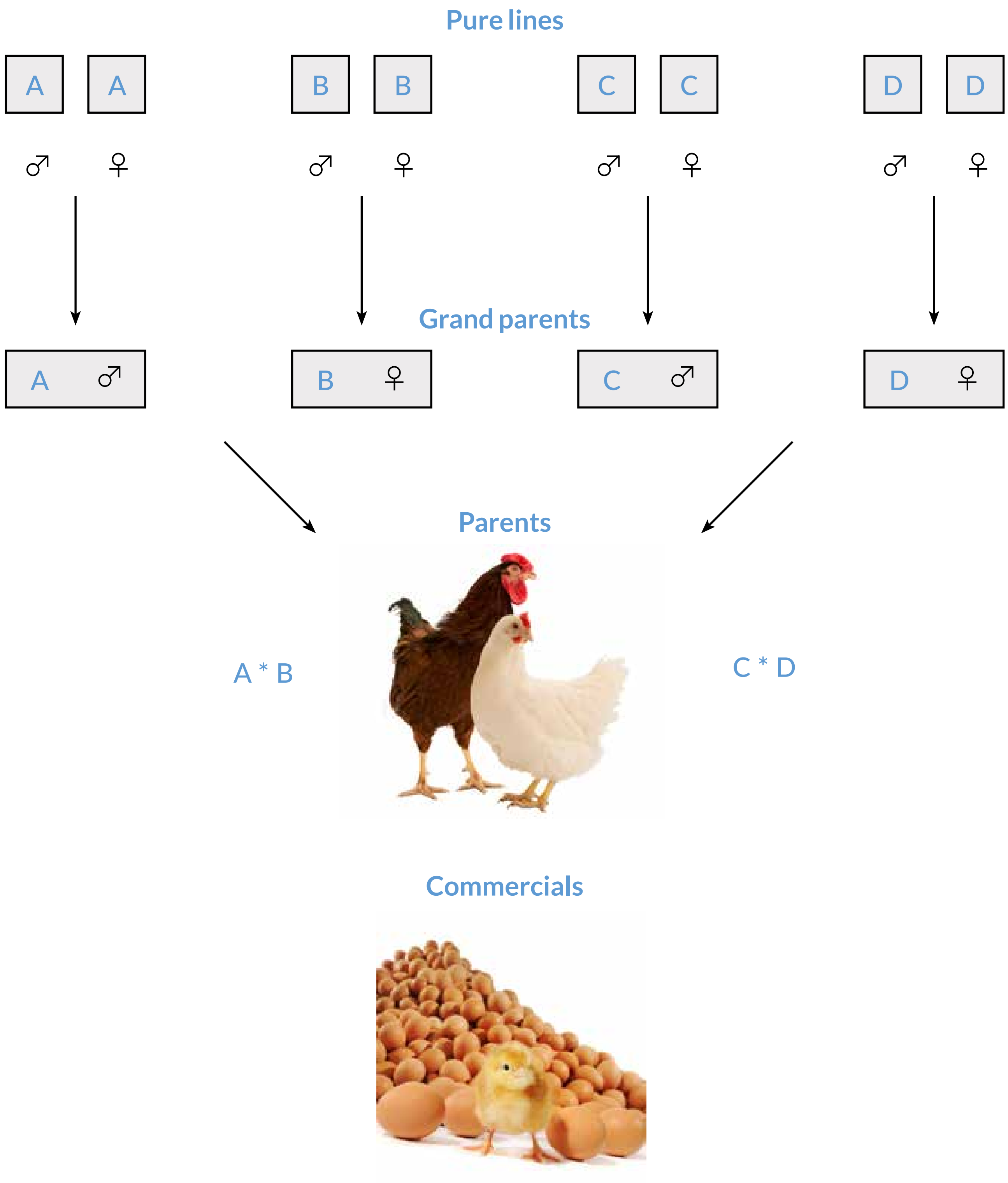
ISA Brown

Commercial performance objectives 18-90 weeks

Bodyweight at 18 weeks:	1537-1615 g	3.39 – 3.56 lb.
Bodyweight at 30 weeks:	1850 g	4.08 lb.
Bodyweight at 90 weeks:	2000 g	4.41 lb.
Hen housed production		
at 60 weeks:	258 eggs	
at 72 weeks:	327 eggs	
at 90 weeks:	420 eggs	
Age at 50% rate of lay:	144 days	
Peak production:	96 %	
Production rate:		
at 60 weeks:	88 %	
at 72 weeks:	82 %	
at 90 weeks:	74 %	
Total egg mass		
at 60 weeks:	15.96 kg	35.2 lb.
at 72 weeks:	20.36 kg	44.9 lb.
at 90 weeks:	26.36 kg	58.1 lb.
Average egg weight:	62.9 g	49.9 lb./case
Feed Conversion (ratio by weight)	2.10 kg/kg	3.49 lb./dozen
Average feed consumption during lay per day	111 g	24.5 lbs./100
Shell Strength	4100 g/cm2	
Haugh Units	82	
Livability (18 – 90 weeks)	94 %	

Breeding scheme



Your commercials chicks are the results of a multiple crossing process which give the commercial layer a high potential for egg production, as well as a good capability in adapting to the various environments.

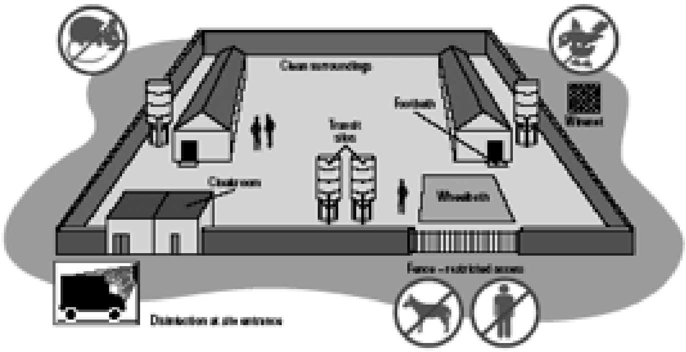
General rules, farm & house design

Basic rules of farm location

Land governing regulations and environmental restrictions must be considered.

Farm should be placed as far as possible from other poultry houses. Each phase of production should be treated as a separate batch, according to the principle of "ALL IN – ALL OUT".

- On a rearing farm: one age only
- On a laying farm: one age only and naturally one source of supply
- No other poultry on the rearing or laying farm
- Ideally three separate laying units, supplied by the one rearing unit



Housing types

General rules:

- Whatever the building style, they should be constructed so that they may be easily and thoroughly cleaned and disinfected between flocks. The walls and roofs should contain insulation with a moisture barrier and rodent proof materials.
- Adequate ceiling height for adequate ventilation purposes
- Equipment used in house should be designed for easy access and removal for clean-out, maintenance and biosecurity consideration
- In open sided housing it is important:
  - To have sun protection
  - To use insulated materials including a shield (protection) for water tanks and pipes
  - To place a wire netting and fencing over openings and ventilation inlets to control predators, rodents and wild birds and other disease vectors
  - To use a reliable source of electric power

Definition of different systems

Cages – traditional, enrichable, enriched.

Alternative systems

Alternative production systems can be defined as a non-cage system with nests, adequate perches and a scratching area.Within alternative production systems different housing sub systems can be defined as:

- A barn (deep litter) system is a house where birds have access to a litter area, and are able to practice natural behaviour like dust bathing and scratching. A barn house also provides nest boxes and can have a slatted area where water and feed are presented.
- An aviary house (multi tier) is like a barn house, in addition, birds are able to move among different levels.

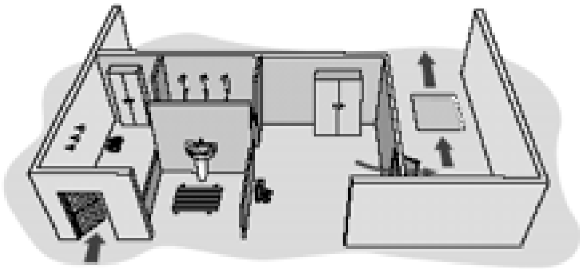
Feed is presented on different levels and water is mainly presented in front of the nest box. Birds need to move through the system to eat, drink, rest and produce eggs.

- Free range is either a barn or an aviary house from which birds have access to an outside range area.

Dirty & clean area concept

Control the entries and restrict to the minimum the number of entries in the farm with strict procedures:

- Floor material choice for easy maintenance (clean up and disinfection)
- Clean hands with soap
- Wear protective clothing within the farm area
- Provide specific protective clothing for veterinarians, consultants, etc...
- Disinfect boots before entry
- Do not allow truck/Lorry drivers to enter the houses



Clean up & disinfection

- Use an insecticide just after the birds have been removed
- Remove all the non-stationary equipment and residual feed from troughs, conveyors and bins
- Exterminate all rodents and wild birds
- Remove all the manure, litter, feathers, dust, and any other organic materials
- Wash equipment, fans, ducts, water tanks, feed bins, walls and floor
- Disinfection is efficient only after cleaning thoroughly
  - Disinfect the interior of the building on surfaces and all equipment
  - f it is permitted and the building can be tightly enclosed, fumigate the building while it is still damp from disinfecting
  - After the building is fumigated, close up for 24 hours and then air out for another 24 hours

THE REARING PERIOD

Key period 1: From chicks arrival to 4 weeks of age

Lighting program	Pre starter feed
Slow step down	4 / 5 weeks in crumbs
Light length & consumption	2950 kcal & 20.5 % of protein

↓ ↓

Target: be at standard bodyweight at 4 weeks	Stocking densities
	Environment control, T°, Humidity
	Water quality
	Equipment
	Quality of beak treatment
	Ventilation

Bodyweight at 4 weeks old influences bodyweight at transfer

Tools to reach the target

- Starting in house conditions (temperature, comfort, hydration of the all the chicks on arrival)
- Important to warm the pullet house 24 hours prior to chicks arrival
- If chicks brooding done in cages – rough, moisture-proof paper should be laid on the wire floor (first 7 days)
- Stocking density in relation to space and equipment (competition creates stress, poor growth and uniformity)
- Observe your birds several times per day
- Control the bodyweight as soon as possible
- Keep a slow down light program, so that all chicks can have enough time to eat
- If beak trimming: strong attention to details (frequency of blade replacement, temperature, proper trim etc.)
- Usage of infrared beak treatment requires that chicks upon arrival to a farm will have very easy access to the source of water (water cups should be filled, droplets of water should be seen from the nipples, water pressure must be reduced during first few days)
- A high energy starter diet in crumb form for at least the first 4 weeks in temperate climates and 5 weeks in hot climates. Do not switch to a 'lighter' feed before you have verified that bodyweight is on target.

Essential points

Light

- During first few days:
- Maintain 22 to 23 hours of light
- With 30 – 40 lux to encourage intake of water and feed
- Afterwards
- Normal decreasing lighting program
- 10 lux at 15 days old (dark houses) and then adapt to bird behaviour

Water

- Wash of drinking system after disinfection
- Any medication should be carried out via the feed
- During the first 2 days, use tepid water at 20-25°C
- 50 g of vitamin C per litre the first day if chicks are dehydrated
- Supplementary drinkers during the first few days (removal should be done gradually)
- Drinkers should be cleaned daily the first 2 weeks and then once a week
- When nipple drinkers are used, we recommend that strips of embossed paper are placed under the nipples

Feed

- Starter diet should be distributed when chicks have drunk enough water to restore their body fluid (4 hours after delivery)
- Diet presented in crumb form with adequate protein and energy concentration
- For first few feeds, special small feed on non-smooth paper help feed consumption
- To avoid built up of fine particles, we advise allowing them to become empty once or twice each week

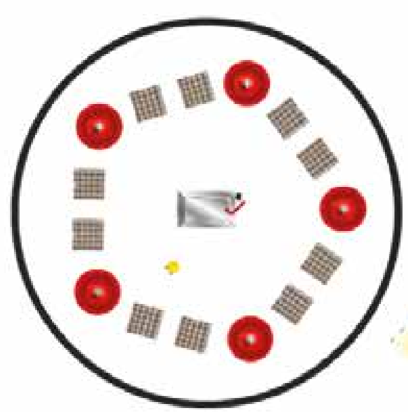
Stocking densities & environment from arrival to 4 weeks of age

Stocking density is one of the most important parameters of the starting conditions. Overcrowded flock tends to have higher mortality and culls, slower growth and lower uniformity. Keep to the optimum stocking densities from the early arrival of the chicks.

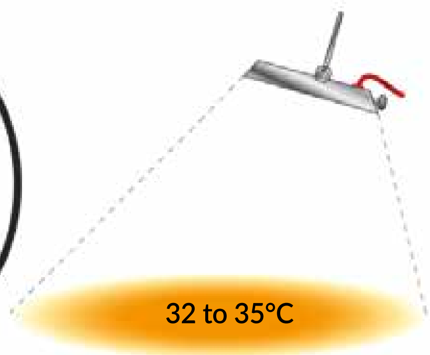
		Floor		Cages	
Stocking density (maximum)		14 birds / m²	1.3 birds / sq.ft	200 cm²	31 sq.in
Minimum ventilation rate		0.7 m³ / h / kg	11.2 cu.ft / h / pds	0.7m³ / h / kg	11.2 cu.ft / h / pds
Heating		2 gas brooders or 2 radiant heaters of 1450 Kcal / 1000 birds			
Drinkers	Starters				
	Temerate climate	1 starter / 100 birds			
	Hot climate	1 starter / 80 birds			
	Bell drinkers	150 birds / hanging bell drinker (80 to 100 in hot climate)			
	Nipples				
	Temerate climate	16 birds / nipple			
	Hot climate	10 birds / nipple			
Feeders	Per starter pans				
	Linear chain	4 cm / bird	1.6 in / bird	1.5 cm / bird	1.0 in / bird
	Per feeder	1 unit / 50 birds	1 unit / 50 birds	1 unit / 50 birds	1 unit / 50 birds

Starting conditions

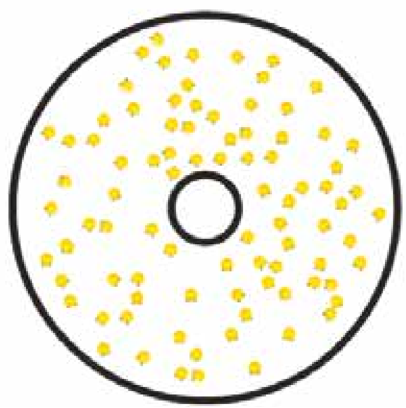
Recommended layout for 500 chicks



Radiant heater position



Optimum distribution of chicks



A: radiant heater of 1450 Kcal capacity
B: drinkers (5) but (7) for hot climate
C: feed trays (10)
D: 75 watt bulb at 1.5M above floor level
E: surround: 4m diameter - 0.6m high

Brooding period (0-5 weeks)

The main goal of this period is to reach the bodyweight standard at 5 weeks of age. The starting conditions in the house – recommended temperature, humidity, light intensity and duration, air exchange, enough space and an easy access to good quality water and feed - will provide the chicks with the necessary comfort to get to this target.

Any delay in growth at 4-5 weeks will be reflected in a reduction in bodyweight at 16 weeks and then in performance, particularly in mean egg weight in temperate climates.

Brooding at high density (double brooding) requires special attention to the following points:

- Adjust the equipment to the bird number
- Do not release birds too late (4-5 weeks)

Otherwise, it will:

- Affect growth and uniformity
- Increase disease challenge
- Affect litter quality

Temperature

Chick body temperature

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. The best way to check if the house temperature is correct during this period, is to measure cloacal temperature of the chicks using digital ear thermometer.

When taking chick body temperature, place the probe gently onto the cloaca. Ensure proper contact without penetration. Push and release button while holding the probe against the vent area of the chick. Hold the probe against cloaca until hearing a long beep which indicates the end of measurement process. Optimum chick body temperature is 40°C or 104°F.

Take temperature of at least 20 chicks throughout the house to get an indication of the situation. Day old chicks cannot regulate their own temperature yet, so they depend on ambient conditions. Be aware, that chick body temperature reacts quickly after ambient conditions have been changed.

Measuring litter temperature

Measuring chick body temperature

Barn temperature.

As a rule, we start with room temperatures of 31- 33°C during the first week and decrease then gradually to reach around 20°C at 5 weeks of age.

We give the temperature standards in the table below, however observation of the flock is the best indicator of real needs. When birds are crowding, temperature is too low. When birds are inactive, lethargic and spreading away from the heat source, temperature is too high.

Some events in the flock (e.g. Post vaccine reaction) might require an increase in the temperature temporarily, to help the chicks to cope with the stress.

On the other hand, high temperatures could limit good feathering, feed intake and consequently the bird's growth. It is also important to prevent floor draughts. Adjust ventilation to achieve an even room temperature without sudden changes. Draught proof circular "chick guards" of a clean and flexible material could be used. They serve to keep chicks comfortable.

In cases of multi age rearing, which we do not recommend, temperature settings must be based on youngest chicks. Chicks should be reared in separate pens to maintain uniformity.

Standards for temperature and humidity

Age (days)	Brooding temperature		Room temperature	Relative humidity
	At the edge of the brooders	At 2-3m from the brooders		Optimum & maximum in %
0 – 3	35°C	29 – 28°C	33 – 31°C	55 – 60
4 – 7	34°C	27°C	32 – 31°C	55 – 60
8 – 14	32°C	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

- For floor rearing, the standard is 500 chicks per 1450 kcal
- Preheat the building for 24 to 36 hours before the chicks arrive to obtain a litter temperature at 28 to 31 °C
- Uniform temperature and relative humidity, throughout the building
- On floor rearing, distribution of chicks throughout the building should be uniform. If the chicks crowd together under the brooder: temperature is too low. If the chicks are close to the surround: the temperature is too high.

Partitioning

Facilities within the poultry house must be designed for maximum comfort and must allow birds to express their natural behaviour. Partitions within the house can be provided to avoid competition and allow birds to have separate areas/pens for feeding and drinking. This will also have positive effect on bird's behaviour in terms of smothering, cannibalism, feather pecking and mortality.

The design should incorporate as many lightweight materials as possible. This gives better flexibility when moving and helps in cleaning and disinfection. Lightweight materials can be either metal, wood or plastic. The design also requires a none solid wall such as wire mesh (large gauge) to allow airflow through and to avoid restrictions due to dust accumulation. To prevent birds on either side of the partition from seeing each other, it is often recommended the bottom part should be blanked off to a height of 30 cm.

Perches

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

- To increase the usable surface per bird and decrease floor density
- To train the bird to jump in the system
- To offer an escape to aggressed birds

The recommended perch surface per bird is 5 cm. The first accessible level must be at 20 cm. height. Perches must be introduced before 4 weeks of age.

Litter

Litter is used to cover the floor in rearing/brooder house. It usually consists of wood shavings or chopped straw. Litter is an important component of the rearing input that must be well managed to prevent unhealthy environment and potential disease conditions. Good quality shavings must be used as litter to avoid the risk of introducing various diseases to the site.

The following advice may assist in good litter management:

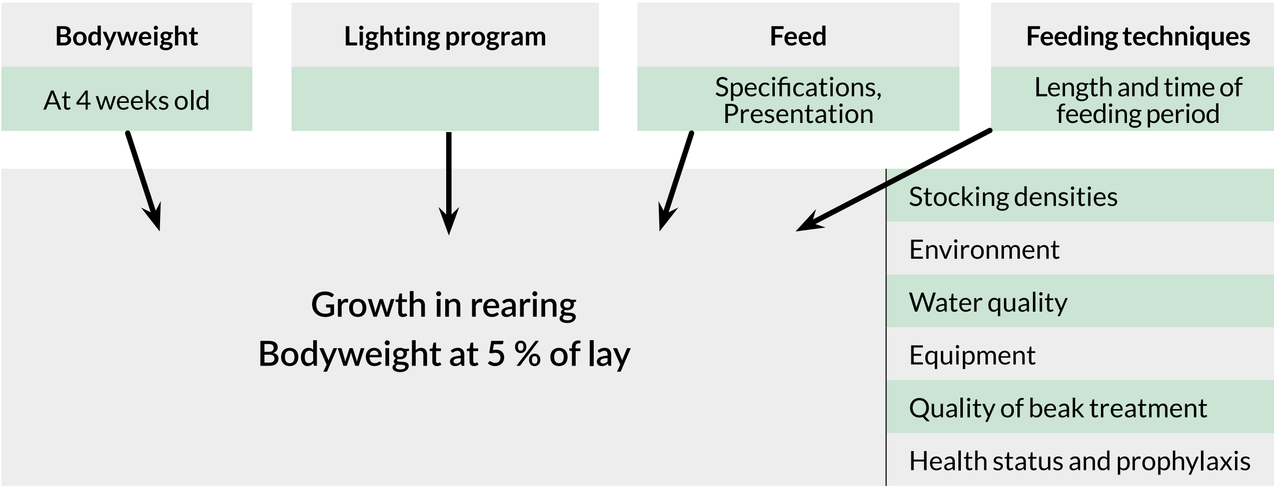
- Fresh shavings must be dried and friable
- Must be a suitable material and particle size
- Be stored in dry, hygienic, rodent-proof premises
- Avoid introducing wet or damp shavings into rearing house
- Do not use saw dust, as this could cause respiratory issues with chicks
- Avoid wet or caked litter

Good litter when pressed in the hand should stick together slightly and break up as the hand released.

Litter is important in the regulation of floor temperature and subsequently the chick's body temperature. The litter temperature should be approximately 30°C at the time the chicks are placed onto the floor. This is very important for the development of the chick in the first few days as they cannot self-regulate their body temperature until approximately 7 days.

Concrete floor houses with significant litter depth can lead to moisture problem.

Key period 2: From 4 to 16 weeks, building potential of the future layer



Too low bodyweight at start of lay could induce overall performance
(below normal egg size, reduction of peak of production and post peak drops)

The achievement of this objective depends on:

- Rearing conditions
  - Stocking density and the age chicks are moved to the laying location
  - Length of the lighting period
  - Quality of beak treatment
  - Prevention of stress
- Feeding methods
  - Emptying of feeders every day
  - Timing in feed distribution
  - Feed presentation
  - Use of midnight feeding in growing (if behind bodyweight standard)

Pullet growing space and equipment requirements (5 - 16 weeks):

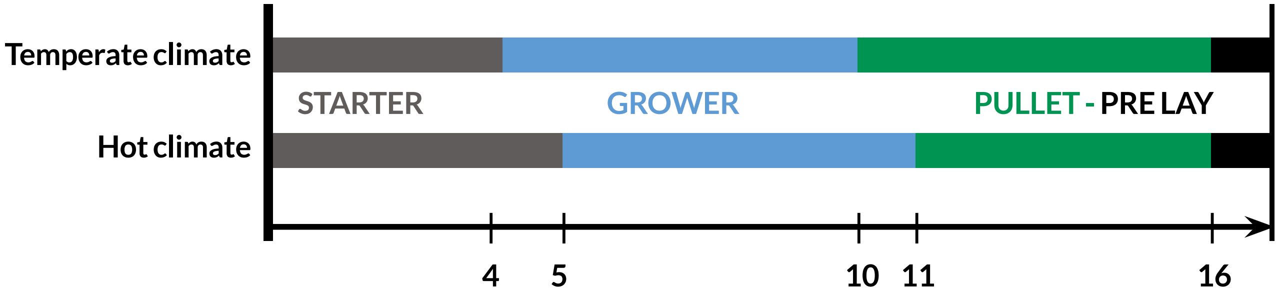
	Floor		Cages	
Stocking density (minimum)				
In temperate climate	10 birds / m²	1.07 sq. ft./bird	361 cm²	56 sq.in.
In hot climate				
With evaporating cooling	9 birds / m²	1.19 sq. ft./bird	400 cm²	62 sq.in.
Without evaporating cooling	8 birds / m²	1.34 sq. ft./bird	497 cm²	77 sq.in.
Minimum ventilation rate				
Temperate climate	4 m3 / h / kg – 64 cu.ft / h / pds1.19 sq. ft./bird			
Hot climate	6 m3 / h / kg – 96 cu.ft / h / pds1.34 sq. ft./bird			
Heating	space heating			
Drinkers				
Temperate climate	10 hanging drinkers / 1000 pullets or 1 nipple / 12 pullets 400 cm²			
Hot climate	13 hanging drinkers / 1000 pullets or 1 nipple / 10 pullets497 cm²			
Feeders	5 cm – 2 in / pullet or 1 pan / 25 pullets			

Bodyweights and approximate feed consumption for ISA Brown pullets

Age		Bodyweight				Feed intake per bird per day				Feed intake per bird cumulative			
Weeks	Days	(g)		(Lbs.)		g/bird		Lbs./100 birds		g/bird		Lbs./100	
		min	max	min	max	min	max	min	max	min	max	min	max
1	0 - 7	64	67	0.14	0.15	10	12	2.2	2.6	70	84	15.4	18.5
2	8 - 14	132	139	0.29	0.31	16	18	3.5	4.0	182	210	40.1	46.3
3	15 - 21	211	221	0.46	0.49	24	26	5.3	5.7	350	392	77.2	86.4
4	22 - 28	296	312	0.65	0.69	31	33	6.8	7.3	567	623	125.0	137.3
5	29 - 35	388	408	0.86	0.90	36	38	7.9	8.4	819	889	180.6	196.0
6	36 - 42	485	510	1.07	1.12	41	43	9.0	9.5	1,106	1,190	243.8	262.3
7	43 - 49	584	614	1.29	1.35	45	47	9.9	10.4	1,421	1,519	313.3	334.9
8	50 - 56	685	720	1.51	1.59	49	51	10.8	11.2	1,764	1,876	388.9	413.6
9	57 - 63	786	826	1.73	1.82	53	55	11.7	12.1	2,135	2,261	470.7	498.5
10	64 - 70	886	932	1.95	2.05	57	59	12.6	13.0	2,534	2,674	558.6	589.5
11	71 - 77	984	1,034	2.17	2.28	60	62	13.2	13.7	2,954	3,108	651.2	685.2
12	78 - 84	1,079	1,134	2.38	2.50	63	65	13.9	14.3	3,395	3,563	748.5	785.5
13	85 - 91	1,169	1,229	2.58	2.71	66	68	14.6	15.0	3,857	4,039	850.3	890.4
14	92 - 98	1,255	1,319	2.77	2.91	69	71	15.2	15.7	4,340	4,536	956.8	1000.0
15	99 - 105	1,335	1,404	2.94	3.09	72	74	15.9	16.3	4,844	5,054	1067.9	1114.2
16	106 - 112	1,409	1,481	3.11	3.27	75	77	16.5	17.0	5,369	5,593	1183.6	1233.0
17	113 - 119	1,476	1,552	3.25	3.42	78	80	17.2	17.6	5,915	6,153	1304.0	1356.6
18	120 - 126	1,537	1,615	3.39	3.56	83	85	18.3	18.6	6,497	6,748	1432.4	1487.9

Feeding: Formulas and techniques to stimulate growth and appetite

The range of diets



Grower Diet

- 4 to 10 weeks in temperate climate
- 5 to 10 or 11 weeks in hot climate
- Can be in mash form if the grist is right or as crumbs

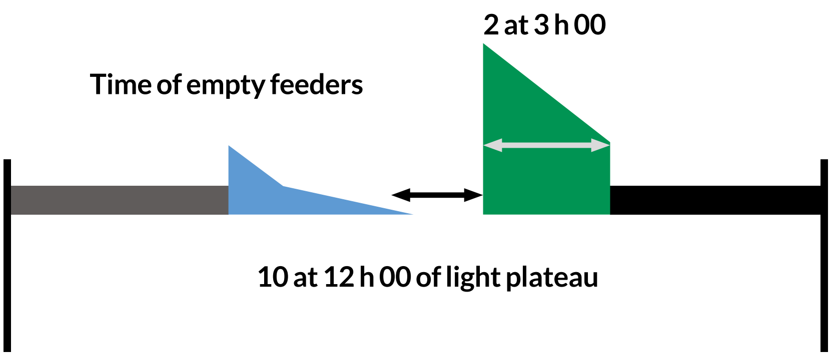
Pullet Diet

- 10/11 to 15/16 weeks
- Must meet birds' requirements for amino-acids
- Too low energy level will result in a reduction of growth
- Too high in energy will restrict the development of digestive tract and lead to reduced feed intake at start of lay
- So, we recommend an energy level slightly lower than layers diet

Pre-lay Diet

- 2 weeks before reaching 2 % lay
- Medullary bone which acts as a reservoir of mobilisable calcium for egg shell formation has its development during this period. Necessary to provide a feed rich in protein, phosphorus and calcium.
- To avoid under-consumption caused by powdery calcium carbonate, around 50% of calcium should be supplied in particles form (2 to 4 mm).

Feeding techniques



In order to:

- Avoid the build up of fine particles
- Encourage crop development by having rapid feed consumption
- Encourage gizzard development by using a coarse grist (50% of calcium in particles from 10 weeks)

Build up of fine particles residues

- Birds are natural grain eaters.
- Start to eat large particles and leave the finest ones.
- But accumulation of fine particles leads to under consumption.
- Essential to empty the feeders once a day.

Feed presentation

- Particles below 0.5 mm: 15 % maximum
- Particles above 3.2 mm: 10 % maximum

Rapid feed intake

- Crop is a storage organ.
- Crop allows the bird to eat enough feed in the evening to satisfy its energy needs throughout the night.
- Rapid feed consumption during rearing leads to the development of the crop.

Use of Insoluble grit or limestone particles

Weekly:

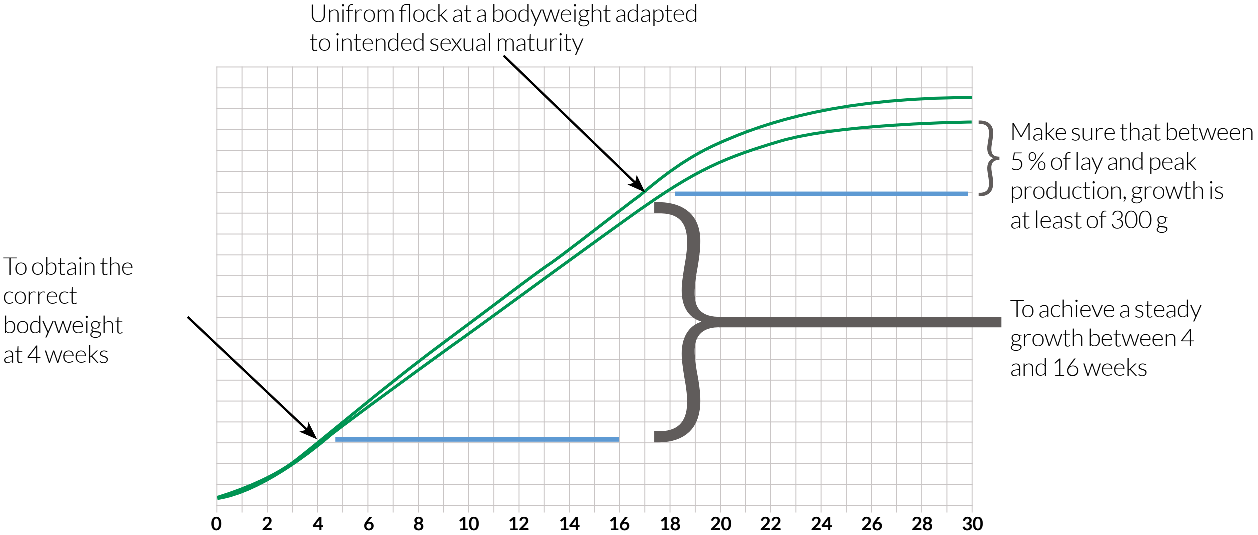
- 3 g / pullet from 3 to 10 weeks (2 to 3 mm)
- -- 4 - 5 g / pullet from 10 weeks (3 to 5 mm)

Feeding TImes

- Birds naturally eat more in the evening and in the morning.
- Empty feeder period is recommended in the middle of the day and could be started between 4 and 8 weeks.
- Length of empty feeder should be gradually increased to get a minimum of 2-3 hours (of empty feeder) at 12 weeks old.
- First feed distribution 2 to 3 hours before lights off.
- If a second one is necessary, it could be done just before lights off, birds will quite easily eat the finest particles in the morning.
- If are difficult to obtain empty feeders, reduce the amount of feed distributed

The control of growth:

A must every week, to check the real evolution of the flock – the earlier you know the earlier you can correct, if necessary



Productivity of laying hens is influenced by:

- The live bird at start of lay and
- By the growth potential from start of lay to peak of production.

The control of growth from day old is an important parameter to control.

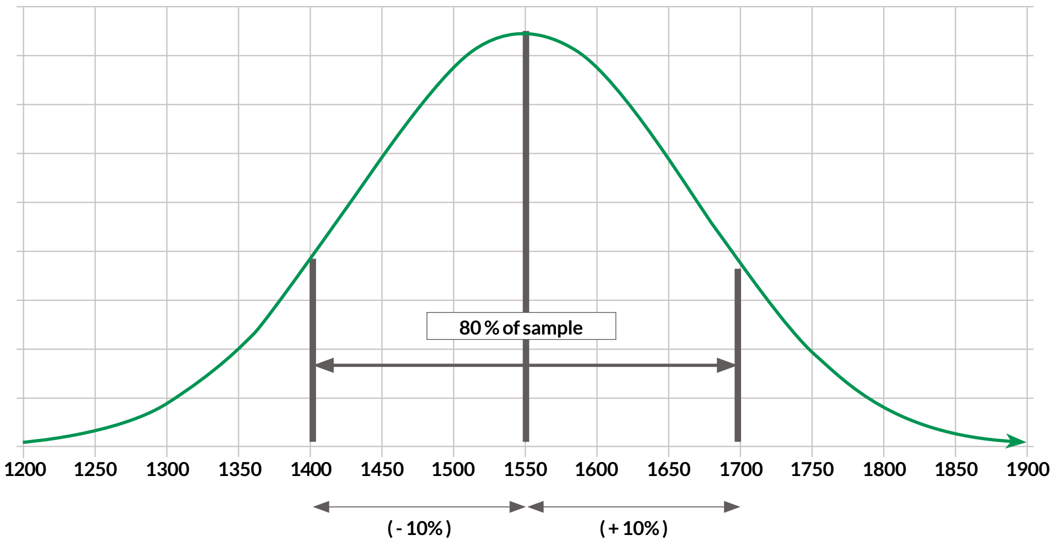
- Bodyweight at 4 weeks depends on brooding conditions, lighting program and feed presentation
- From 4 to 16 weeks, exceeding the growth rate often leads to a reduction in appetite during the first weeks of production. So we recommend during this period to keep the pullets' appetite active thanks to a daily empty feeder. Ration during this period should be adapted in order to maintain growth at higher standard line.

Method of weighing

- Time of weighing should be fixed preferably in the afternoon
- We advise carrying out individual weighing when chicks are 4 weeks old
- Surround a group of bird in the middle of the flock, and then weigh all the birds in the pen

A sampling with a minimum of 100 birds gives a good estimate of mean bodyweight and uniformity (or 2 times 50 birds if there are 2 pens). When rearing in cages, one should weigh all the birds from 5 or 6 cages chosen at random in different parts of the building.

Uniformity of the flock



- Uniformity of individual birds is important as well as average flock weights
- A batch is uniform when all the weights within the sample fall between ±20 % of the mean or , when 80 % of the weights lie within ±10% of the mean.
- Within the limits of ± 20 % of the mean, the smallest and the heaviest birds are of the same quality. Only those which are too small should be culled.

The Beak treatment:

To be carried out with strict guidance in accordance with welfare requirements

Why to beak treat?

- Reduction of incidence of pecking when it is a recurrent problem
- Reduction of feed wastage.

When to beak treat?

In dark houses (cages)

Beak treatment should be carried out carefully, at day old or at about 10 days old.

In some conditions

Beak treatment at around 10 days will not prevent pecking entirely. Therefore, we recommend a light treatment at 10 days (cauterisation of the beak tip and of the lateral edges) and then carrying out a second operation between 8 and 10 weeks of age, if it is allowed by codes and regulations of the country.

Carrying out beak treatment

Delicate operation

Risk of unevenness + difficulties with feeding and drinking **= Performed only by trained personnel**

Before treatment

- Do not beak treat when the birds are not healthy or when reacting to vaccinations
- Add vitamin K to the drinking water (to prevent haemorrhages)
- Check the equipment (temperature of the treatment blade: 600-650°C)
- Replace blade with frequency specified by equipment manufacturer, do not treat with dull blade

Beak treatment at hatch

Use standard beak treatment protocol for infrared beak treatment at hatch. Infrared beak treated chicks should have very easy access to water upon arrival to brooding facility. Usage of 360 dergee nipples is strongly recommended.

Beak treatment at about 10 days

Choose carefully the correct diameter hole on the beak-trimming machine, so as to cut the beak at least 2 mm from the nostrils. Hold the chick in one hand, with the thumb behind the head (the head firmly in position resting on the thumb. Tilt the chick's beak upwards through 15° and cauterize the reinforced side edges of the beak, to avoid unequal re-growth of the 2 mandibles. Check the temperature of the blade, each operator and the machine every hour.

At 8-10 weeks

Female where the beak has been trimmed at 8-10 weeks of age for floor housed laying systems or in cages in naturally lit houses

Insert a finger between the 2 mandibles. Cut the beak perpendicularly at a right angle to its long axis, so that after cauterisation about half the length of the beak between the tip and the nostrils is left. Cauterize each mandible with care, particularly at the sides of the beak, so as to round off the sides of the beak and avoid lateral re-growth.

At transfer

If necessary, re-trim the beaks of any birds which require it, if it is allowed by codes and welfare regulations of the particular country. Increase the water level in the drinkers, and the pressure in the pipes. Make sure that the depth of feed is adequate (do not empty the feeders for a week).

Growth and sexual maturity control through lighting program

How to encourage growth?

- Feed consumption is greatly influenced by light duration to which the pullets are exposed.
- Continuous light during the first three days
- From three days to 7 weeks old, reduce light duration to a constant light duration in temperate climate
- From 7 weeks old, maintain a constant light duration of 10.00:
  - In open house system, the light duration at the plateau has to be adapted to type of housing, time of the year and location of the rearing farm.
  - In summer time, in dark house system, the constant light duration at the plateau could be increased to 12.00 hours
  - In hot climate, a program of long days decreasing until 15 weeks allows the bird to eat during the cooler parts of the days in order to compensate reduction of bird's appetite due to heat causes.
  - In production, 15 hours of light duration at 50 % production encourage feed intake and allows birds to counteract the harmful effects of decreases of natural day-length.

How to manage sexual maturity?

- In absence of photo stimulation (constant light duration), the age at start of lay is determined by bodyweight. Once photo stimulation has started, age at start of lay is no more influenced by bodyweight.
- At all latitudes and irrespective type of house:
  - Never increase day length between 8 and 14 weeks
  - Never increase day length before 1250 g bodyweight
  - Never decrease day length after start of lay
  - Any decrease leads to drop of production.
- Egg weight depends on bodyweight at start of lay. So there is a strong correlation between precociousness and mean egg weight. A low bodyweight at sexual maturity:
  - Reduces mean egg weight
  - Could also induce lower overall performance (egg numbers, shell quality, livability,...)
  - To modify the mean average egg weight obtained, we recommend to advance or delay photo stimulation according to bodyweight as previously explained.
  - Two weeks modification in photo stimulation will modify start of lay by one week, the egg number by 4.5 eggs and mean egg weight by 1 g. Total egg mass produced will be not affected.
  - In order to control egg weight profile, an adequate lighting program has to be defined according to type of poultry house, location...

Target egg weight (Expressed as difference from standard)				
Bodyweight at simulation	**- 1 g / std**	**Standard**	**+ 1 g / std**	**+ 2 g / std**
1100 g	+ 2 h 00			
1175 g	*			
1250 g	*	+ 2 h 00		
1325 g	*	*		
1400 g	*	*	+ 2 h 00	
1475 g	*	*	+ 1 h 00	
1550 g	*	*	*	+ 2 h 00
1625 g	*	*	*	+ 1 h 00
*	*	*	*	+ 1 h 00
*	Then 30 minutes per week until 16 hours			

How to adapt light intensity?

- For the first few days, an intensity of 30-40 lux is recommended. After that the intensity used will depend on the intensity to be experienced during the laying period.
- Buildings are considered as dark houses when light penetration from outside, through all kinds of openings and produces intensity less than 0.5 lux. Others are considered as semi-dark.

In dark building:

- An intensity of 5 to 10 lux is sufficient if laying house is a dark building.
- If laying house is an open sided house design, to avoid too much of an increase in intensity at transfer, we recommend maintaining an intensity of 40 lux.

In a naturally lit or semi-dark house, in order to have an effective light program and to control sexual maturity, 40 lux may be required. An increase of light intensity is not needed to stimulate the pullets

Rearing in dark poultry house (Less than 0.5 lux above 20° latitude)

Basics rules:

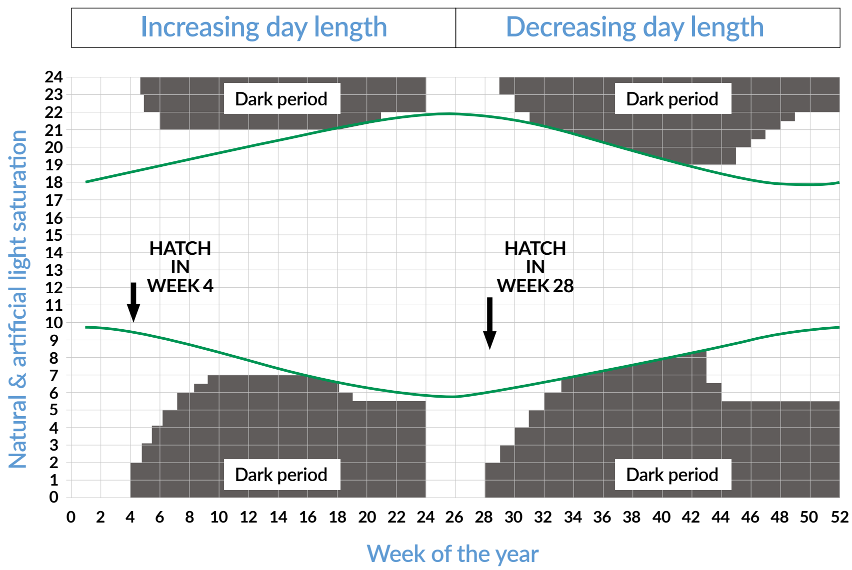
- Slow step down lighting program till 7 weeks
- 10.00 hours of light as a constant day length, or 12.00 hours in summer time
- 2.00 hours of photo stimulation and then 30 min per week

If production in natural-lit laying house:

- It is important to maintain 40 lux of light intensity to avoid too much of an increase in intensity at transfer.
- It is important to have constant light duration at the plateau in order to avoid too much of an increase in light duration at transfer
- Get 16.00 hours light at 50 % lay. It is not necessary to exceed 16 hours light in production

Rearing in naturally lit house

- It is very difficult to have a good control of lighting programs in open house systems.
- The following examples suggested are only guides. They should be modified according to results previously obtained.
- The lighting programs have to be planned in conjunction with changes in the natural day length.
- One should make sure that lights on and lights out coincide with sunrise and sunset at the time photo stimulation starts.
- It is not necessary to exceed 16 hours in production, but we advice to get 16 hours at 50 % production



Increasing day-length

- In increasing day-length, to avoid a too early sexual maturity, the length of the lighting given should be equal to the natural day-length to which the birds will be exposed
- Light stimulation should start by increasing the length of light by one hour (same increases should be done during next four consecutive weeks).
- After increase of light of 30 minutes per week.

Decreasing day-length

- In decreasing day-length, a step down lighting program will meet the natural day-length
- To reduce delay in sexual maturity induced by decreasing day-length, we advice to start the photo stimulation by 2 hours.
- And then 30 minutes per week.

Hot climate between 20° North latitude and 20° South

- In these areas, we face nearly constant hours of natural day-length during the whole year.
- To compensate reduction in bird's appetite due to heat causes, a slowly decreasing light program till 15 weeks old is advised.
- By giving light early in the morning, we encourage feed consumption during the cooler part of the day.
- Photo stimulation at 5 % production

To get an efficient light stimulation, we advise light is added on in the morning instead of the evening

THE PRODUCTION PERIOD

Key Period 3: The transfer to the production house

Rearing unit → **Laying unit**

Sources of stress:

- Transport
- Housing system (close, open house,...)
- Drinking system
- Feeding system
- Environment
- Light duration
- Temperature

How to reduce its negative effect?

"The transfer is a major stress, accompanied by changes in environment (temperature, humidity...) and equipment. It should be carried out as fast as possible, ideally being completed within a day. The following points should reduce the severity of this stress."

When? Transfer at 16 - 17 weeks old

Because of stress to which birds are subjected during transfer and immediately afterwards:

- It is extremely important that transfer has been completed before the appearance of the first eggs (Major developments of reproductive organs occurs during the 10 days prior to the first egg).
- We advise that vaccinations are given at least a week before transfer.
- A late transfer or a too long transfer often leads to delayed start of lay and higher mortality

Encouraging rapid adaptation to the new environment

- Give 22 hours of light the first day
- Light duration should be decided according to what has been used during rearing
- Increase the light intensity for 4 to 7 days to help the birds in the darkest cages to find nipples.
- High light intensity for longer than 7 days can increase the risks of pecking

Encouraging water consumption

The duration of transfer can be an important source of water loss, especially in some atmospheric conditions.

- Birds could be dehydrated
- Pullets should drink before feeding
- Absence of feed helps them to find the nipples
- Wait for 3 or 4 hours before distributing feed and check if drinking system is working properly
- A daily water consumption control is of paramount importance

It is also important to maintain the temperature at point of lay as close as possible to which they have become acclimatised during rearing.

Note: if nipples used in production, necessary to have nipple drinkers in growing.

Adult space requirements

	Cages	Litter	Litter & slats	All slats
Floor	450 cm^2 (69.8 sq.in.) / bird	6 birds/m^2 1.8 sq.ft./bird	8 birds/m^2 1.3 sq.ft./bird	9 birds/m^2 1.2 sq.ft./bird
Feeder Trough Pans	10 cm (4") / bird -	7.5 cm (3") / bird 4/100 birds		
Drinker Trough	10 cm (4") / bird	5.0 cm (2") / bird		
Birds/Round Bell Drinker	-	90		
Cups or Nipples	maximum 10 birds/cup or nipple a minimum of 2 cups or nipples per cage	maximum 10 birds/cup or nipple		

Laying period – key points for alternative systems

Housing equipment

It is strongly recommended to rear birds using the same system that will be used in production.

Slats

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. However, if the slats edge is too high (>90cm), birds will have difficulty accessing the slatted area.

To assist the birds to move from the litter to the slats/ system the provision of perches is required. Perch rails are generally preferable to 'ladders', as birds may choose to lay their eggs, or even to crowd and smother in the area under ladders. A gradual (enclosed) slope from floor to slatted area can also be used – angle to be at a level in which to avoid birds from perching/resting on it. If the slope is too steep, it could lead to an increase in floor eggs and make the access to the feeding and drinking system difficult for the bird.

Feed and water

We recommend the use of a feeding system that distributes the feed rapidly throughout the house and enables the birds to finish all the distributed daily feed. 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 its` peak of production. Rapid floor mounted chain feeders are proving to be the best option and have the easiest feed intake control. If pan or tube feeders are being used they should be adapted properly to this technique.

It is very important that birds find the same type of drinkers already accustomed to in the rearing house (for example nipples to nipples).

The feeders, as well as drinkers, should have their height adapted to the size of the birds so they are easily accessible and seen by the birds. They should not form a big obstacle to the movement of the birds throughout the house. They should be placed on slats (preferably in front of the nests), in case slatted areas are used in the house so that the birds are encouraged to use them. The drinker line attracts the birds to the nest boxes.

As already stated, the standards for drinking and feeding space given in the section on stocking densities and environment must be followed from transfer till depletion.

Remember: if the bird does not drink enough for any reason it will not eat enough and so the growth, uniformity and production of the flock will be compromised.

Nests

One comfortable individual nest should be available for 5 – 6 birds or 1 m^2 of collective nest for 120 birds (in some specific situations 100 birds / m^2 can be beneficial, see floor eggs section). If an individual nest is used, nests should be strawed to encourage the birds to use them. Nests must always be clean and well maintained. A good practice is to fit the nests with a dim (0.3-0.5 lux) light that allows the birds to find the nest before the normal day starts. If this is not possible a dim light placed over the slats and close to the nest must be switched on 1.5 h before lights on to avoid floor eggs.

Perches

Perches improve the welfare by allowing the bird to express its natural behaviour.

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

Recommended perch length per bird is a minimum of 10 cm. The first accessible level must be at 20 cm high. These values may be adjusted according to local regulations. The perches should be situated on the slats to maintain good litter conditions. Distance between perches should be 40 cm and a slope of 45°.

Partitioning and fencing

Pen size must be adapted according to local regulation. Partitioning the house in different pens has two advantages:

- Better distribution of the birds
- Easier flock management

Fencing – outside

Perimeter fencing is needed to protect birds from foxes, domestic pets, feral cats, mink, badgers, other predators and to reinforce security and bio security.

A typical fencing example could be a wire type mesh construction, 2 metres with an overhang of 30cm, placed at an angle of 45 degrees to the vertical on the outside of the fence. The bottom of the fence would be approx 30 cm underground to act as an anti- tunnelling 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. To avoid gaining access under the fence it is recommended to go approximately 50 cm underground (horizontal) with the fence.

Heating

The laying 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 hen increases feed intake as the maintenance requirements increase. 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 production 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 pullets and to respect minimum ventilation (cf. Ventilation part) requirements to avoid damage caused by high CO^2 and NH3 levels. It is however preferable to go down in temperature than to go up in CO2/ NH3 levels. If necessary, use heaters.

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 0.7 m^3 / hour / kg live bird.

Besides supplying the poultry house with fresh air, these 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 atmosphere helps to prevent disease. There is a strong association between dust particles and disease, as disease organisms tend to associate with particles of dust.
- 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.

Ventilation system

- A free range house may be ventilated mechanically, naturally, or by a combination of both systems. Fundamental to any system is the need for finely adjustable air inlets, usually at eaves level on both sides of the house, and outlets in the apex of the roof – the ridge. However, some houses may be cross ventilated, with inlets one side of the building and the extractor fans on the other side.

Air circulation

When rate of air change is low, it is important that air is circulated 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, birds will enjoy a more balanced temperature.
- Mixing air allows greater removal of moisture from the litter, keeping it dry.
- During hot weather, the effect of air moving over the birds is one of comfort, which can help mitigate the effect of temperature being above the optimum.
- Avoid direct draughts on the birds.

There are a number of ways to make air circulate within the house, one of the least expensive is to purchase an axial fan or air distribution fans.

Air quality recommendations

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

Frequent problems associated with poor ventilation

Too little ventilation	Too much ventilation	Uneven ventilation
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	Crowding	Poor production
Litter quality		Crowding
		Litter quality

Litter

Litter enables the birds to perform the natural functions of scratching and dust bathing, which most welfare authorities deem necessary for bird wellbeing. 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 of 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, in order to deter floor egg laying.

Litter management

The objective of litter management is to maintain a dry, friable and almost odourless 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

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. Both materials should be dry and uncontaminated when spread in the poultry house. Straw should be chemically treated to ensure freedom from moulds, 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. Avoid wet and caked litter.

Lighting systems

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 line are the optimum, one for scratching area, one for slats 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 behaviour inside the building and avoid dark areas where birds may lay on 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 birds 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 birds. Warm colour type (yellow-orange spectrum) must be used. In the event of negative bird behaviour, the use of lampshades and red painted light covers can help.

Floor eggs prevention

Prevention of floor eggs is a key factor for flock success. Avoiding this behaviour requires a lot of attention at the beginning of the lay.

In this section, we define floor eggs as all eggs laid out of the nest; it could be floor, slats, system eggs.

The two main points are:

- The nest must be more attractive and comfortable than other parts of the hen house
- Access to nest has to be easy for birds

Light

Light management is one of the key factors to prevent floor eggs.

- Light must be well spread in the laying house; shadow areas need to be avoided. Birds naturally lay in darkened areas. A simple action like replacing broken bulbs, can prevent it. When it is possible, a progressive light off process should be done. Lateral light should be turned off first, this will encourage birds to go close to the nest and to sleep on slats and lastly, the central light should be switched off.
- According to the breed used and the lighting program applied, a variable percentage of birds will lay before lights on; the propensity to lay on the floor is higher for these birds. Night light in the nest encourages these early birds to go into the nests for laying before the general lights come on.
- Where the legislation allows it, a night flash during the dark period (for example 1h30 of light, 3 hours after light off), will delay the lay of one part of the flock and reduce the competition in the nest. This will be more efficient if the number of birds per nest is high. In this case, all hens will get easy access to the nest.
- In some situations, adding one extra hour of light in the morning could solve floor eggs probem

General management advices

- All the corners caused by the equipment or the building design are potential areas for eggs to be laid. Therefore, limiting corners access prevents floor eggs.
- It has been observed that keeping the birds too long on the slats may increase the incidence of floor eggs. The floor scratching area needs to be accessible when the flock has discovered the upper area (nest, feeder, drinker).
- At the beginning of the lay, frequent floor egg collection has to be done (several times per day). A floor egg will encourage other birds to lay in the same place.
- Ensure all the birds are sleeping on the slatted area or system
- The observation of where and when the floor eggs are laid can give the reason for this behaviour. This information could be very useful to understand the problem and apply solutions to solve it.
- Grit distribution on floor discourages floor eggs by eliminating the building of potential nests in the litter
- Installation of a deflection barrier between the nest boxes enables the birds to be evenly distributed, diluting the pressure in the nest boxes. This also helps prevent overcrowding of nests located near to partitions.
- To prevent the floor to seem too comfortable, frequently remove the manure.

Behaviour

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

- Active nest searching
- Choice of nest
- Nest creation

Birds shouldn't be disturbed during the process of searching for a nest otherwise they stop the search. Disturbances induce them to lay where they are and increases floor egg numbers. For instance, feed distribution or egg belt running can also disturb the process of searching for a nest. Therefore, it is not recommended in the case of floor eggs to disturb birds with feed distribution or egg collection during the lay.

Ventilation and nests

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

Rearing

The rearing system should be as close as possible to the laying system to avoid the risk of increased floor eggs. It is recommended to install perches in the rearing house before 4 weeks of age. Light intensity does not need to be to high, because high intensity increases the sensitivity to dark areas in the laying house. Early transfer is strongly recommended in order to avoid the onset of lay in the rearing house, which can encourage the birds to lay on the floor in the laying house.

Equipment

Equipment position and stocking density can affect floor eggs.

- Feeder / drinker:
  - Not too close to the nest (no bird accumulation in front of the nest)
  - Take care of feeders and drinkers height (no creation f physical barrier between bird and nest)
  - Enough feeders and drinkers to avoid competition and stagnation near to them
- Nest:
  - Clean (without broken eggs, manure, etc.), attractive
  - Adequate number (120 birds / m² communal nest r 5-6 hens/single nest)
  - Nest access management: close the nest before light off; open the nest before light on.
- Slats:
  - Not too high, installation of ramp / ladder: easy access from scratching area to slats
  - Slat slope not too sharp: comfortable area, facilitate
  - Nest access
  - Electric fence
  - Installed next to the walls and corners

System eggs for aviary houses

Eggs laid on the system is a common problem in aviary systems. To avoid it we recommend:

- To promote birds perching as high as possible during night, this avoids crowding in front of the nest box in the morning.
- High perching can be promoted by using a longer dimming period.
- A light intensity in the system close to the light intensity in the rest of the house helps to create a space in the system not comfortable to lay eggs.
- Avoid lights in the system that also light the nest box.
- It is essential to promote birds use of perches and platforms to move up and down in the system or in between systems.
- Vertical movement can be stimulated by limiting access to water or feed on certain levels. When this is practised it is at the utmost importance to check if birds living on these levels eat and drink sufficiently.

When eggs are produced on the top level in most occasions this is because birds are afraid to move down. Placement of extra perches can help vertical movement and avoid mislaid eggs on the top level. It also can help not to feed on the upper level for the first feed distribution.

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

A floor / system egg collecting scheme can help to understand what happens after changing feed, water or light management.

Prolapse prevention

Prolapse refers to a condition seen in laying hens characterized by part of the oviduct remaining outside of the vent after the hen has laid an egg. Prolapse is very often combined with pecking of the vent and cloacal area or at the everted oviduct, leading to a rapid death.

The main causes of prolapse are the following:

- Improper bodyweight and frame development: underweight pullets at point of lay, before the reproductive tract is completely mature and oviduct muscles have developed elasticity and strength. Pullets with excess fat are also more prone to prolapse since fat excess contributes to lower elasticity and tone of the tissues involved in egg laying.
- Lighting program: too early light stimulation, before complete development, or giving excessively large light increments, leading to an increased incidence of double yolks.
- Any condition encouraging pecking behaviour: high light intensity, unbalanced feed, poor quality beak trimming, enteritis... increasing the chances of physical damage to oviduct tissues.

To control prolapse we advise:

- Making sure the flock is uniform during rearing
- Ensuring bodyweight is on target by getting a steady growth since early age
- Avoiding excess weight (i.e. fattening) during rearing
- Avoiding any sudden increase in light period
- Applying a proper lighting program to compensate natural light and avoiding unwanted early light simulation

Bird Behaviour

Individual or flock behaviour is influenced by many factors, singly but more usually in combination.

Normal Behaviour

In general, the bird can cope with moderate stress, such as temperature rise or fall, transfer from rearing to laying facilities, or change of ration, etc.

It is important to recognise any change in behaviour, as this may indicate some problem, and it is better that this is both recognised and remedied sooner rather than later. The most important behavioural characteristics to recognise are aggression and crowding.

Abnormal Behaviour

Pecking

We recognize different kinds of pecking. Gentle pecking we consider as normal behaviour and severe pecking as abnormal behaviour.

Gentle pecking: careful pecks, not resulting in feathers being pulled out and usually without interaction from the recipient bird. This is a social and explorative behaviour

Severe/injurious pecking: forceful pecks, sometimes with feathers being pulled out and with the recipient bird moving away. This is clearly an aggressive behaviour.

There are stressful circumstances, which may result in aggression. If some of the birds start pecking aggressively (not all pecking is aggressive, much is occupational and non-damaging) it is usual to hear squawks of pain from the pecked birds. This needs early identification, as it is abnormal. It is an indication that there is a serious stress affecting the flock, and prompt remedial action is essential.

Loss of feather cover leads to increased heat loss and consequently to higher feed consumption.

Possible causes are as follows:

- Parasitic infection:
  - Red mite.
  - Worms, ascarid, capillaria infestation.
- Enteritis and diarrhea
- Ventilation:
  - Inadequate ventilation, leading to higher levels of humidity and smell (ammonia)
  - Drafts.
- Non-respect of density and equipment specification
  - Insufficient floor space
  - Stress of overcrowding
  - Limited access to drinkers and feeders (insufficient number/ poor distribution).
  - Inability to access nests, resulting in floor laying – leading to pecking of exposed vents.
- Shortage of water or feed:
  - Drinkers / feeders empty.
  - Water or feed unpalatable
  - Too low pressure / leakage
  - Shortage
- Feeder and water equipment not earthed properly
- Poor beak trimming
- Feed not suitable:
  - Sodium deficiency
  - Amino acids deficiency
  - Lack of insoluble fibre
  - Sudden change of grist presentation
  - Too high energy level, due to a reduction in consumption time
  - Faulty manufacture – for instance, incorrect salt inclusion.
- Intensity of light too bright:
  - Light source generally too powerful.
  - Direct light from fluorescent bulbs (especially) or tubes; depending on the type.
  - Entry of direct sunlight into the poultry house.
  - Flickering bulbs
  - Sudden increases in light duration
- Nests brightly illuminated – bird's vents targeted during egg laying.

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

In case of a pecking outbreak, you need to react quickly to:

- Decrease light intensity*
- Paint bulbs or light covers in red
- Add salt into the water (0.5-1 kg/1000 l)
- Add extra vitamins / minerals / amino-acids in water

- Add a fibre source within the house (see fibre to layer)
- Add enrichment within the house (pecking blocks, fibre – good quality alfalfa hay, etc.).

*Caution: floor eggs could appear and feed intake could be decreased

Crowding

Floor-reared birds sometimes have a tendency to crowd together. This natural behaviour can be triggered by different situations:

- Panic reaction: when birds are frightened, they try to avoid danger
- Attraction: when they are attracted by something, as they are curious and want to find feed and discover their environment
- Sleeping behaviour: it enables them to reduce the loss of body heat during the night, maintain social links and protection against dangers

Smothering may occur during lay in different parts of the poultry house and often the reason is not clear. However, in production flocks, it is most commonly observed around the peak of production, as it seems to be related to stress situations.

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

- In the evening at “lights off”
- At the moment of 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 or feed intake is low
- When direct sunlight is getting in the poultry house
- Inadequate ventilation, uneven in-house temperature and draughts

To control the risk of smothering:

- Minimise the number of corners (e.g. feeder). It is sometimes better to sacrifice a little floor space, keeping a few less birds, in order to maintain straight line partitions.
- Ensure an even light distribution within the house. Install a light trap/deflector.
- Construct partitions with wire mesh; birds crowding against a mesh partition are still able to breathe
- Use wire mesh covered triangles in order to eliminate corners.
- Install electric wires along the walls, corners and partitions
- 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. Deflector installation in front of the pop holes could solve this issue.
- It is necessary to visit the birds at the end of the day or when lights go off to check behaviour, especially in the first few days after delivery.
- Install music in the houses so the birds react less to noises.
- Carry out a feed distribution one hour before lights go off. It will evenly distribute birds through out the building. The extra heat produced during digestion will avoid crowding before the night.
- Lighting program must be adapted to natural day length. Try to avoid switching off the lights before sunset, mainly during the longer day. This needs to be considered at flock placement.
- Ensure that available perch space is adequate
- Adapt the ventilation to obtain a uniform environment in the house and to avoid draughts
- Avoid any feed restriction at the critical periods
- Give scratching material (e.g. Grain/grit) in the afternoon to keep birds occupied

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. Floor laying leads to broodiness, preventing floor laying and frequent egg collection limits the amount of broodiness.

Broodiness can be identified by characteristic behaviour patterns such as staying in the nest, fluffed feathers, clucking and aggression. Therefore, we advise closing nests at the end of the afternoon. Nests should not be closed until 4 hours before lights off to avoid loss of late laid eggs.

The pause in lay depends upon rapid action.

Broodiness and lay link duration

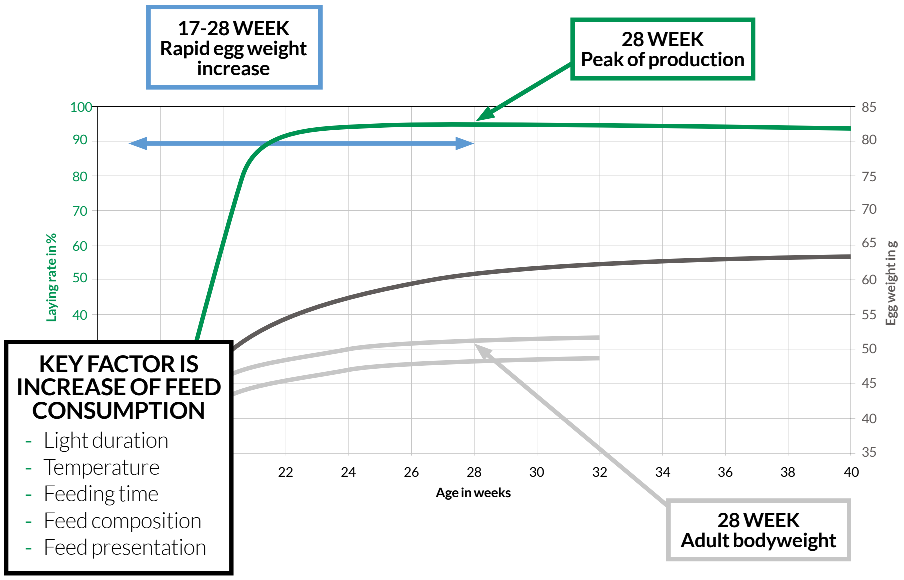
Time broody (days)	Pause in lay (days)
1	7
2	9
3	12
4	18

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

We advise isolation of broodies from the moment they appear (in the evening). Place them in a spacious pen, on a concrete or slatted floor without a nest. Treatment is made more effective by dipping the broodies in cold water for 20 to 30 seconds and administering aspirin (a 125 mg tablet) before transfer to the broody pen. 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.

The best system is to have 2 broody pens. The birds picked up on Monday, Tuesday and Wednesday are put in the first pen where they stay until the following Monday. The other pen is used for the other days and follows a similar time lapse. Avoid leaving broodies to brood on the floor, to reduce the spread of the behaviour.

Key Period 4: Laying phase 17-28 weeks



Between transfer and 28 weeks old, the bird has to cover:

- Its growth till adult bodyweight
- Its requirements to achieve peak of production
- Its requirements to get a rapid egg weight increase

Advice on how to encourage feed consumption

Adapted light duration:

- Achieving 15 hours of light at 50 % production
- Using midnight feeding till 1850 g for brown egg layers

Feeding times should take into account the behaviour of the birds:

- 60% of the feed is eaten during the last 5-6 hours of the day
- Minimizing the number of feed distributions according to equipment. Too many feed distributions leads to strong competition among the birds and a lack of uniformity due to preference for the larger feed particles

Below, we give some examples of feed distribution times:

- 2 distributions: 2/3 of the feed is given 5 to 6 hours before "lights-out" and the remaining 1/3 about 2 to 3 hours after "lights-on".
- 3 distributions: the first should be 5 to 6 hours before "lights-out", the second about 3 hours before "lights-out", and the third at lights on.
- 4 distributions: the same timetable as for 3 distributions, but with an extra distribution during the period of light given in the middle of the night.

By giving an early lay feed to satisfy the production and growth requirement:

- Using a diet with an amino acid content about 7 % higher than that of the diet used after peak
- Energy levels remain the same. As birds adapt their feed intake according to energy intake, too high energy diet content penalises the feed intake

Ambient temperature is strongly influencing feed consumption. Lower temperatures in the laying barn encourage birds to consume more feed to maintain their body temperature. Very important: after the housing give young layers opportunity to gain bodyweight and reach fast good early egg size. It is advisable to house layers with 70-71°F (21.1-21.7°C) to develop eating capacity and reach adult feed consumption. When peak production reached and feed consumption stabilized at around 30 weeks of age advisable gradually reach temperature in the barn at around 76°F or 24.4°C.

After 28 weeks: Managing for the best economical performances

Feed conversion ratio

When the bodyweight of the bird is correct, the feed conversion ratio can be improved slightly by:

Increasing house temperature:

- A change of 1°C in the ambient temperature brings about an inverse change in feed consumption in the order of 1.4 g per bird per day. In such temperature, egg weight is slightly reduced
- Increase of temperature is only possible if temperature throughout the poultry house is uniform
- Ventilation should always be satisfactory in accordance with requirements
- Above 27 °C, the appetite falls too much and the pullet under-consumes. It is important to avoid 27°C in the hottest parts of the house.

Monitoring dietary caloric content and consequential feed consumption:

- Energy content of the feed influence quantity of feed consumed. Higher energy in the feed will make hens eat less, and vice versa.
- Amount of bird activity and ambient temperature influence how much feed she will consume for maintenance.

Uniformity

In order to achieve persistency and good shell quality late in lay, it is essential to keep the flock uniform. Loss of uniformity during lay is the result of competition for the biggest feed particles. That depends upon:

- The percentage of particles greater than 3.2 mm in diameter
- The number of feed distributions
- The space and positioning of the feeders

Livability

Livability depends, in naturally lit buildings, on the quality of beak trimming (see chapter on "Beak-Trimming") and in dark buildings, on the lighting intensity used during the production period and most of all on the uniformity of light distribution (see chapter on "Light intensity").

Chlorination of the drinking water is essential to prevent infections from contaminated water. Frequent checks should be made on water quality.

Lighting programs: Several options possible, according to the local conditions and targets

The amount of feed eaten is dependent on the day-length. A change in day-length of one hour changes feed intake by about 1.5 to 2.0 g.

Normal lighting program

15 hours light from 50 % production:

- Provide 15 hours light from 50 % lay.
- The day length (Interval between lights on and lights out) should not be decreased during lay.
- A day-length longer than 16 hours is not necessary in dark buildings.
- In naturally lit or semi dark buildings, day-length should be equal to the longest natural day experienced.

1.0 h or 1.30 h light in the middle of the night

Light should be switched on about 3 hours after lights out, in order to:

- Encourage feed consumption and growth in pullets at start of lay
- It can be discontinued at about 30 weeks of age if bodyweight and feed consumption are on target
- Towards the end of lay, night lighting improves the quality and colour of the egg shell to satisfy the specific appetite for calcium during the egg shell formation.
- In hot climates or during a hot spell, lighting during the night reduces the ill effects of heat by encouraging feed consumption.

Lighting program in temperate climate

The programs suggested are only guides. They should be modified according to results previously obtained.

Production in dark laying houses			
Age and / or bodyweight	Duration of lit period Temperate season	Hot season	Intensity Lux
1 – 3 days	22 h	22 h	20 – 40
4 – 7 days	20 h	20 h	15 – 30
8 – 14 days	18 h	18 h	10 – 20
15 –21 days	16 h	16 h	5 – 10
22 – 28 days	15 h	15 h	5 – 10
29 – 35 days	13 h 30	14 h	5 – 10
36 – 42 days	12 h	13 h	5 – 10
43 – 49 days	11 h	12 h 30	5 – 10
After 49 days	10 h	12 h	5 – 10
17 weeks (113 days)	12h	14 h	5 – 15
Week 18	12 h 30	14 h 30	5 – 15
Week 19	13 h	15 h	5 – 15
Week 20	13 h 30	15 h 30	5 – 15
Week 21	Increase by 30 min / week		
	So as to have 15 to 16 h at 50 % production		

Note: Important to reach standard bodyweight at the point og light stimulation

Production in naturally lit or semi-dark houses					
Age and / or bodyweight	Duration of light at 14 weeks				
	≤ 10 h	11 h	12 h	13 h	≥ 14 h
1 – 3 days	22 h	22 h	22 h	22 h	22 h
4 – 7 days	20 h	20 h	20 h	20 h	20 h
8 – 14 days	18 h	18 h	18 h	18 h	18 h
15 –21 days	16 h	16 h	16 h	16 h	16 h
22 – 28 days	15 h	15 h	15 h	15 h	15 h
29 – 35 days	13 h 30	14 h	14 h	14 h	14 h 30
36 – 42 days	12 h	13 h	13 h	13 h 30	14 h
43 – 49 days	11 h	12 h	12 h 30	13 h	14 h
Decreasing day lengths:					
After 49 days	10 h	NL	NL	NL	NL
Week 17	12 h	13 h	14 h	15 h	16 h
Week 18	13 h	14 h	14 h 30	15 h 30	16 h 30
Week 19	13 h 30	14 h 30	15 h	16 h	16 h 30
Increasing day lengths:					
After 49 days	10 h	11 h	12 h	13 h	14 h
Week 17	11 h	12 h	13 h	14 h	15 h
Week 18	12 h	13 h	14 h	14 h 30	15 h 30
Week 19	13 h	14 h	14 h 30	15 h	16 h
Week 20 and after	Increase by 30 min / week in order to have 15 to 16 h at 50 % production				

Note: Important to reach standard bodyweight at the point of light stimulation

Lighting program in hot climate

Lighting program for hot climates between latitudes 20 ° north and 20° south		
1 – 3 days	23 or 24 h	40
4 – 7 days	22 h	40
8 – 14 days	20 h	40
15 –21 days	19 h	40
22 – 35 days	18 h	40
36 – 49 days	17 h	40
50 – 63 days	16 h	40
64 – 77 days	15 h	40
78 – 91 days	14 h	40
92 – 98 days	13 h	40
99 – 105 days	13 h	40
106 – 112 days	Natural light	40
113 – 126 days	Natural light	40
After 127 days	Natural light	40
5 % lay	14 h (+ 2 h)	40
After 35 % lay	15 h (+ 2 h)	40
After 60 % lay	16 h (+ 2 h)	40

Note: (+ 2 h) refers to the period of artificial light given in the middle of the night to encourage feed consumption.

Adjusting egg weight to meet market requirements

Bodyweight of the pullet at sexual maturity

If one has a standard growth curve, and the age at start of lay is changed, then the bodyweight at sexual maturity is also changed. The age at start of lay has a direct effect on the adult weight and, therefore, on the egg size throughout the whole laying period. Earlier maturing flocks will produce a greater number of eggs, but these eggs will be smaller than those from delayed flocks because the pullets are lighter.

Control of the sexual maturity

- Research has shown that mean egg weight increases by 1 g when sexual maturity is delayed by one week. Conversely, the number of eggs will be decreased. For each change of one week in age at start of lay, there will be a change of about 4.5 eggs in number laid. By using the appropriate techniques, the age at start of lay can be modified to produce eggs of the required weight, without affecting the total egg mass produced.
- Rather than giving light stimulation according to age only, we advice starting to increase day-length when pullets have reached the target weight planned. By that means, they will not be allowed to come into lay at too low bodyweight, which would be prejudicial to egg weight and overall performance.

Bodyweight at 24 weeks

Egg weight is highly dependent on bodyweight at 24 weeks. Between 5 % lay and peak production, bodyweight should increase by at least 300 g.

Our research has enabled us to determine optimum bodyweights throughout the rearing and laying periods. This plays an essential role in obtaining performance as measured by egg numbers, egg weights and feed conversion ratio.

Management

For a more precise treatment of this subject please refer to the chapter, lighting program in the production period.

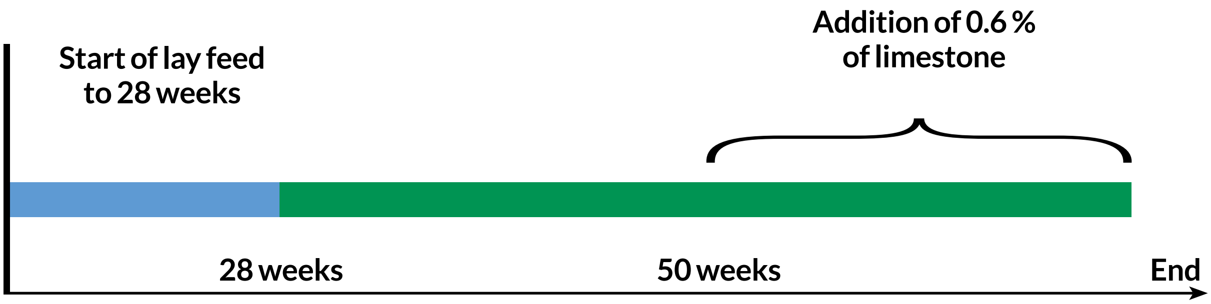
- 1.0-1.5 hours light in the middle of the night: this technique encourages feed intake at start of lay and allows egg weight to increase rapidly
- Temperature of 21.1-21.7°C (70-71°F) at onset of lay will encourage feed consumption and consequently increase early egg size.

- Between 23 and 27°C, egg weight falls by 0.5 to 1 % for each 1°C rise in temperature. Above 27°C, it falls by 1 to 1.5 % per°C.

Oil

Egg size can be increased by the use of vegetable oil rich in linoleic acid. Its inclusion leads to an improvement in the digestibility of the diet and an increase in the energy intake (by about 2 %) due to the improvement in palatability. The addition of oil also causes the finer feed particles to stick together.

Feeding in production: Cover the daily requirement to maintain the persistency of lay & shell quality



Energy requirements

Chickens regulate their feed consumption quite well, according to its energy content at constant oil level. This can vary within relatively wide limits. Which energy level to choose depends more on economic than on nutritional considerations.

However, an important decrease of the energy level from pre-lay feed to layer feed will penalize quite a lot the capacity of the birds to intake the daily nutrient requirements. At a constant energy level, the birds already need to increase its feed consumption by 40 % between 17 and 26 weeks old.

Energy consumption is influenced by the percentage of oil, percentage of fiber added to the feed and feed presentation. Consequently a poor feed grist size can be compensated by a higher percentage of oil.

Protein requirements

- Between 17 and 24 weeks, feed consumption should increase by about 40 %. Maximum feed intake should be reached for several weeks around peak production. In order to satisfy the daily nutrient requirements, we have to consider that the average daily food consumption, between 17 weeks and 28 weeks old, is about 7 g lower than that observed in the period 28 –72 weeks. So, the protein (digestible amino acids) specifications should be adapted to the mean intake level recorded during this period.
- Taking into account persistency in lay, individual variability and egg weight, the requirement for amino acids 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 obtained, when one maintains the intake level of amino acids. Any deficiency of amino acids, no matter, which type of amino acid, shows up as a reduction in performance, of which 2/3 is due to a reduction in rate of lay and the remaining 1/3 is a decrease in mean egg weight.

Mineral requirements

Calcification of the shell starts shortly before "lights out" and finishes mainly at the end of the night. Its lasts for about 12 hours. The quality of the shell depends on the quantity of calcium available during shell formation. Getting the correct feeding timetable, and giving extra light in the middle of the night, enables us to improve the shell quality.

Calcium retention depends on the size of particles used. Particles of less than 1.5 mm diameter are poorly retained in the gizzards, and some calcium is found in the droppings. This results in deterioration in shell quality.

- About 70 % of the total calcium supplied should be provided in granular form. This implies that 65 kg of granular calcium carbonate should be included per tonne of feed. To be retained in the gizzard these particles should be between 2 and 4 mm in diameter.
- The remaining 30% should be supplied in powder form to be used for replenishing the bone calcium reserves.

Shell weight increases with age throughout lay. For that reason, we advise increasing the calcium concentration in the diet throughout the laying cycle. Starting with 4.0-4.1% Ca and finishing with 4.5% Ca at the end of laying cycle.

The quality of the shell also depends on the solubility of the calcium. Sources of calcium, which are too soluble, lead to poor shell quality.

Failure to supply enough phosphorus leads to demineralisation of the hen's skeleton, possibly causing long term fractures and mortality.

During shell calcification, part of the bone calcium is mobilised bringing about the release into the blood of calcium and phosphate ions. The phosphate ions are then re-absorbed by the kidneys. The replenishment of bone reserves necessitates a supply of phosphate. The phosphorus requirement depends on how much is called on from the bone reserves. The phosphorus requirement is, therefore, dependent on the form in which calcium is supplied and on the methods by which it is fed.

At end of lay, an excess of phosphorus tends to lead to deterioration in shell quality.

Water quality

Chemical substances

As yet, there are no standards for drinking water in farm animal production. However, we indicate below the maximum concentrations of some chemical substances, which can lead to physiological troubles and a reduction in performance Their presence can also lead to deterioration of the pipelines.

- Chlorides (Cl) 500 ppm
- Sodium (Na) 500 ppm
- Magnesium(Mg)200 ppm
- Potassium (K) 500 ppm
- Iron (Fe) 500 ppm
- Nitrites (NO2) 5 ppm
- Sulphates(So4) 1100 ppm
- Nitrates (NO3) 50 ppm
- Arsenic (As) 0.01 ppm

Where the water is very saline, it could be worth reducing the level of salt in the feed, but at the same time making sure that there is no deficiency.

In areas, where the water is very hard, the use of softeners or ion exchangers can lead to a significant increase in the sodium content. A high content can be responsible for liquid droppings and shell quality problems, and even production problems.

For birds, the ideal pH lies between 6 and 7. If the pH is too acidic, corrosion of the pipes sets in. Above pH 7 conditions favour the growth of bacteria. Organic acids can be used to lower the pH.

Monitoring water quality

The value of any analysis depends on when, where, and how the sample has been taken. One should not forget that an analysis only refers to the quality of the water at the time, when the sample was taken, and is never a guarantee of its quality at another time. Where farms have their own water supply, it is necessary to take a sample at least twice a year. On farms using the mains supply an annual measurement should be adequate.

Treatment of drinking water

Chlorination is still the best and most economic method of treating drinking water. The chlorine can be injected by means of a dosing pump. A contact time of 15 to 30 minutes between the water and the chlorine is necessary for good disinfection. It is essential to monitor the residual active chlorine at the end of the pipe system once a week. The residual level of active chlorine at the end of the system should be 0.3 - 0.4 mg/litre (0.3 - 0.4 ppm).

Cleaning the drinkers

The water in drinkers often becomes soiled with feed residues, and possibly with infections. To prevent the development of germs in the drinkers, they should be cleaned at least once a day during the first 2 weeks, and once a week thereafter.

In a hot climate, the drinkers should be cleaned every day. The depth of water in the drinkers should be 15 mm.

It is essential to decontaminate the pipelines when the birds have gone, using alkaline and acid cleaners in succession in order to avoid accumulation of mineral and organic deposits in drinker pipelines.

Water consumption

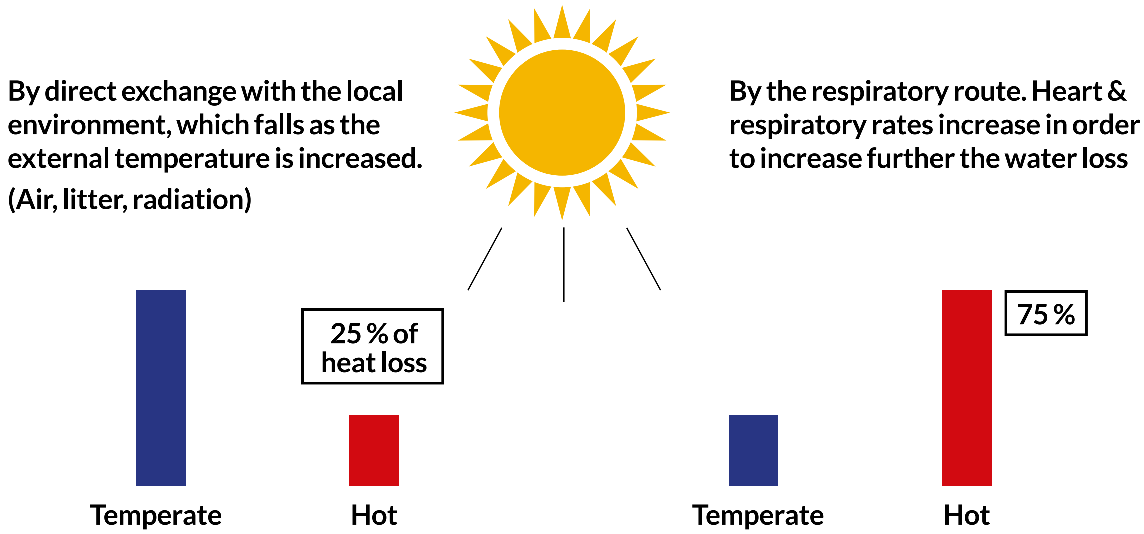
Water consumption depends on ambient temperature. Above 20°C, consumption increases to enable the bird to maintain body temperature (respiratory evaporation). The actual consumption depends on temperature and humidity of the ambient air. The following table shows the relationship between water and feed consumption according to house temperature:

Temperature	Rearing	Production
15°C	1.6	1.70 (210 ml)
20°C	1.7	1.80 (215 ml)
25°C	2.3	2.10 (230 ml)
30°C	3.0	3.10 (320 ml)

In hot periods it is essential to provide cool water for the birds. In a hot climate, cool water will improve productivity. It is extremely important to protect the water tanks from the direct sun's rays.

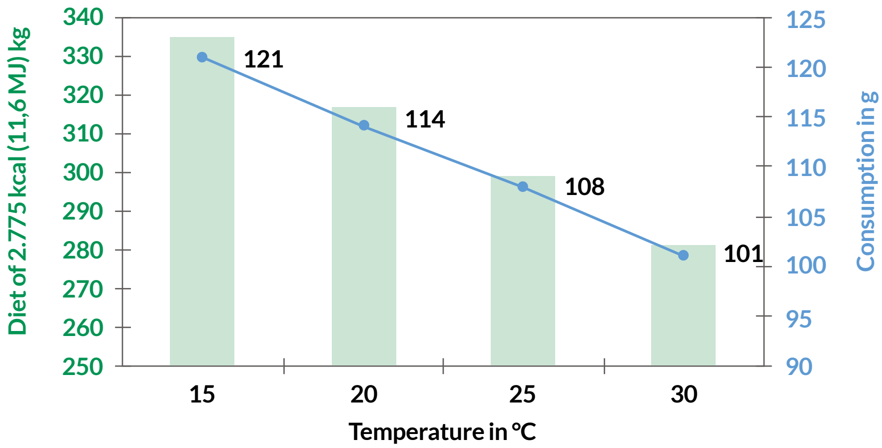
Hot seasons and climates: the effect of heat

The control of the body temperature of the bird is done...



" Drop in production is a consequence of a reduction of the capacity to lose heat."

With the increase of external temperature, a lower feed intake is noticed. This is the result of the reduction of the bird's ability to lose heat



Lower growth rates during rearing and the reduced production during lay are only consequences of the reduction in feed consumption when the birds are incapable of regulating their temperature

Reduce the ambient temperature	Increase the air speed	Equipment
Insulation of the roof	By using air movers (paddle fans)	Have cages designed to facilitate air circulation
Wide roof overhangs	With longitudinal ventilation	Reduce stocking density
Use of pad (evaporative) cooling		

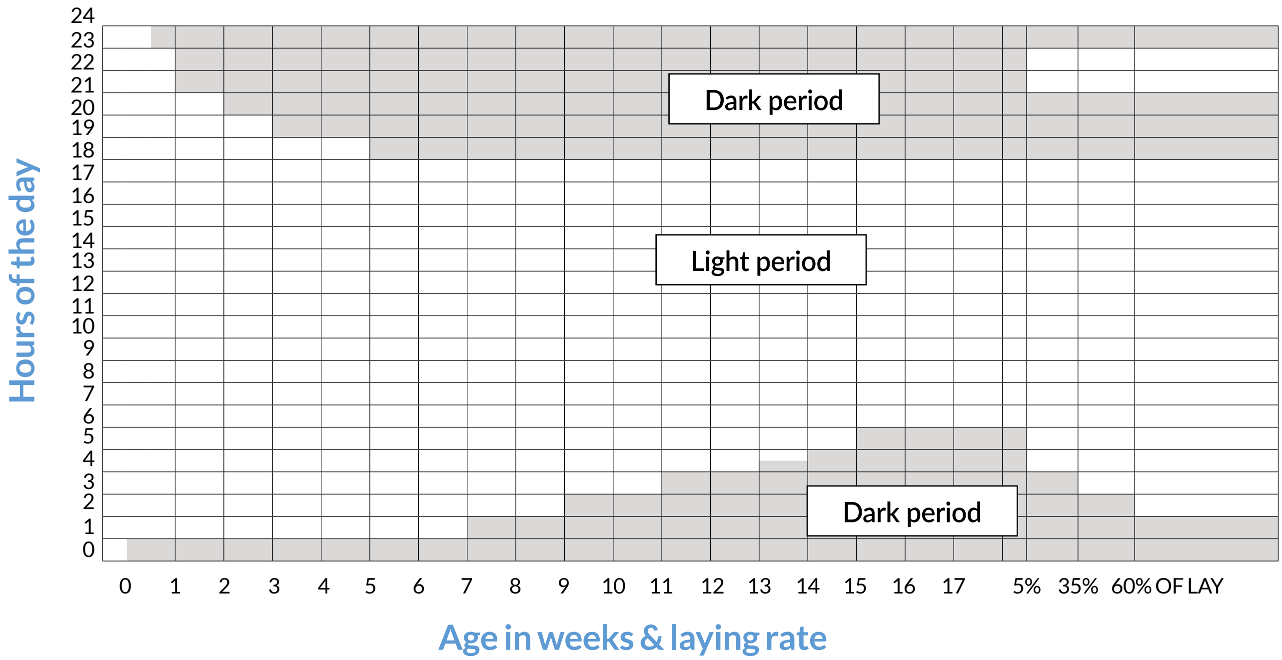
Hot season: How to encourage feed consumption & growth?

" Allow birds to eat during the coolest hours: during night and early in the morning " to maintain feed consumption and increase heat losses

Encourage growth

Lighting program:

- Use a slowly decreasing light program
- Give early morning light to encourage feeding during the cooler part of the day
- Starting at 15 weeks, give 1.0 – 1.5 hours of light in the middle of the night
- To avoid too early sexual maturity, never stimulate before they reach 5 % production
- At 5 % production:
  - Add 2 hours of light in the morning
  - And add 1 hour per week till 16 hours light (16 hours light at 50% production)



(Lighting program which could be used in hot climates between 20° North latitudes and 20° South)

Food specifications: and food presentation:

- Use a diet in crumb form rich in energy and protein for the first 5 weeks (diet similar to a broiler diet)
- After 5 weeks, use a diet in crumb form or one with a very good texture (80% of the particles between 0.5 and 3.2 mm)

Feeding timetable:

- Avoid the build up of fine particles by getting the feeders empty in the middle of the day
- Distribute the food 3 hours before lights out

Stockmanship:

- Provide cool drinking water of good bacteriological quality
- Make a good job of beak trimming
- Weigh the birds regularly (once a week)

Encourage food consumption

Lighting:
- Encourage food consumption in the cooler part of the day:
- By giving light early in the morning
- By giving 1.0-1.5 hours of light in the middle of the night (3 hours after light out)

Quality of the diet:
- Use a diet of good granular texture (75-80% particles between 0.5 to 3.2 mm)
- Provide 70 % of the calcium in granular form
- Use a protein level appropriate to the actual feed intake level

Feeding timetable:
- Distribute 1/2 of the food 5 to 6 hours before lights out
- Distribute 1/2 of the food 2 to 3 hours after lights on
- Avoid a built up of fine food particles by getting the feeders empty in the middle of the day

Stockmanship:
- Provide cool water of good bacteriological quality
- Weigh the birds regularly

PULLET AND HEN HEALTH

Bird health results from the interface between adequate biosecurity, sanitation, animal welfare, poultry husbandry, proper housing and equipment usage, nutrition, immunization, and general disease prevention, control and monitoring. This section is intended to serve as a general guide for maintaining healthy flocks. Pullets and hens reared and maintained on the floor may have slightly different requirements to maintain bird health depending on many items. Details on actual procedures should be provided by a poultry health professional. This section is intended to be used only as a reference for pullet and hen health. The end user is responsible for the use or misuse of this information and ISA do not accept liability for the results of the use of this reference information.

Biosecurity

The concept of biosecurity may be complex and difficult to generalize or adapt to every possible circumstance. However, the important notion and objective of biosecurity is to prevent infectious disease from affecting otherwise healthy flocks; to prevent disease spreading from already infected flocks or contaminated premises; and to ensure adequate flock performance through disease prevention and control. Among the many strategies used to prevent infectious disease, some of the most effective ones include: **a)** limit access of unnecessary visitors and preventing access to contaminated vehicles and equipment; **b)** prescribe a quarantine period of at least 72 hours for any visitors prior to visiting the farm; **c)** maintain a record of all visitors; **d)** avoid visits to multiple farms in the same day; **e)** shower in and out of any poultry facility; **f)** even when showering is not possible, it is imperative to wear clean clothes or coveralls, footwear, hairnets and to cover facial hair with personal protective equipment or clothes (ppe) that should not leave the farm being visited; **g)** establish, maintain and monitor adequate programs for rodent and insect control and prevent direct or indirect contact with wild birds and other animals; and **h)** practice biosecure entry procedures to every barn or chicken house. A good practice is the "Danish entry system", which consists of entering a vestibule in the barn where there are "clean" and "dirty" areas separated by a physical barrier at the knee level. Personnel entering the dirty area should already be wearing clean and sanitized biosecure boot covers. The physical barrier dividing the clean and dirty zones should not be crossed without a complete change of footwear. The footwear to be used in the clean area and inside the chicken barn should never leave the clean area and barn and it should be fitted such that it never touches the dirty area. It is a good idea to have a bench around the dividing barrier so that personnel can sit down, remove one shoe or boot at a time and fit the "clean area" boot without touching the dirty area. Once one clean boot is fitted, it can go on the ground while the second foot is fitted with a clean area boot. In addition, it is important to consider all major risks in terms of biosecurity such as moving birds into and from the farm; sales, maintenance, equipment and construction personnel; manure removal personnel, pullet transfer and vaccination crews; beak conditioning crews; welfare and food safety auditing personnel; and vehicles and equipment among other personnel and fomites. Service personnel should not visit any flocks after having been in contact with flocks with known, suspect or obvious signs of disease caused by agents such as MG, MS, ILT, NDV, AIV or IBV.

Certainly, other disease agents must be considered as well. Oftentimes a simple drop of water and/or feed consumption, or even a drop in egg production or egg weight could be the very first sign of disease in the poultry house. In those circumstances it is best to limit visits to any other farms until absence of infectious disease can be confirmed. Poultry houses must be thoroughly cleaned and disinfected prior to placing or housing pullets or hens. All chicken houses must be bird-proof and care must be followed not to track wild bird droppings into the chicken house. For this purpose, footbaths with a clean disinfectant and/or a careful change of footwear just prior to entering the premises can help to minimize the risk of infection with unwanted disease agents. Avoid having bodies of water close to or around the farm since this may attract wild birds that may carry deadly diseases such as avian influenza. Do not use open water reservoirs as a source of drinking water. If there is no other choice, always sanitize the water by acidification and chlorination, but verify that the water pH is not lower than 6.0 and that chlorine at the drinker level is not higher than 3 ppm. Do not share equipment with other farmers without thoroughly cleaning and disinfecting it and simply do not share it if at all possible. Finally, be aware of the fact that one of the most effective ways to spread infectious diseases is through contaminated manure trucks and equipment; mortality and rendering trucks and equipment; spent fowl collection vehicles, equipment and personnel; and pullet crews and vaccination crews.

Welfare and poultry husbandry

Overall bird health and welfare are relatively easy to maintain by simply applying good husbandry practices. The health and productivity of chickens is closely related to their welfare, which in turn depends on the use of adequate biosecurity and husbandry practices. In many areas, official regulations dictate specific requirements related to animal welfare and it is important to ensure compliance with regulatory agencies. Local or national poultry associations and Government institutions are usually a good source of welfare guidelines that are relevant for each geographical area. Although it may seem counterintuitive, keep in mind that maintaining birds on the floor (cage-free, free-run or cage-free with access to pasture) in a variety of housing systems may not necessarily result in better livability compared to maintaining the birds in enriched or community cages because birds on the floor are subject to possible trauma, intestinal diseases and even predation if they have access to the outdoors.

Disease prevention by immunization

An individual becomes "immune", "immunized" or resistant to a specific disease after inoculation of a specific vaccine, or after exposure to a disease agent in the field. Vaccination programs should be designed to "immunize" flocks against diseases of economic importance; 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 should be minimal, and at times or ages 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; cause skin infections; or represent a food safety concern. Fortunately there are biosecurity procedures and vaccines and vaccination methods available to protect chickens against most of these groups of conditions or diseases.

Prior to using any vaccines, ensure that their use is legal locally and that it will not disqualify specialty flocks because of the type of preservatives contained in the vaccines. Always verify the contents of the vaccine vial and vaccine diluent, and keep a record of the type of vaccine being used, the manufacturing company, serial number, expiration date and number of doses per vial and per diluent container (bag or bottle) according to the label.

Types of vaccines

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

- Live attenuated virus vaccines
- Recombinant virus vaccines
- Live attenuated bacterial vaccines

- Inactivated (killed) bacterial vaccines (also called bacterins)
- Gene-modified and gene-deletion mutant live attenuated bacterial vaccines
- Autogenous inactivated bacterial vaccines or bacterins
- Autogenous inactivated viral vaccines
- Live coccidiosis vaccines
- Live Mycoplasma vaccines
- Inactivated Mycoplasma vaccines (bacterins)
- Recombinant Mycoplasma vaccines
- Competitive exclusion products, probiotics and prebiotics

Vaccination methods

It is important to know 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 and are intended to be given at specific age ranges. Some should be administered only as booster and not as a primer.

Individual vaccination methods include:

- Ocular (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

Ocular (eye drop), beak dipping and intranasal vaccination

Eye drop vaccination is commonly used to protect chickens against some respiratory viruses, Mycoplasma and occasionally against infectious bursal disease. Ocular vaccination is most suitable for delivery of live vaccines against respiratory diseases or agents such as (but not exclusively) Newcastle disease, infectious bronchitis, infectious laryngotracheitis, avian metapneumovirus and Mycoplasma gallisepticum (MG). 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 or Newcastle disease. Intranasal and beak dipping application of vaccines has the same objectives as with the ocular route but the tissues preferentially stimulated reside in the nasal cavity, the paranasal sinuses and the oropharynx and larynx. 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 and some may even be missed altogether. Because eye drop vaccination requires individual handling of birds, biosecurity is most important and the vaccination crews must follow strict biosecurity procedures 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 an even vaccine uptake is not possible using the drinking water or spray methods, or with the objective of minimizing vaccine reactions. Care should be exercised not to accidentally inoculate fowl pox vaccines by eye drop because this will cause severe local inflammation, loss of the affected eye and even death, or at least a severe delay in pullet development.

Subcutaneous and intramuscular injection

Injection via the intramuscular and subcutaneous routes is reserved primarily for inactivated vaccines and bacterins in the case of growing pullets, but it can also be used for some live vaccines such as Marek's disease vaccines given to pullets at hatch. 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 but in many cases layer operations may be forced to apply killed vaccine injections at younger or later ages. Should it be necessary to vaccinate younger chickens with inactivated products it should be kept in mind that bird handling and administration of inactivated vaccines or bacterins between 6 and 11 weeks of age might delay or alter the development of the pullets. Inactivated viral vaccines are usually available in aluminum hydroxide, or in a water-in-oil (WO) or water-in-oil-in-water (WOW) emulsion; the latter is typically less reactive. Such products can be injected via the intramuscular or subcutaneous routes, provided the injection is done in the proper site and without depositing any of the vaccine product in the abdominal cavity or directly into the internal organs. Inactivated products containing killed Mycoplasmas and/or killed bacteria such as Salmonella, Pasteurella, E. coli or Avibacterium (the causative agent of infectious coryza) 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 the vaccine too close to the head or to the base of the neck. Injections done too close to the head or too low towards the base of the neck tend to induce unnecessary swelling. For intramuscular injections (in the breast muscle), every effort should be made to avoid injecting the product into the cavity. Vaccinations in the thigh may contribute to reduce adverse reactions but care must be exercised to minimize injuries resulting in lameness.

Transcutaneous injection (wing web)

Transcutaneous (wing web) application is used almost exclusively to vaccinate chickens against fowl poxvirus (POX), avian encephalomyelitis (AE), and for live fowl cholera vaccines. For convenience, manufacturers of vaccines have added other agents to the AE vaccines such as chicken infectious anemia virus (CAV) for breeder hens and avian encephalomyelitis virus (AE) to POX vaccines and thus it is possible to vaccinate pullets simultaneously against AE, POX and CAV in a single wing web injection. CAV is only necessary in layer breeders or grandparents but AE and POX are routinely used in commercial layers. In addition, there are recombinant vaccines containing fowl poxvirus as a vector that carries genes that express proteins from ILTV or MG. Such products can also be administered by wing web application.

Vent brush vaccination

Vent brush vaccination was developed decades ago to protect chickens against ILTV using vaccine strains that were extremely reactive and caused vaccine-induced ILT (VLT). The procedure involves dipping a rough brush into the reconstituted ILTV vaccine vial and brushing harshly the mucosa of the vent. This procedure is still used with relative success in a few countries for administration of live attenuated vaccines against ILTV.

In ovo injection

In ovo vaccination is a mass-application procedure that is reserved for vaccination of embryos in the hatchery and is typically done at 17 to 19 days of incubation. The procedure was designed for immunization against Marek's disease virus (MDV). With the advent of recombinant vaccines, in ovo vaccination can now be used to protect chickens against diseases such as Marek's disease, fowl poxvirus, infectious laryngotracheitis, infectious bursal disease (Gumboro) and Newcastle disease. In addition, some coccidiosis vaccines are now registered and approved for in ovo administration. However, commercial layers are typically vaccinated at hatch for the first time and not in ovo.

Drinking water (oral) vaccination

Vaccination via the drinking water is a suitable method to vaccinate pullets against hardy viruses such as infectious bursal disease virus (IBDV) and CIAV, but it can also be used to vaccinate chickens against diseases such as Newcastle disease, infectious bronchitis, infectious laryngotracheitis (only for chicken embryo origin vaccines), colibacillosis, salmonellosis and other diseases. Along with spray vaccination and in ovo vaccination, administration of live vaccines via the drinking water is considered a mass-application method. Although practical, mass application methods usually result in less-than-optimal vaccine coverage and thus protection might be suboptimal compared to individual vaccination methods. Vaccination via the drinking water should be used in birds that are at least one week old or older because water consumption in younger pullets might be too irregular for every pullet to get an even dose of vaccine. Oral vaccination can be done by directly adding the vaccine into the water reservoirs supplying water to the barn to be vaccinated; it can also be accomplished by using "medicators", "dosifiers" or "medication tanks" that can be connected to the main water pipelines feeding the drinkers.

The method relies on the preparation of a stock solution of vaccine that is to be placed in a container (a clean bucket) from which the medicator draws small quantities of vaccine to be mixed automatically with fresh incoming water in the water pipelines. For example, 1 ounce of stock solution of vaccine (approx. 28.5 ml) is drawn by the medicator and mixed with every 1 gallon (approx. 3.78 liters) of fresh water to be consumed. This method requires that the birds to be vaccinated be thirsty so that water consumption results in relatively rapid vaccine consumption (within approximately 60 minutes or less). Thus, access to water by the birds should be interrupted for approximately 2-4 hours or longer (depending on the barn temperature, barn humidity, age of the birds, etc.) prior to vaccination. Because the stock solution is drawn in a pulse manner, and because it must be mixed with incoming water automatically before it is delivered it is not possible to achieve an even vaccination in all birds. Using this method in the early morning hours as the lights are turned on ensures rapid vaccine consumption since the pullets or hens tend to be thirsty after several hours of darkness during the night.

Vaccination through a medicator is one of the methods of vaccination with live virus vaccines which is least recommended, albeit 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, giving very poor results. The best vaccination age for coccidiosis is at hatch but several provisions must be followed after vaccination for proper vaccinal oocyst cycling.

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, CIAV, NDV, IBV or ILTV. 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 pullets in the 2-3 hours prior to vaccination. For pullets or hens in cages where the drinker lines are fixed or can be removed away from the reach of birds, one must take advantage of the hours of darkness when birds do not drink water and vaccinate immediately as the lights are turned on while the birds are thirsty.

Water vaccination requires flushing the drinker lines with fresh water a day ahead of vaccination to minimize 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 in order to avoid chemical residues that may inactivate vaccine viruses. 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 or precipitates in the drinker lines. Prior to vaccination, it is important to allow the birds to become thirsty by interrupting their access to water. Check the drinkers or nipple drinkers to ensure they are clean and operational and shut down all water sanitizing systems (interrupt the use of added chlorine to the water). The amount of time required for the birds to become thirsty will depend on their age, environmental temperature, environmental relative humidity, feed formulation, etc. The goal should be for all pullets to consume the vaccine in a matter of 60 minutes or less, but not in less than 30 minutes. If the birds consume the vaccine in less time, it would mean they were too thirsty and it is possible that only or mostly the dominant birds will consume an immunizing dose. On the other hand, if it takes the birds more than one hour to fully consume the vaccine this would be an indication that the water was not removed long enough prior to vaccination and therefore vaccine strength (virus titer) may be compromised after sitting indefinitely in the water lines. 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.
- Interrupt access to drinking water so that the pullets 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 is still viable (before expiration); 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 expiration date and who actually reconstituted the vaccine and administered it to the flock.
- 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. Follow closely the recommendations of the manufacturer of the vaccine stabilizer and the vaccine itself. 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 sun light. The water used for vaccination should not be too acidic or too basic. The ideal pH for vaccine delivery should be between 5.5 and 7.2 but slight deviations should be harmless provided a suitable vaccine stabilizer is used. The water temperature should not exceed 26C if the vaccination is to be done via the drinking water.
- 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-grade vaccine dye and let the vaccine be flushed to the end of the water 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 until the vaccine is consumed completely. If the premise is an open-sided house avoid the vaccine to be exposed directly to sunlight.
- If there are automatic (mechanical) feeders in the barn, activate the feeders to stimulate feed consumption, which might prompt the birds to drink the vaccine more rapidly.
- Once the vaccine has been consumed (when the vaccine dye is no longer visible in the drinking water), check the oral cavity and tongues of at least 100 birds throughout the barn to verify that they have consumed the vaccine and that the vaccine dye is easily seen in their oral cavity and tongue. If enough dye was used, it should be easy to observe a blue coloring of the tongue, head feathers and occasionally the crop, which may be visible through the skin. Vaccine coverage of at least 97% should be a realistic and acceptable goal.

Spray vaccination

Spray vaccination is used primarily for immunization against respiratory viruses such as Newcastle disease virus (NDV) and infectious bronchitis virus (IBV). At least one of the commercially available MG vaccines is labeled for spray administration, albeit the best results with these vaccines are attained when given by eye drop. 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, albeit other vaccine strains may be suitable for spray vaccinations (always check with the vaccine supplier). 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 even some strains of MS. Coccidiosis vaccines are sometimes sprayed on the feed of layer breeders or cage-free layer pullets in some areas, but more recently spray application of coccidiosis vaccines has become a popular practice in commercial hatcheries, with substantially better results than with field vaccinations. Some live Mycoplasma gallisepticum vaccines (but not all) can be sprayed directly on chickens in the field, although the best method for live MG vaccine application is by eye drop. 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. During the hot weather season, the minimum ventilation fans may be run during vaccination but care must be observed not to allow the sprayed vaccine to be sucked out of the house via the exhaust fans and at the same time the reduction of ventilation rates during vaccination must not threaten the welfare and health of 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 if pullets are grown on the floor, but keep in mind that if the equipment scares the birds away from the vaccinator, the vaccine coverage may be poor. The particle size will range between 100 and 300 um, which is suitable for most respiratory viruses but some sprayers produce rather a mist that consists of very fine droplets. Mist vaccination induces very good immune responses but may cause significant vaccine reactions that could potentially result in respiratory complex. In general, spray vaccination is used for protection against respiratory viruses and Mycoplasma in pullets; and for protection against respiratory viruses in caged hens in production. Water vaccinations are better suited for cage-free pullets and hens. A few essential considerations for spray vaccination are listed as follows:

- Record the type of vaccine used, the expiration date, vaccine strains contained, number of doses in the vials, amount of diluent used, serial number for the vaccine and vaccine stabilizer, manufacturer, age of the birds being vaccinated, etc.
- 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; and/or in dusty environments; and/or wherever air quality is suboptimal. Spray vaccination against Infectious Laryngotracheitis should be avoided and must never be done in chickens in production. Vaccinate only healthy chickens.
- For adult flocks, verify the flock antibody titers prior to vaccination. If IBV or NDV antibody titers are low, vaccine reactions may be harsh and egg production and eggshell quality may be detrimentally affected. Avoid using spray vaccination for MG-positive hens.
- 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. If birds are flighty or too nervous, do not vaccinate by spray and choose the water vaccination method instead.
- Calculate the total number of doses and the total volume of diluent (distilled deionized water) required to vaccinate all chickens. The water used should not be chlorinated and should have a pH of 5.5 to 7.2 (ideally 6.8 to 7.2). Using a commercial vaccine stabilizer helps to minimize water pH and chlorine problems.
- Turn off the lights, space brooders and ventilation system (only briefly while leaving on minimal ventilation and ensuring the birds do not overheat or suffocate). The flock should be relatively calm at the moment of 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 and after they have developed a robust antibody response after previous vaccinations against the same virus (es). MG-infected chickens tend to react too severely to spray vaccinations, particularly if the droplet size is too small and thus they should be vaccinated via the drinking water instead or by eye drop and using mild vaccine strains.
- Use distilled water or clean water without chlorine 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 large diameter range, and consequently only part of the vaccine will be inhaled. Hence, it is necessary to spray the vaccine at a distance not larger than 50 cm 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 or on 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.

- Spray-vaccinate only 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 or alcohol-based products. 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 and ensure that all vaccines being given are compatible with each other.
- Always comply with local regulations and make sure that the vaccine preservatives are allowed for use in organic egg production or antibiotic-free (ABF) production according to local regulations.
- Reconstitute the vaccine only immediately prior to use.
- Close up the house including curtains and doors and shut the ventilation system (while allowing minimum ventilation and ensuring the birds do not overheat or suffocate) and dim the lights while the birds are being vaccinated and if possible, during the 20-30 minutes after vaccination (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 and restore ventilation immediately. Make sure the ventilation system is not running at the time the vaccine is being applied or that it runs at a minimum power.
- 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 about not leaving the farm without making sure the ventilation system and the lights have been reengaged. Ventilation should be restored approximately 20 minutes after the initiation of the vaccination process, but this may vary according to the time of the year and the prevailing environmental temperature and relative humidity.
- Rinse, clean, disinfect and rinse again 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.

Parasite control

The most common internal parasites in laying hens include coccidia, Histomonas ("black head"), Capillaria worms, round (Ascaridia) worms, cecal (Heterakis) worms and various tape worms. External parasites frequently seen in layer operations include the Northern fowl mite (Ornythonyssus). The red mite or roost mite (Dermanyssus) and poultry lice are less frequent but can be frequently seen in some areas. The Northern fowl mite completes its entire life cycle on the birds, whereas the red mite feeds on the birds only at night. As a whole, 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. Of these, the only type of parasite that can be prevented by vaccination is Eimeria (coccidia). Tape and round worms as well as external parasites should be controlled by using a combination of cleaning, disinfection, biosecurity and preventative or therapeutic treatments that must comply with local regulations for their use and in accordance to the type of bird (conventional production, organic, ABF, etc.).

Vaccination against coccidiosis

Pullets reared in battery cages do not ordinarily experience significant internal parasitic diseases. However, if they have access to droppings in the hen house because of the type of equipment and manure removal systems and/or because of poor fly control, outbreaks of coccidiosis could potentially occur. Pullets reared on the floor (cage-free, free-run, chickens on pasture or in aviary systems) are commonly exposed to coccidia parasites at a relatively young age. 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, pullets reared on the floor may be treated with anticoccidial drugs for up to 8-12 weeks of age to allow for a gradual acquisition of immunity. Commonly used drugs for this purpose include (not exclusively) amprolium and salinomycin. However, other anticoccidial drugs have been used successfully. Perhaps the best approach to control coccidiosis in pullets reared on the floor is vaccination.

Pullets can be vaccinated by spray at the hatchery 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, E. necatrix and E. brunetti. Coccidiosis vaccines for broiler chickens do not contain E. necatrix, an essential component of coccidiosis vaccines for long-lived birds. Ideally, the volume of vaccine per 100 chicks should be at least 21 ml or up to 25 ml to ensure proper coverage and vaccine consumption through preening. Gel-based coccidiosis vaccines may require a different total volume per 100 chicks. 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 two to three complete coccidial cycles, which normally occurs at approximately 14-16 days of age, depending on various factors including litter moisture, bird density, environmental temperature, etc. It is also important to allow vaccinated birds to remain in the brood chamber for the duration of at least 2 complete coccidial cycles before allowing them to occupy the entire barn. If vaccinated pullets are given the entire barn prior to the second cycle being completed, many of them will not be properly immunized and might develop coccidiosis at a later age, with the significant consequences of increased mortality, delayed growth, poor uniformity and the need for treating the flock. This means that if pullets are maintained on 100% plastic or wooden slats or wire floor from day of age, the floor should be covered with paper and kept covered with paper until at least 16 days of age to allow for proper coccidial oocyst cycling and consumption, and to allow for at least 2-3 coccidial cycles. Specialty flocks may not be treated with drugs of any kind and thus it is critical to ensure proper coccidiosis control with the use of vaccines.

Histomoniasis and round worms

Histomonas meleagridis (HM) is the causative agent of histomoniasis or histomonosis ("black head") and affects almost exclusively pullets reared on the floor, particularly in premises with dirt floors or in flocks with access to the outdoors. The condition, which can be devastating, has made a come back after the ban of many anti-parasitic drugs and upon rearing pullets on the floor (cage-free). Histomoniasis is difficult to control since there are no effective drugs that can be used legally in many areas of the world. Because the microscopic parasite depends to some extent on the life cycle of cecal worms and earthworms (round worms or nematodes), one of the strategies for control involves the control of worms. Early administration of drugs against round worms might contribute to maintain HM under control. The layer industry uses most commonly piperazine and anti-worm compounds in the family of the benzimidazole drugs such as levamizole, albendazole or fenbendazole in the drinking water; or feed-grade hygromycin (12 grams per ton of feed); or, where legal, antiparasitic drugs in the family of the ivermectins. Controlling worms reduces the challenge posed by HM. Where legal, HM infection may be treated with drugs such as nitarsone, but even this drug is only partially effective and has been withdrawn from the market in many countries. Control of HM involves not only treating birds against worms, but also proper cleaning and disinfection, adequate husbandry, biosecurity, proper coccidosis control, particularly of E. tenella, and avoiding rearing birds on dirt floor.

Mites

The best form of prevention for mite infestation is biosecurity. Infested flocks should never be visited before visiting mite-free flocks. Mites can easily be mechanically carried from farm to farm on birds, in clothes, footwear, on people, equipment, egg flats and egg boxes, etc. Such parasites usually thrive in sexually mature flocks and thus most treatments become necessary while the infested flocks are in production. Effective control requires direct application of "acaricide" products. A variety of products can be used for mite control, including pyrethroids, ivermectin, organophosphates, carbamates, mineral-based products, vegetable oils, citrus concentrated extracts and other products. Some of such products can be administered by dry (dust) spray, or as a wet spray. Careful observation of precautions with each of these drugs should be practiced. Prior to using any of these products it is critical to determine whether they are locally approved for use in hens in production, and also whether the personnel applying the products require personal protective equipment. Some products are poorly effective if applied dry but quite effective when applied wet directly on the birds, which requires considerable more time than the application of dry products. 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. Heating the affected barn to as high a temperature as possible for several days may help reduce viability of the parasites. Breeder houses and cage-free houses can be treated with sulphur prior to housing hens. The barns are cleaned, disinfected, treated for rodents and insects, and then (where legal) sulphur is carefully applied (using personal protective equipment) to the ground prior to furnishing the barn with wood shavings, rice hulls or other suitable bedding material. The skin of birds or humans should not be allowed to come in direct contact with sulphur to avoid chemical dermatitis. The best approach is to exercise adequate biosecurity and never to transit from infested flocks to clean flocks, or to share equipment and egg flats or boxes between infested and clean premises.

Controlling groups of diseases by vaccination

Infectious diseases can be grouped by the organ system they affect. Thus, infectious diseases can affect the respiratory, digestive, nervous, urinary, reproductive and immune systems among others. Other diseases tend to affect the integument (skin or cutaneous tissues) and yet some others are considered a concern for food safety.

Respiratory diseases

Respiratory diseases of major concern in commercial layers include Newcastle disease, infectious bronchitis, infectious laryngotracheitis, avian influenza, avian metapneumovirus infection (swollen head syndrome), avian mycoplasmosis (MG and MS), infectious coryza, avian pasteurellosis (fowl cholera) and Gallibacterium anatis (formerly Pasteurella haemolytica) infection. All such diseases or disease agents can be prevented or controlled by using a combination of biosecurity and vaccination. In general, vaccination against respiratory viruses is done with live vaccines followed by killed (inactivated) vaccines. Live attenuated avian influenza vaccines are not legally available anywhere, but recombinant vaccines and killed vaccines are (in some areas or countries). Bacterial diseases (infectious coryza, fowl cholera and Gallibacterium infection) are typically prevented by means of inactivated (killed) vaccines or bacterins, which are given once or twice during the rearing period. Bacterins are usually administered by intramuscular or subcutaneous injection at approximately 10-14 weeks of age or earlier. Live vaccines against viral respiratory diseases may be administered by spray or in the drinking water once or multiple times while the flocks are in production.

Peritonitis in layers

Peritonitis in layers is frequently caused by E. coli strains that are unrelated to E. coli strains affecting cattle or humans. However, they can induce severe economic losses if there is no adequate control. Colibacillosis associated with peritonitis in layers is not strictly a respiratory condition, but E. coli can penetrate via the respiratory tract (descending infection). 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. Peritonitis in layers should be controlled by a variety of approaches, including maintaining proper husbandry practices, adequate ventilation, and vaccination against E. coli among other strategies. Vaccination against E. coli in layers is a very effective 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. Live E. coli vaccines can also be given safely in flocks in production or soon before onset of production if they were not vaccinated during rearing. It should be kept in mind that E. coli is not the sole pathogen inducing peritonitis in layers. Another common pathogen causing peritonitis, salpingitis and polyserositis is Gallibacterium anatis (formerly Pasteurella haemolytica), for which inactivated vaccines (bacterins) may be available in some countries but not in the U.S.

Diseases of the digestive system

Diseases of the digestive system that are preventable by vaccination include the parasitic disease coccidiosis. Coccidiosis vaccines are typically administered at the hatchery in ovo or by spray, or by spray on the feed during the first week of life.

Diseases affecting the nervous system

Diseases affecting the nervous system such as avian encephalomyelitis (AE) require effective vaccination for prevention. Flocks may be vaccinated via the drinking water or by transcutaneous injection in the wing web, usually along with POX vaccination at approximately 10-12 weeks of age. AE vaccines should not be given for the first time before 10 weeks of age or too soon before the flock initiates egg production because they can induce disease or drops in egg production. AE vaccines that are combined with fowl pox can only be given safely by wing web application.

Diseases affecting the urinary and reproductive tracts

Diseases affecting the urinary and reproductive tracts are represented typically by infectious bronchitis. Prevention of infectious bronchitis requires vaccination at various ages with the same or similar serotypes of virus circulating in the field. It may be necessary to vaccinate 3-4 times the pullets with live viruses during rearing and once with a killed vaccine containing at least the same or similar serotypes circulating in the field. Still, in many instances it might be necessary to vaccinate flocks in production by spray or drinking water several times in order to maintain a healthy urinary, respiratory and reproductive tract.

Diseases affecting the immune system

Diseases affecting the immune system can be numerous. Well-known diseases affecting the immune system include infectious bursal disease (IBDV, or Gumboro disease), chicken infectious anemia (CIAV), and Marek's disease (MDV), the latter being a disease that also causes tumors and mortality. IBDV can be prevented by vaccination with live attenuated vaccines, immune complex vaccines, or recombinant vaccines. Live attenuated vaccines are becoming less popular because of the need to give them multiple times in order to control IBDV effectively during the rearing period and because of the time and labor required for vaccination, even though they are quite effective and inexpensive, and they have contributed very positively to the successful control of IBDV in the field, particularly in floor rearing operations. Some immune complex live attenuated IBDV vaccines are given 3-4 times during the first 8 weeks of age, beginning with an initial application at approximately 14 days of age. It is not necessary to vaccinate commercial layers against CIAV because they are clinically susceptible to this immunosuppressive agent mostly during the first 3 weeks of life, and the layer parents should provide protection after being exposed and/or vaccinated themselves. All layer pullets must be vaccinated against MDV to prevent losses to mortality, immunosuppression and tumors. The most potent vaccines against MD in layers include vaccines that contain serotype 1 vaccines (Rispens strain, or CVI-988) and serotype 3 or HVT (herpes virus of turkey). Serotype 2 vaccines (SB-1 or 301/B1 strains) can also be added, albeit a trivalent vaccine has not been shown to have a significant advantage over bivalent vaccines (HVT+Rispens). Wherever MD is not a significant challenge, bivalent HVT+SB-1 vaccines may be sufficient to protect hens against MD in the field. Still the best combination known to date is HVT+Rispens as a MD vaccine for day-old pullets. In this case, HVT may be represented as such or as recombinant HVT vaccines (rHVT) expressing proteins from other viruses such as Newcastle disease virus (NDV), infectious laryngotracheitis virus (ILTV) or infectious bursal disease (IBDV)

Fowl adenovirus

Fowl adenovirus (FAdV) causes inclusion body hepatitis (IBH) and hydropericardium syndrome (HS) in young chickens, primarily meat type chickens. However, in some countries FAdV can be an economically significant problem affecting the livability of commercial layers reared on the floor. Inactivated IBH vaccines are available for layer chickens in some countries but not in the United States and Canada. Another important disease caused by a unrelated adenovirus (Egg Drop Syndrome 1976; or EDS76), may induce severe egg production drops and is preventable by vaccination.

Disease agents of concern for food safety

Salmonella control requires a very complex approach, part of which involves vaccination. Where legal, vaccination against Salmonella is one of the most effective means of control (albeit insufficient by itself) and is usually done with live attenuated or genetically-modified vaccines against S. typhimurium, or with live attenuated S. enteritidis (SE) vaccines followed by killed vaccines against S. enteritidis or containing other Salmonella serovars that may be residents in a particular area or operation. Live attenuated SE vaccines are available and legal only in some countries. It is recommended to use two live Salmonella vaccines (SE and/or ST) and at least one killed vaccine (but ideally two) containing SE and other serovars to reduce gut and reproductive colonization and bacterial shedding into the egg and the environment. It should be emphasized that vaccinations against Salmonella are an essential tool in the fight against Salmonella, but many other intervention and prevention strategies must be implemented in order to achieve effective Salmonella control.

Fowl typhoid caused by Salmonella gallinarum is a high impact disease that results in high mortality and severe drops in egg production. Salmonella gallinarum may be prevented by first, biosecurity; and second vaccination, where applicable.

Nutritional specifications for growing diets

Between 18 & 24°C	Units	Starter 0 - 4 weeks 1 - 28 days	Grower 4 - 10 weeks 28 - 70 days	Pullet 10 - 16 weeks 70 - 112 days	Pre - lay 112 days to 2% lay
Forcast quantity / bird	g	600	2100	3000	
Metabolisable energy	kcal/kg	2950	2850	2750	2750
	kcal/lb	1340	1295	1250	1250
Crude protein	%	20.5	19	17	17
Methionine	%	0.52	0.45	0.35	0.40
Methionine + Cystine	%	0.86	0.76	0.62	0.67
Lysine	%	1.16	0.98	0.74	0.80
Threonine	%	0.78	0.66	0.50	0.56
Tryptophan	%	0.21	0.19	0.16	0.18
Digestible amino acids (1)					
Dig. Methionine	%	0.48	0.41	0.32	0.38
Dig. Meth. + Cystine	%	0.78	0.66	0.55	0.60
Dig. Lysine	%	1.00	0.85	0.64	0.71
Dig. Threonine.	%	0.67	0.57	0.43	0.48
Dig. Tryptophan	%	0.18	0.17	0.15	0.15
Major minerals					
Calcium	%	1.05 - 1.10	1.0 - 1.20	1.0 - 1.20	2.1 - 2.5
Available Phosphorus	%	0.48	0.45	0.42	0.45
Chlorine minimum	%	0.16	0.16	0.16	0.16
Sodium minimum	%	0.18	0.18	0.18	0.18

Above 24°C	Units	Starter 0 - 4 weeks 1 - 28 days	Grower 4 - 10 weeks 28 - 70 days	Pullet 10 - 16 weeks 70 - 112 days	Pre - lay 112 days to 2% lay
Forcast quantity / bird	g	850	1700	2800	
Metabolisable energy	kcal/kg	2950	2850	2750	2750
	kcal/lb	1340	1295	1250	1250
Crude protein	%	20.5	20.0	17.0	17.5
Methionine	%	0.52	0.47	0.36	0.42
Methionine + Cystine	%	0.86	0.80	0.63	0.70
Lysine	%	1.16	1.03	0.78	0.87
Threonine	%	0.78	0.69	0.53	0.59
Tryptophan	%	0.22	0.20	0.17	0.19
Digestible amino acids (1)					
Dig. Methionine	%	0.48	0.43	0.35	0.40
Dig. Meth. + Cystine	%	0.78	0.69	0.58	0.63
Dig. Lysine	%	1.00	0.89	0.68	0.77
Dig. Threonine.	%	0.67	0.61	0.45	0.50
Dig. Tryptophan	%	0.19	0.17	0.15	0.16
Major minerals					
Calcium	%	1.05 - 1.10	1.0 - 1.20	1.0 - 1.20	2.1 - 2.5
Available Phosphorus	%	0.48	0.45	0.44	0.47
Chlorine minimum	%	0.16	0.16	0.16	0.16
Sodium minimum	%	0.18	0.18	0.18	0.18

Protein and Amino acid requirements for laying period

Recommendations for amino acids expressed in total or digestible and ideal proteins established for a production of 59.5 egg mass per day

Limiting amino acids	Based on European table 2002				
	Ideal protein	Requirements in mg per g of egg		Daily requirements in mg per day	
		Dig. AA	Total AA	Dig. AA	Total AA
Lysine	100	13.34	15.0	795	895
Methionine	53	7.1	7.56	420	450
Methionine + Cystine	82	10.9	12.1	650	720
Tryptophan	22.5	3.00	3.50	178	208
Isoleucine	91	12.2	13.35	725	795
Valine	97	13.0	14.35	775	855
Threonine	70	9.4	11.0	560	655

These daily amino acids requirement must be adjusted according to the feed consumption:

Daily amino acids requirement in mg/day / Feed consumption observed in g / 10 = % of amino acids in the feed

Formulation of layer diets can be carried out by introducing ISOLEUCINE and VALINE as nutritional constraints, replacing protein as a constraint. If this is not possible, these are recommendations for a minimum of protein for feed containing or not containing Meat and Bone Meal (MBM).

From a practical point of view, we estimate that it is necessary to increase the concentration of amino acids by about 6 % during the 17-28 weeks period in relation to the feed consumption observed after 28 weeks. Total or digestible amino acids levels are established for a production of 59.5 g egg mass per day.

Added vitamins and minerals

Added trace elements		Rearing period		Laying period
		0 – 10 weeks	10 weeks – 2 % LAY	
Manganese (Mn)	PPM	85	85	85
Zinc (Zn)	PPM	80	80	80
Iron (Fe)	PPM	80	80	80
Iodine (I)	PPM	1	1	1
Copper (Cu)	PPM	10	10	10
Selenium (Se)	PPM	0.3	0.3	0.3
Cobalt (Co)	PPM	0.5	0.5	0.2
Added vitamins per kg of diet in IU or mg				
Vitamin A	IU	13.000	10.000	12.000
Vitamin D3	IU	2.500	2.500	3.500
Vitamin E	mg	25	25	30
Vitamin K3	mg	3	3	3
Vitamin B1 (Thianine)	mg	2.5	2.5	2.5
Vitamin B2 (Riboflavin)	mg	7	5	6.5
Vitamin B6 (Pyridoxine)	mg	5	5	5
Vitamin B12	mg	0.03	0.02	0.02
Nicotinic Acid (Niacin)	mg	60	30	40
Calcium Pantothenate	mg	15	10	10
Folic Acid	mg	1	1	1
Biotin	mg	0.2	0.2	0.2
Choline	mg	1000	1000	1000

Nutritional recommendations for the laying period

Recommended energy: 2800-2880 kcal / kg 1275-1310 kcal /lb	FROM 2 % LAY TO 28 WEEKS OLD				
Average food intake in g / day	**95**	**100**	**105**	**110**	**115**
Crude Protein Total amino acids %:	(20.5)	(19.5)	(18.6)	(17.7)	(17.0)
Lysine	1.00	0.95	0.90	0.86	0.82
Methionine	0.51	0.48	0.45	0.43	0.42
Methionine + Cystine	0.85	0.81	0.73	0.69	0.66
Tryptophan	0.23	0.22	0.21	0.20	0.19
Threonine	0.72	0.69	0.66	0.63	0.60
Isoleucine	0.88	0.83	0.80	0.77	0.73
Valine	0.94	0.90	0.86	0.82	0.79
Arginine	1.22	1.16	1.10	1.05	1.03
Digestible amino acids %:					
Lysine	0.89	0.84	0.80	0.77	0.73
Methionine	0.48	0.46	0.43	0.41	0.39
Methionine + Cystine	0.75	0.72	0.66	0.63	0.60
Tryptophan	0.20	0.19	0.18	0.17	0.16
Threonine	0.62	0.59	0.57	0.54	0.52
Isoleucine	0.80	0.76	0.73	0.70	0.67
Valine	0.85	0.81	0.78	0.75	0.71
Arginine	1.10	1.05	1.00	0.95	0.91

From 2% lay up to 28 weeks, one should base it on a level of consumption, which is 7 g lower than the intake observed after 28 weeks.

Recommended energy: 2750-2850 kcal / kg 1250-1295 kcal /lb	FROM 29 WEEKS TO THE END OF THE LAY				
Average food intake in g / day	105	110	115	120	125
Crude Protein Total amino acids %:	(18.6)	(17.7)	(17.0)	(16.3)	(15.6)
Lysine	0.85	0.81	0.78	0.74	0.71
Methionine	0.43	0.41	0.39	0.38	0.36
Methionine + Cystine	0.69	0.66	0.63	0.60	0.58
Tryptophan	0.20	0.19	0.18	0.17	0.16
Threonine	0.62	0.59	0.56	0.54	0.52
Isoleucine	0.76	0.72	0.69	0.66	0.64
Valine	0.81	0.78	0.74	0.71	0.68
Arginine	1.10	1.05	1.03	0.97	0.93
Digestible amino acids %:					
Lysine	0.76	0.72	0.69	0.66	0.64
Methionine	0.40	0.38	0.37	0.35	0.34
Methionine + Cystine	0.62	0.59	0.57	0.55	0.52
Tryptophan	0.17	0.16	0.15	0.15	0.14
Threonine	0.53	0.51	0.49	0.47	0.45
Isoleucine	0.69	0.66	0.63	0.61	0.58
Valine	0.74	0.70	0.67	0.65	0.62
Arginine	1.00	0.95	0.91	0.88	0.84

Mineral Nutrition

Daily mineral recommendations

Daily requirements	From 17 to 28 weeks	From 29 to 50 weeks	From after 50 weeks
Available Phosphorus g	0.45 - 0.48	0.44 - 0.46	0.38 - 0.40
Calcium g	4.0 - 4.2	4.2 - 4.4	4.5 - 4.7
Sodium minimum mg	180	180	180
Chlorine min.-max. mg	170 - 260	170 - 260	170 - 260
Oil min.-max. (1) %	2 - 3	1 - 2	0.5 - 1.5

(1): Vegetable oil rich in unsaturated fatty acid improves egg weight, according to the requirement of the market and the appetence a level of 2 to 3% is required. To avoid egg size becoming too large at the end of lay, we advise reducing the quantity of vegetable oil being used.

All these daily mineral requirements must be divided by the observed feed consumption, to get the ideal percentage in the feed.

Daily requirement in mg/day / Feed consumption observed in g / 10 = % in the feed

Feed for birds in alternative production

Energy

The main difference between cage and alternative production feed is energy requirement. Birds in alternative production system are much more active and when they have access to the range are confronted by temperature variations. These two factors lead to an increase in their energy requirement. To cover their higher energy requirement, birds eat more. According to the housing system used, temperature and bird feathering, feed consumption can be increased by 3 to 20%.

In alternative production, it is essential for point of lay pullets to reach their mature body weight quickly. Energy intake is usually the limiting factor for production and growth when lay is starting. It is highly advisable to use a higher energy diet from 18 to 30/35 weeks of age. Birds are able to adapt on wide range of energy values. However, observations show energy levels of 2800 to 2880 kcal/kg or 1275 – 1310 kcal/lb. are adapted for start of lay diet.

For the second part of the production until depletion energy concentration must be decreased to prevent fattening, improve feathering and livability. Lower energy diets contain more insoluble fibre, increase consumption time and affect bird behaviour (see 'Fiber for laying hen' section). However, diets with lower energy values increase feed consumption. Observing local regulations and raw material availability, a compromise between feed intake/FCR, bird behaviour and bird bodyweight must be found. Classical energy feed range, observed after 35 weeks of age, are from 2750 to 2850 kcal/kg or 1250 - 1295 Kcal/lb.

All the other nutrients requirements in alternative production are very close to those used for cage system.

Fibre for layer

Birds have a specific requirement for fibre. They must find fibre in the feed or in their immediate environment. It has been shown that if birds are deficient in fibre, it can lead to feather pecking and then feathers are used by the bird as a fibre source. A poor feathering observed in a flock without feathers visible on the floor could be a sign of a lack of fibre.

It is clear that a good supply of fibre improves feathering, decreases mortality, improves gut health and digestion.

Fibre provided to layer flocks must be insoluble with as much as possible of a coarse texture. Fibre could be provided through the feed. According to the raw material available, total fibre content can be very variable 2.5% of raw cellulose is considered as low level, above 5% as a high level. Most of the fibre can be provided by oilseed meal (sunflower / rapeseed), alfalfa (or lucerne), and oats. Cereal by-products could provide a good amount of fibre in the feed, but their texture is usually too fine to have 'structure effect' on the digestive tract.

Fibre should be provided directly in the building. We advise the use of a coarse fibre such as straw, alfalfa (lucerne), wood shavings, rice/oat husk, sillage, etc. These materials must be available in the building through round feeders or directly as a ball on the scratching area. Birds must have a free access to fibre sources at all times. We advise not spreading fibre directly on the floor. To prevent floor eggs, fibre supply must be introduced after the peak of production when the birds are well trained to use the nest.

Feeding management

Feeding management during production should follow several simple rules:

- Hens are grain eaters and have a preference for bigger feed particles. They need to eat all the components of the formulated feed including the fine with higher concentration of amino acids, minerals and vitamins.
- For this reason we recommend that the birds finish their ration every day so that the feeders rest empty for a while.
- In case of floor or dirty eggs, we recommend not disturbing the birds with feed distribution during their oviposition time, so we recommend not feed distribution during the first 5-6 hours of the day
- The birds should preferably eat a greater part of their daily ration during the second half of the day. The fast accumulation of calcium in the eggshell starts at this time and the birds can very effectively utilize the calcium from the feed to form a good eggshell. These are the reasons why the feed for laying hens in production should be distributed in the second half of their day.

- Make the least number of distributions possible to avoid selection of bigger particles (ideally 1-3 distributions in the afternoon – depending on the capacity of the feeding system). The whole daily ration should be distributed during this time. Besides the specific appetite for calcium that the hen shows during the eggshell formation, they also naturally eat more in the last hours of a day to meet energy needs for the night period.
- The last feed distribution 1-2 hours before lights off also encourages the birds to get to the house from range and to the system (slatted area and perches) and to sleep there. The amount of the feed distributed must be sufficient to cover the increased consumption during the next morning (the birds are hungry after the night period and will easily finish the less attractive fine part of the ration). As the feed is not distributed in the morning the hens have time to find a nest and lay the eggs there. The remains of feed from the previous day is eaten during this time and the feeding system may stay empty for one or two hours. The birds have finished their ration, all the feed is consumed, the eggs are laid and the feeding system is ready for the first feed distribution of the day. The birds have enough appetite to start the intensive feed consumption of the afternoon.

Pasture and range management

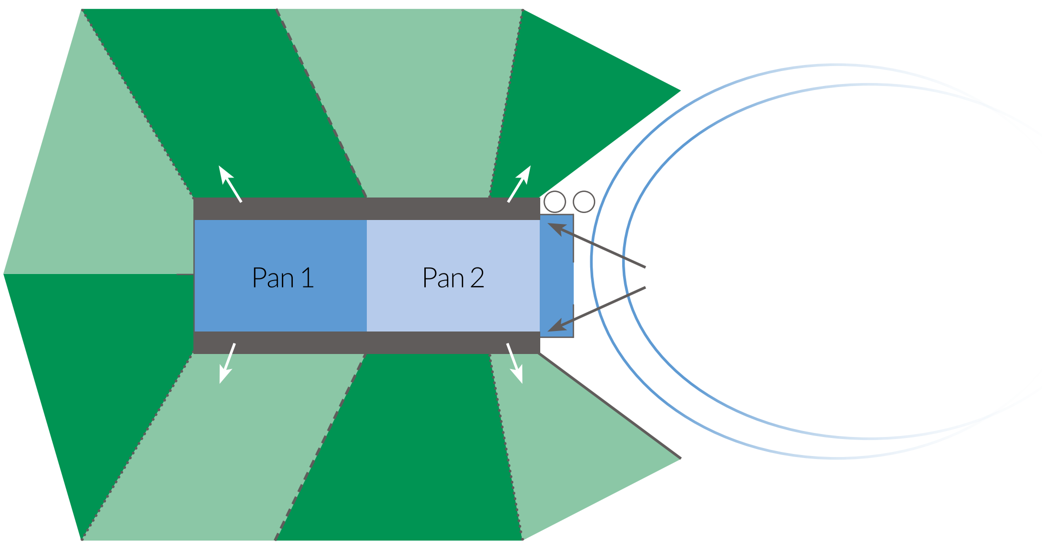
Good pasture management and range enhancement improves welfare of the birds.

Range enhancement

The most critical part of the range is the immediate access of the range (first 5/10 meters) in and around the area of the popholes. It is recommended to place large stones or slats immediately adjacent to the popholes or the winter garden. The stones beside the house help to keep the birds' feet clean and assist to the drainage. Puddles surrounding the house can be a source of contamination and need to be avoided.

Trees and shelter provision on the range allows birds to utilize the range better and protect them against climatic conditions.

Pasture management



Access zone 1

Access zone 2

Fence separating paddock

Fence separating access zones

Pasture comprises not only plants and grasses, but also includes soil – which should have a certain structure if the plant population is to flourish. The pasture has to be managed if firstly it is to thrive, and secondly the birds are to find it acceptable.

The 'paddock' grazing system, where the pasture is divided into 3 or 4 paddocks (or more) and grazed alternately for periods of 3 to 4 weeks, is most useful from several standpoints:

- The plants have a recovery period, during which in the appropriate season, it is possible to re-seed worn areas, in order to maintain good pasture quality.
- When paddocks are not stocked they may be cut and hay may be taken.
- It is possible to chain harrow the pasture, breaking up any mat of dead herbage – an essential feature of pasture management.
- Owing to the break periods, the ground does not become 'fowl sick'. In particular the development of parasitic worms is kept under control.

The areas close to (within 50 metres) the poultry house suffer heavy wear, and will need to be repaired from time to time. The ground may well need cultivating, prior to re-seeding, in order to improve soil structure. Grass does not flourish unless the soil conditions are correct.

It may be necessary to plough areas of ground, allowing exposure to frost and rain, during the winter period, in order to repair soil structure. Reseeding would then be during the early spring.

If reseeding can be carried out during early autumn, this is generally preferable to spring planting. Autumn sowing usually enables the plant population to become much better established, with deeper root growth, before the dry periods that often occur during late spring and summer.

Reseeding will normally be using hard wearing ryegrass species – these are the most durable.

Decontamination of the range

In case of heavy contamination of the range, 500g/m^2 quicklime powder could be spread in this area. Other actions like using chain harrow, could be applied to allow sunlight (ultraviolet) to treat the infected soil.

ISA Brown production table

Age in Weeks	% Hen Day Production	% Livability	Cumulative Eggs / Hen Housed	Average Egg Weight			Daily Egg Mass	Cumulative Egg Mass / Hen Housed		Feed Intake		Bodyweight	
				g / egg	Oz./Doz.	Lbs. / case	grams	kg	lb.	bird/day (g)	100/day (lbs)	grams	Lbs
19	16.9	99.8	1	46.1	19.5	36.6	7.8	0.1	0.2	89	19.7	1630	3.59
20	40.1	99.8	4	49.3	20.9	39.1	19.8	0.2	0.4	97	21.3	1676	3.70
21	63.8	99.7	9	52.0	22.0	41.3	33.2	0.4	0.9	104	23.0	1713	3.78
22	82.1	99.6	14	54.2	22.9	43.0	44.5	0.7	1.5	110	24.3	1750	3.86
23	92.4	99.5	21	56.0	23.7	44.4	51.7	1.1	2.4	112	24.7	1767	3.90
24	95.4	99.4	28	57.4	24.3	45.6	54.8	1.5	3.3	112	24.7	1782	3.93
25	96.1	99.3	34	58.6	24.8	46.5	56.3	1.9	4.2	112	24.7	1796	3.96
26	96.1	99.3	41	59.5	25.2	47.2	57.2	2.3	5.1	112	24.7	1809	3.99
27	96.0	99.2	48	60.2	25.5	47.8	57.8	2.7	6.0	112	24.7	1821	4.01
28	96.0	99.1	54	60.8	25.7	48.3	58.4	3.1	6.8	112	24.7	1831	4.04
29	96.0	99.0	61	61.2	25.9	48.6	58.8	3.5	7.7	112	24.8	1841	4.06
30	95.9	98.9	68	61.6	26.1	48.9	59.1	3.9	8.6	112	24.8	1850	4.08
31	95.9	98.9	74	61.9	26.2	49.1	59.3	4.3	9.5	112	24.8	1858	4.10
32	95.8	98.8	81	62.1	26.3	49.3	59.5	4.7	10.4	112	24.8	1866	4.11
33	95.7	98.7	87	62.3	26.4	49.4	59.6	5.1	11.2	112	24.8	1873	4.13
34	95.6	98.6	94	62.5	26.5	49.6	59.7	5.5	12.1	112	24.8	1879	4.14
35	95.4	98.5	101	62.7	26.5	49.8	59.8	6.0	13.2	112	24.8	1885	4.16
36	95.3	98.4	107	62.9	26.6	49.9	59.9	6.4	14.1	112	24.8	1891	4.17
37	95.2	98.4	114	63.1	26.7	50.1	60.0	6.8	15.0	112	24.8	1896	4.18
38	95.0	98.3	120	63.2	26.8	50.2	60.0	7.2	15.9	113	24.8	1901	4.19
39	94.8	98.2	127	63.3	26.8	50.2	60.0	7.6	16.8	113	24.8	1906	4.20
40	94.6	98.1	133	63.4	26.8	50.3	60.0	8.0	17.6	113	24.8	1911	4.21
41	94.4	98.0	140	63.4	26.8	50.3	59.9	8.4	18.5	113	24.8	1915	4.22
42	94.2	98.0	146	63.5	26.9	50.4	59.8	8.8	19.4	113	24.8	1919	4.23
43	94.0	97.9	153	63.5	26.9	50.4	59.7	9.3	20.5	113	24.8	1923	4.24
44	93.7	97.8	159	63.5	26.9	50.4	59.5	9.7	21.4	113	24.8	1927	4.25
45	93.5	97.7	165	63.5	26.9	50.4	59.4	10.1	22.3	113	24.8	1931	4.26
46	93.2	97.6	172	63.6	26.9	50.5	59.2	10.5	23.1	113	24.8	1935	4.27
47	92.9	97.5	178	63.6	26.9	50.5	59.1	10.9	24.0	113	24.8	1939	4.27
48	92.6	97.5	184	63.6	26.9	50.5	58.9	11.3	24.9	113	24.9	1942	4.28
49	92.3	97.4	191	63.6	26.9	50.5	58.7	11.7	25.8	113	24.9	1946	4.29
50	92.0	97.3	197	63.7	27.0	50.6	58.5	12.1	26.7	113	24.9	1949	4.30
51	91.6	97.2	203	63.7	27.0	50.6	58.4	12.5	27.6	113	24.9	1953	4.31
52	91.3	97.1	209	63.7	27.0	50.6	58.2	12.9	28.4	113	24.9	1956	4.31
53	90.9	97.0	216	63.7	27.0	50.6	58.0	13.3	29.3	113	24.9	1959	4.32
54	90.5	97.0	222	63.8	27.0	50.6	57.7	13.7	30.2	113	24.9	1962	4.33
55	90.2	96.9	228	63.8	27.0	50.6	57.5	14.0	30.9	113	24.9	1965	4.33

Age in Weeks	% Hen Day Production	% Livability	Cumulative Eggs / Hen Housed	Average Egg Weight			Daily Egg Mass	Cumulative Egg Mass / Hen Housed		Feed Intake		Bodyweight	
				g / egg	Oz./Doz.	Lbs. / case	grams	kg	lb.	bird/day (g)	100/day (lbs)	grams	Lbs
56	89.8	96.8	234	63.8	27.0	50.6	57.3	14.4	31.7	113	24.9	1967	4.34
57	89.4	96.7	240	63.8	27.0	50.6	57.1	14.8	32.6	113	24.9	1969	4.34
58	89.0	96.6	246	63.9	27.0	50.7	56.8	15.2	33.5	113	24.9	1971	4.35
59	88.5	96.6	252	63.9	27.0	50.7	56.6	15.6	34.4	113	24.9	1973	4.35
60	88.1	96.5	258	63.9	27.0	50.7	56.3	16.0	35.3	113	24.9	1975	4.35
61	87.7	96.4	264	63.9	27.0	50.7	56.1	16.3	35.9	113	24.9	1976	4.36
62	87.2	96.3	270	64.0	27.1	50.8	55.8	16.7	36.8	113	24.9	1978	4.36
63	86.8	96.2	276	64.0	27.1	50.8	55.5	17.1	37.7	113	24.9	1980	4.36
64	86.3	96.1	281	64.0	27.1	50.8	55.3	17.5	38.6	113	24.9	1981	4.37
65	85.9	96.1	287	64.0	27.1	50.8	55.0	17.8	39.2	113	24.9	1982	4.37
66	85.4	96.0	293	64.1	27.1	50.9	54.7	18.2	40.1	113	25.0	1984	4.37
67	84.9	95.9	299	64.1	27.1	50.9	54.4	18.6	41.0	113	25.0	1985	4.38
68	84.4	95.8	304	64.1	27.1	50.9	54.1	18.9	41.7	113	25.0	1986	4.38
69	84.0	95.7	310	64.1	27.1	50.9	53.9	19.3	42.5	113	25.0	1987	4.38
70	83.5	95.7	315	64.2	27.2	51.0	53.6	19.6	43.2	113	25.0	1988	4.38
71	83.0	95.6	321	64.2	27.2	51.0	53.3	20.0	44.1	113	25.0	1989	4.38
72	82.5	95.5	327	64.2	27.2	51.0	53.0	20.4	45.0	113	25.0	1990	4.39
73	82.0	95.4	332	64.2	27.2	51.0	52.7	20.7	45.6	113	25.0	1991	4.39
74	81.5	95.3	337	64.3	27.2	51.0	52.4	21.1	46.5	113	25.0	1991	4.39
75	81.0	95.2	343	64.3	27.2	51.0	52.1	21.4	47.2	113	25.0	1992	4.39
76	80.6	95.2	348	64.3	27.2	51.0	51.8	21.8	48.1	113	25.0	1993	4.39
77	80.1	95.1	354	64.3	27.2	51.0	51.5	22.1	48.7	113	25.0	1993	4.39
78	79.6	95.0	359	64.4	27.3	51.1	51.2	22.4	49.4	113	25.0	1994	4.40
79	79.1	94.9	364	64.4	27.3	51.1	51.0	22.8	50.3	113	25.0	1995	4.40
80	78.7	94.8	369	64.4	27.3	51.1	50.7	23.1	50.9	114	25.0	1995	4.40
81	78.2	94.8	375	64.4	27.3	51.1	50.4	23.4	51.6	114	25.0	1996	4.40
82	77.8	94.7	380	64.5	27.3	51.2	50.1	23.8	52.5	114	25.0	1996	4.40
83	77.3	94.6	385	64.5	27.3	51.2	49.8	24.1	53.1	114	25.0	1997	4.40
84	76.8	94.5	390	64.5	27.3	51.2	49.6	24.4	53.8	114	25.0	1997	4.40
85	76.3	94.4	395	64.5	27.3	51.2	49.3	24.8	54.7	114	25.1	1998	4.40
86	75.8	94.3	400	64.6	27.3	51.3	49.0	25.1	55.3	114	25.1	1998	4.41
87	75.4	94.3	405	64.6	27.3	51.3	48.7	25.4	56.0	114	25.1	1999	4.41
88	74.9	94.2	410	64.6	27.3	51.3	48.4	25.7	56.7	114	25.1	1999	4.41
89	74.4	94.1	415	64.6	27.3	51.3	48.1	26.0	57.3	114	25.1	2000	4.41
90	73.9	94.0	420	64.7	27.4	51.3	47.8	26.4	58.2	114	25.1	2000	4.41

ISA Brown egg weight distribution (%) – Canadian system

Age in Weeks	Weekly						Cumulative					
	Jumbo over 70 g	Extra Large 64-70 g	Large 56-64 g	Medium 49-56 g	Small 42-49 g	Peewee under 42 g	Jumbo over 70 g	Extra Large 64-70 g	Large 56-64 g	Medium 49-56 g	Small 42-49 g	Peewee under 42 g
19	0.0	0.0	0.4	21.6	65.0	13.1	0.0	0.0	0.3	18.1	62.5	19.1
20	0.0	0.0	4.6	48.9	43.4	3.1	0.0	0.0	3.1	38.4	49.9	8.6
21	0.0	0.2	16.7	59.6	22.7	0.8	0.0	0.1	10.0	49.3	36.0	4.6
22	0.0	1.2	32.7	54.6	11.3	0.2	0.0	0.5	19.0	51.4	26.2	2.9
23	0.1	3.6	46.2	44.2	5.8	0.1	0.0	1.5	27.4	49.1	19.9	2.0
24	0.3	7.3	54.6	34.4	3.3	0.0	0.1	2.9	34.0	45.6	15.9	1.5
25	0.7	11.7	58.5	27.0	2.0	0.0	0.2	4.6	38.8	42.0	13.2	1.2
26	1.4	15.9	59.7	21.7	1.4	0.0	0.4	6.4	42.2	38.6	11.2	1.0
27	2.1	19.5	59.3	18.1	1.0	0.0	0.7	8.3	44.6	35.8	9.8	0.9
28	2.9	22.5	58.3	15.5	0.8	0.0	0.9	10.0	46.3	33.3	8.7	0.8
29	3.6	24.9	57.2	13.7	0.6	0.0	1.2	11.6	47.5	31.1	7.8	0.7
30	4.3	26.7	56.0	12.4	0.5	0.0	1.5	13.1	48.3	29.3	7.1	0.6
31	5.0	28.2	54.9	11.4	0.5	0.0	1.8	14.5	48.9	27.7	6.5	0.6
32	5.6	29.5	53.9	10.6	0.4	0.0	2.1	15.7	49.3	26.3	6.0	0.5
33	6.1	30.6	53.0	9.9	0.4	0.0	2.5	16.8	49.6	25.0	5.6	0.5
34	6.7	31.6	52.1	9.3	0.3	0.0	2.7	17.9	49.8	23.9	5.2	0.5
35	7.3	32.5	51.2	8.8	0.3	0.0	3.0	18.8	49.9	22.9	4.9	0.4
36	7.8	33.3	50.2	8.3	0.3	0.0	3.3	19.7	49.9	22.0	4.6	0.4
37	8.4	34.1	49.3	7.8	0.3	0.0	3.6	20.6	49.9	21.2	4.4	0.4
38	9.0	34.8	48.5	7.5	0.2	0.0	3.9	21.3	49.8	20.5	4.1	0.4
39	9.4	35.3	47.9	7.2	0.2	0.0	4.2	22.1	49.7	19.8	3.9	0.3
40	9.7	35.7	47.4	7.0	0.2	0.0	4.5	22.7	49.6	19.2	3.8	0.3
41	9.8	35.8	47.2	6.9	0.2	0.0	4.7	23.3	49.5	18.6	3.6	0.3
42	9.9	35.9	47.1	6.8	0.2	0.0	5.0	23.9	49.4	18.1	3.4	0.3
43	10.0	36.0	46.9	6.8	0.2	0.0	5.2	24.4	49.3	17.6	3.3	0.3
44	10.1	36.1	46.8	6.7	0.2	0.0	5.4	24.9	49.2	17.2	3.2	0.3
45	10.2	36.2	46.7	6.7	0.2	0.0	5.6	25.3	49.1	16.8	3.1	0.3
46	10.3	36.3	46.5	6.6	0.2	0.0	5.7	25.7	49.0	16.4	3.0	0.2
47	10.4	36.4	46.4	6.6	0.2	0.0	5.9	26.1	48.9	16.0	2.9	0.2
48	10.5	36.5	46.2	6.5	0.2	0.0	6.1	26.5	48.8	15.7	2.8	0.2
49	10.6	36.6	46.1	6.5	0.2	0.0	6.2	26.8	48.7	15.4	2.7	0.2
50	10.7	36.7	46.0	6.4	0.2	0.0	6.3	27.1	48.6	15.1	2.6	0.2
51	10.8	36.8	45.8	6.3	0.2	0.0	6.5	27.4	48.5	14.8	2.5	0.2
52	10.9	36.9	45.7	6.3	0.2	0.0	6.6	27.7	48.4	14.6	2.5	0.2
53	11.0	37.0	45.5	6.2	0.2	0.0	6.7	28.0	48.4	14.4	2.4	0.2
54	11.1	37.1	45.4	6.2	0.2	0.0	6.9	28.2	48.3	14.1	2.3	0.2
55	11.2	37.2	45.3	6.1	0.2	0.0	7.0	28.4	48.2	13.9	2.3	0.2

Age in Weeks	Weekly						Cumulative					
	Jumbo over 70 g	Extra Large 64-70 g	Large 56-64 g	Medium 49-56 g	Small 42-49 g	Peewee under 42 g	Jumbo over 70 g	Extra Large 64-70 g	Large 56-64 g	Medium 49-56 g	Small 42-49 g	Peewee under 42 g
56	11.3	37.3	45.1	6.1	0.2	0.0	7.1	28.7	48.1	13.7	2.2	0.2
57	11.4	37.4	45.0	6.0	0.2	0.0	7.2	28.9	48.0	13.5	2.2	0.2
58	11.5	37.5	44.8	6.0	0.2	0.0	7.3	29.1	48.0	13.3	2.1	0.2
59	11.6	37.6	44.7	5.9	0.2	0.0	7.4	29.3	47.9	13.2	2.1	0.2
60	11.7	37.7	44.5	5.9	0.2	0.0	7.5	29.5	47.8	13.0	2.0	0.2
61	11.8	37.8	44.4	5.8	0.2	0.0	7.6	29.7	47.7	12.8	2.0	0.2
62	11.9	37.8	44.2	5.8	0.2	0.0	7.7	29.9	47.7	12.7	2.0	0.2
63	12.1	37.9	44.1	5.7	0.2	0.0	7.8	30.0	47.6	12.5	1.9	0.2
64	12.2	38.0	44.0	5.7	0.2	0.0	7.9	30.2	47.5	12.4	1.9	0.2
65	12.3	38.1	43.8	5.6	0.2	0.0	8.0	30.4	47.4	12.2	1.8	0.1
66	12.4	38.2	43.7	5.6	0.2	0.0	8.1	30.5	47.4	12.1	1.8	0.1
67	12.5	38.3	43.5	5.6	0.2	0.0	8.1	30.7	47.3	12.0	1.8	0.1
68	12.6	38.4	43.4	5.5	0.2	0.0	8.2	30.8	47.2	11.9	1.7	0.1
69	12.7	38.4	43.2	5.5	0.2	0.0	8.3	30.9	47.1	11.8	1.7	0.1
70	12.8	38.5	43.1	5.4	0.2	0.0	8.4	31.1	47.1	11.6	1.7	0.1
71	12.9	38.6	42.9	5.4	0.2	0.0	8.5	31.2	47.0	11.5	1.7	0.1
72	13.0	38.7	42.8	5.3	0.2	0.0	8.5	31.3	46.9	11.4	1.6	0.1
73	13.2	38.8	42.6	5.3	0.1	0.0	8.6	31.5	46.9	11.3	1.6	0.1
74	13.3	38.8	42.5	5.2	0.1	0.0	8.7	31.6	46.8	11.2	1.6	0.1
75	13.4	38.9	42.4	5.2	0.1	0.0	8.8	31.7	46.7	11.1	1.6	0.1
76	13.5	39.0	42.2	5.1	0.1	0.0	8.8	31.8	46.6	11.0	1.5	0.1
77	13.6	39.1	42.1	5.1	0.1	0.0	8.9	31.9	46.6	11.0	1.5	0.1
78	13.7	39.2	41.9	5.1	0.1	0.0	9.0	32.0	46.5	10.9	1.5	0.1
79	13.8	39.2	41.8	5.0	0.1	0.0	9.1	32.1	46.4	10.8	1.5	0.1
80	14.0	39.3	41.6	5.0	0.1	0.0	9.1	32.2	46.4	10.7	1.5	0.1
81	14.1	39.4	41.5	4.9	0.1	0.0	9.2	32.3	46.3	10.6	1.4	0.1
82	14.2	39.5	41.3	4.9	0.1	0.0	9.3	32.4	46.2	10.5	1.4	0.1
83	14.3	39.5	41.2	4.8	0.1	0.0	9.3	32.5	46.2	10.5	1.4	0.1
84	14.4	39.6	41.0	4.8	0.1	0.0	9.4	32.6	46.1	10.4	1.4	0.1
85	14.6	39.7	40.9	4.8	0.1	0.0	9.5	32.7	46.0	10.3	1.4	0.1
86	14.7	39.7	40.7	4.7	0.1	0.0	9.5	32.8	46.0	10.3	1.4	0.1
87	14.8	39.8	40.6	4.7	0.1	0.0	9.6	32.9	45.9	10.2	1.3	0.1
88	14.9	39.9	40.4	4.6	0.1	0.0	9.7	33.0	45.8	10.1	1.3	0.1
89	15.0	39.9	40.3	4.6	0.1	0.0	9.7	33.0	45.8	10.1	1.3	0.1
90	15.2	40.0	40.1	4.6	0.1	0.0	9.8	33.1	45.7	10.0	1.3	0.1

ISA Brown egg weight distribution (%)– U.S.A. system

Age in Weeks	Weekly						Cumulative					
	Jumbo over 30 Oz./Doz.	Extra Large 27-30 Oz./Doz.	Large 24-27 Oz./Doz.	Medium 21-24 Oz./Doz.	Small 18-21 Oz./Doz.	Peewee under 18 Oz./Doz.	Jumbo over 30 Oz./Doz.	Extra Large 27-30 Oz./Doz.	Large 24-27 Oz./Doz.	Medium 21-24 Oz./Doz.	Small 18-21 Oz./Doz.	Peewee under 18 Oz./Doz.
19	0.0	0.0	0.2	17.2	66.4	16.2	0.0	0.0	0.2	14.4	62.7	22.8
20	0.0	0.0	3.1	44.3	48.4	4.2	0.0	0.0	2.1	34.1	53.3	10.5
21	0.0	0.2	12.7	58.9	27.0	1.1	0.0	0.1	7.5	46.8	39.9	5.7
22	0.0	1.3	26.9	57.3	14.1	0.3	0.0	0.6	15.2	51.0	29.6	3.6
23	0.0	4.0	39.6	48.6	7.6	0.1	0.0	1.7	22.8	50.2	22.8	2.5
24	0.0	8.1	48.1	39.2	4.3	0.1	0.1	3.2	28.9	47.6	18.4	1.9
25	0.0	12.9	52.3	31.6	2.7	0.0	0.1	5.1	33.5	44.5	15.3	1.5
26	1.0	17.5	53.9	25.9	1.9	0.0	0.2	7.1	36.8	41.4	13.1	1.3
27	1.0	21.5	53.9	21.9	1.4	0.0	0.4	9.2	39.2	38.7	11.5	1.1
28	2.0	24.9	53.2	19.0	1.1	0.0	0.6	11.1	40.9	36.3	10.2	1.0
29	2.0	27.5	52.3	16.9	0.9	0.0	0.8	12.9	42.2	34.2	9.2	0.9
30	3.0	29.6	51.3	15.4	0.7	0.0	1.0	14.5	43.1	32.3	8.3	0.8
31	3.0	31.3	50.4	14.2	0.7	0.0	1.2	16.0	43.7	30.7	7.6	0.7
32	4.0	32.8	49.6	13.3	0.6	0.0	1.4	17.4	44.2	29.3	7.1	0.7
33	4.0	34.0	48.7	12.5	0.5	0.0	1.6	18.7	44.5	28.0	6.6	0.6
34	5.0	35.1	47.9	11.8	0.5	0.0	1.8	19.8	44.8	26.8	6.1	0.6
35	5.0	36.2	47.1	11.1	0.4	0.0	2.1	20.9	44.9	25.8	5.8	0.5
36	6.0	37.2	46.3	10.5	0.4	0.0	2.3	21.9	45.0	24.9	5.4	0.5
37	6.0	38.1	45.5	10.0	0.4	0.0	2.5	22.8	45.0	24.0	5.2	0.5
38	6.0	38.9	44.8	9.6	0.4	0.0	2.7	23.7	45.0	23.2	4.9	0.4
39	7.0	39.5	44.2	9.2	0.3	0.0	2.9	24.5	45.0	22.5	4.7	0.4
40	7.0	39.9	43.8	9.0	0.3	0.0	3.1	25.3	44.9	21.9	4.4	0.4
41	7.0	40.1	43.6	8.9	0.3	0.0	3.3	26.0	44.9	21.3	4.3	0.4
42	7.0	40.3	43.5	8.8	0.3	0.0	3.5	26.6	44.8	20.7	4.1	0.4
43	7.0	40.4	43.3	8.7	0.3	0.0	3.6	27.2	44.7	20.2	3.9	0.4
44	7.0	40.5	43.2	8.7	0.3	0.0	3.8	27.7	44.7	19.7	3.8	0.3
45	7.0	40.6	43.1	8.6	0.3	0.0	3.9	28.2	44.6	19.3	3.6	0.3
46	7.0	40.7	43.0	8.5	0.3	0.0	4.0	28.7	44.6	18.9	3.5	0.3
47	8.0	40.9	42.8	8.5	0.3	0.0	4.2	29.1	44.5	18.5	3.4	0.3
48	8.0	41.0	42.7	8.4	0.3	0.0	4.3	29.5	44.4	18.2	3.3	0.3
49	8.0	41.1	42.6	8.3	0.3	0.0	4.4	29.9	44.4	17.9	3.2	0.3
50	8.0	41.2	42.4	8.3	0.3	0.0	4.5	30.3	44.3	17.6	3.1	0.3
51	8.0	41.3	42.3	8.2	0.3	0.0	4.6	30.6	44.2	17.3	3.0	0.3
52	8.0	41.4	42.2	8.1	0.3	0.0	4.7	30.9	44.2	17.0	2.9	0.3
53	8.0	41.6	42.1	8.1	0.3	0.0	4.8	31.2	44.1	16.7	2.9	0.2
54	8.0	41.7	41.9	8.0	0.3	0.0	4.9	31.5	44.1	16.5	2.8	0.2
55	8.0	41.8	41.8	7.9	0.3	0.0	5.0	31.8	44.0	16.3	2.7	0.2

Age in Weeks	Weekly						Cumulative					
	Jumbo over 30 Oz./Doz.	Extra Large 27-30 Oz./Doz.	Large 24-27 Oz./Doz.	Medium 21-24 Oz./Doz.	Small 18-21 Oz./Doz.	Peewee under 18 Oz./Doz.	Jumbo over 30 Oz./Doz.	Extra Large 27-30 Oz./Doz.	Large 24-27 Oz./Doz.	Medium 21-24 Oz./Doz.	Small 18-21 Oz./Doz.	Peewee under 18 Oz./Doz.
56	8.0	41.9	41.7	7.9	0.3	0.0	5.1	32.0	43.9	16.1	2.7	0.2
57	8.0	42.0	41.5	7.8	0.3	0.0	5.2	32.3	43.9	15.8	2.6	0.2
58	8.0	42.1	41.4	7.8	0.3	0.0	5.2	32.5	43.8	15.6	2.5	0.2
59	9.0	42.2	41.3	7.7	0.3	0.0	5.3	32.8	43.8	15.5	2.5	0.2
60	9.0	42.3	41.2	7.6	0.3	0.0	5.4	33.0	43.7	15.3	2.4	0.2
61	9.0	42.4	41.0	7.6	0.3	0.0	5.5	33.2	43.6	15.1	2.4	0.2
62	9.0	42.6	40.9	7.5	0.2	0.0	5.5	33.4	43.6	14.9	2.3	0.2
63	9.0	42.7	40.8	7.5	0.2	0.0	5.6	33.6	43.5	14.8	2.3	0.2
64	9.0	42.8	40.6	7.4	0.2	0.0	5.7	33.8	43.5	14.6	2.3	0.2
65	9.0	42.9	40.5	7.3	0.2	0.0	5.7	34.0	43.4	14.5	2.2	0.2
66	9.0	43.0	40.4	7.3	0.2	0.0	5.8	34.2	43.3	14.3	2.2	0.2
67	9.0	43.1	40.2	7.2	0.2	0.0	5.9	34.3	43.3	14.2	2.1	0.2
68	9.0	43.2	40.1	7.2	0.2	0.0	5.9	34.5	43.2	14.1	2.1	0.2
69	9.0	43.3	40.0	7.1	0.2	0.0	6.0	34.6	43.2	13.9	2.1	0.2
70	10.0	43.4	39.8	7.0	0.2	0.0	6.1	34.8	43.1	13.8	2.0	0.2
71	10.0	43.5	39.7	7.0	0.2	0.0	6.1	35.0	43.0	13.7	2.0	0.2
72	10.0	43.6	39.6	6.9	0.2	0.0	6.2	35.1	43.0	13.6	2.0	0.2
73	10.0	43.7	39.4	6.9	0.2	0.0	6.2	35.2	42.9	13.5	1.9	0.2
74	10.0	43.8	39.3	6.8	0.2	0.0	6.3	35.4	42.9	13.4	1.9	0.2
75	10.0	43.9	39.2	6.8	0.2	0.0	6.4	35.5	42.8	13.3	1.9	0.2
76	10.0	44.0	39.0	6.7	0.2	0.0	6.4	35.6	42.8	13.2	1.9	0.2
77	10.0	44.1	38.9	6.7	0.2	0.0	6.5	35.8	42.7	13.1	1.8	0.2
78	10.0	44.2	38.8	6.6	0.2	0.0	6.5	35.9	42.6	13.0	1.8	0.1
79	10.0	44.3	38.6	6.6	0.2	0.0	6.6	36.0	42.6	12.9	1.8	0.1
80	10.0	44.4	38.5	6.5	0.2	0.0	6.6	36.1	42.5	12.8	1.8	0.1
81	11.0	44.5	38.4	6.4	0.2	0.0	6.7	36.2	42.5	12.7	1.7	0.1
82	11.0	44.6	38.2	6.4	0.2	0.0	6.8	36.4	42.4	12.6	1.7	0.1
83	11.0	44.6	38.1	6.3	0.2	0.0	6.8	36.5	42.3	12.5	1.7	0.1
84	11.0	44.7	37.9	6.3	0.2	0.0	6.9	36.6	42.3	12.5	1.7	0.1
85	11.0	44.8	37.8	6.2	0.2	0.0	6.9	36.7	42.2	12.4	1.7	0.1
86	11.0	44.9	37.7	6.2	0.2	0.0	7.0	36.8	42.2	12.3	1.6	0.1
87	11.0	45.0	37.5	6.1	0.2	0.0	7.0	36.9	42.1	12.2	1.6	0.1
88	11.0	45.1	37.4	6.1	0.2	0.0	7.1	37.0	42.1	12.1	1.6	0.1
89	11.0	45.2	37.3	6.0	0.2	0.0	7.1	37.1	42.0	12.1	1.6	0.1
90	11.0	45.3	37.1	6.0	0.2	0.0	7.2	37.2	41.9	12.0	1.6	0.1

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BODYWEIGHT REARING GRAPH

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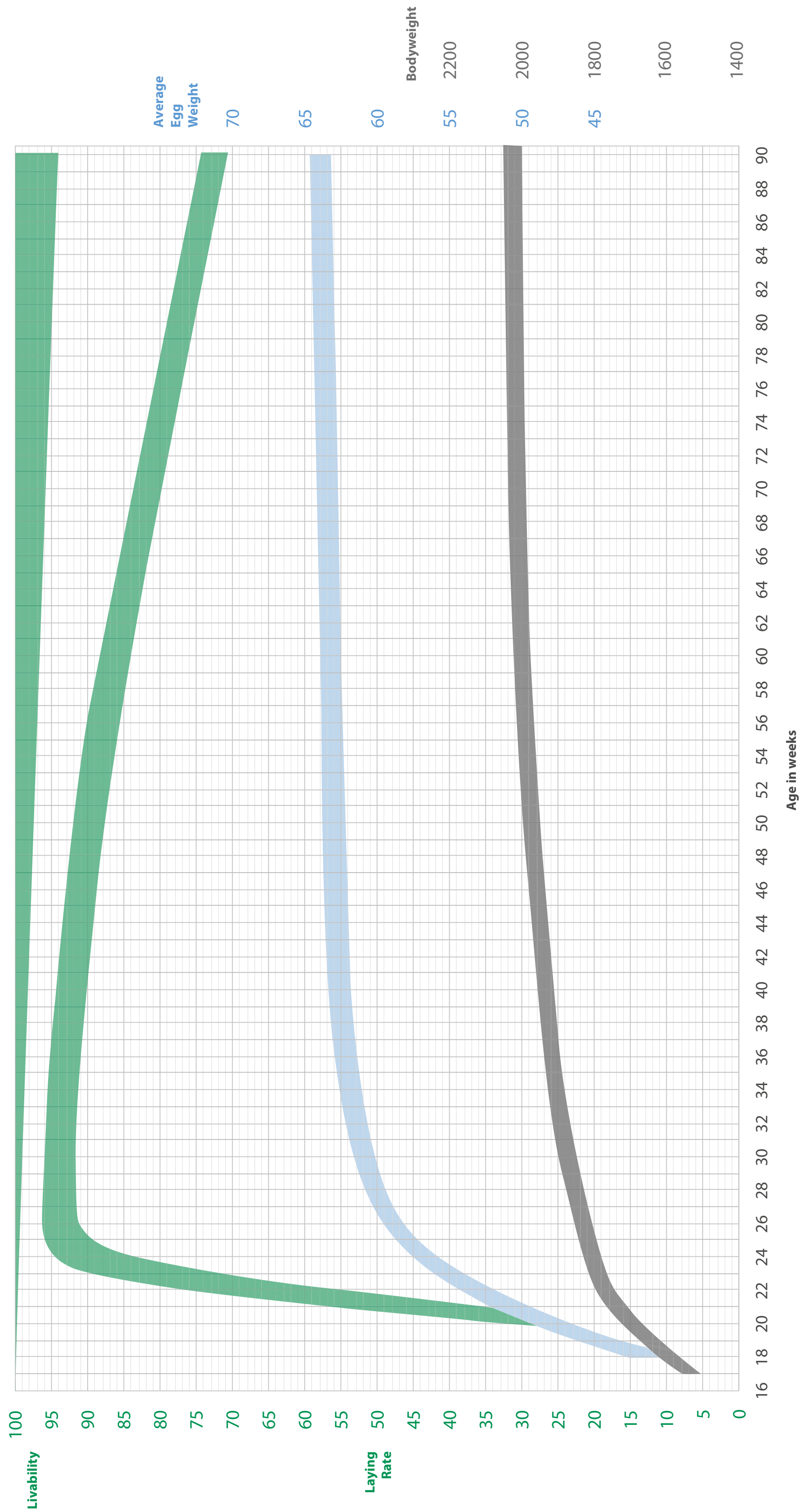
PRODUCTION RECORDING GRAPH



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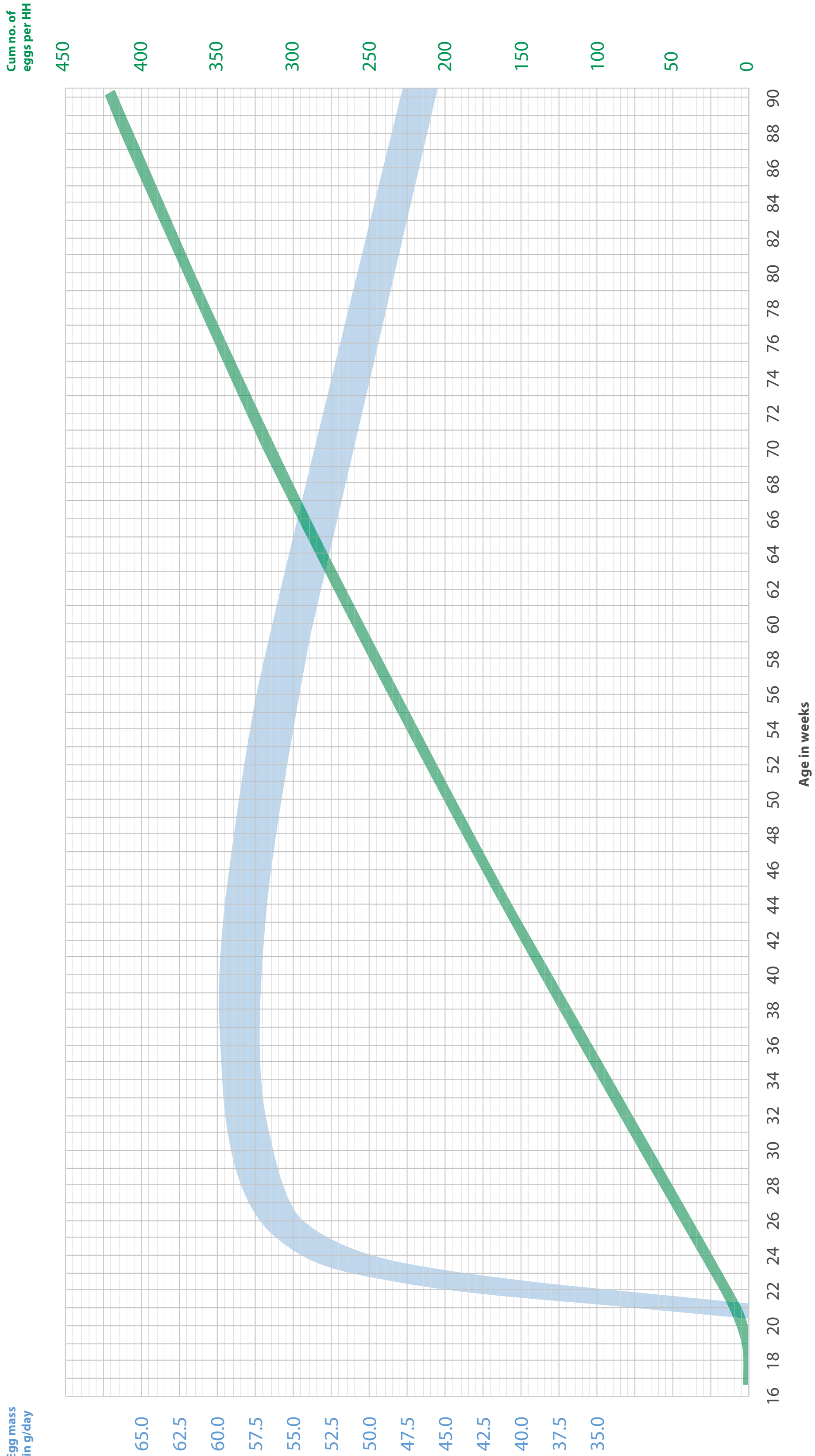
EGG MASS & EGGS PER HEN-HOUSE GRAPH



NOTES

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