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Section 1

Brooding and Rearing Management (0–15 weeks)

Controlling and Monitoring Broiler Breeder Growth

- Development Of Organs And Tissue
- Sex-separate Brooding And Rearing
- Monitoring Broiler Breeder Growth
- Monitoring Body Conformation Characteristics
- Abdominal Fat Development

Brooding (0 - 10 Days)

- Chick Processing
- Beak Treatment
- House Preparation
- Brooding Area Preparation
- Temperature And Humidity
- Ventilation
- Stocking Density 0-28 Days (0-4 Weeks)
- Feeding And Drinking Space
- Key Points For Brooding

Rearing From 10 Days - 15 Weeks

- Feeding Management
- Suggested Procedures To Alleviate Body Weight Problems
CONTROLLING AND MONITORING BROILER BREEDER GROWTH

Objective
To obtain uniform growth by following a gradually increasing feeding program and managing the environment in order to prepare the birds for sexual maturity.

Overview
Broiler parents exhibit the same inherent growth rate and feed efficiency characteristics as the broiler generation. As the flock increases in age and body weight, the rate of feed increases must keep pace with the greater nutritional needs of the growing bird. It is important to follow the product-specific body weight profiles provided as supplements to this manual. These standards are based on research conducted on the particular breed to determine the appropriate profiles for optimum egg and chick production.

As a general rule, if environmental temperatures are maintained >20°C (68°F), breeder females will need to consume cumulative energy of at least 23,000 kcal metabolizable energy (ME) and 1.2 kg of well-balanced protein by the time they are 20 weeks of age. By 22 weeks of age, now a common age of photo-stimulation, these cumulative intakes should have increased to at least 27,000 kcal ME and 1.4 kg of protein.

In order to check whether feed allocations are accomplishing the expected body weight gains, bird weights should be sampled weekly. It is also extremely important to monitor the conformation of pullets and cockerels to ensure proper growth and development. Body weight trends and conformation over a 2–3 week period should be evaluated before making changes to the standard feeding program.

Development of Organs and Tissue

Diagram 1 shows how the bird grows in phases and how organs and tissues develop as the bird ages. In each phase of growth, management decisions should take into account the organ or tissue developing at that time. Diagram 2 (page 5) indicates important management considerations at different growth phases.

Diagram 1: Physiological Development
Sex-separate Brooding and Rearing

Basic principles for managing males and females in the brooding and rearing periods are the same, but body weight profiles and feeding programs will differ. Although males constitute a small percentage of the total flock number, they represent 50% of the breeding value; therefore, it’s equally important for males and females to achieve their most appropriate weight goals.

Most successful flock managers grow males and females separately for the entire growing period. Some sex-separate rearing advantages are:

- Allowing different feed quantities for the males and females, providing significantly more control over body weights and fleshing.
- Allowing more light for males during the starting period, facilitating early growth and achieving larger frame (skeletal) growth.
- Achieving proper skeletal development in males by reaching target body weights from 7 days onward — skeletal size and fertility are closely correlated.
- Enhancing the biosecurity program — if one sex becomes infected with a disease, contamination of the other may be prevented.

It has been traditional practice in some areas to mix males and females at young ages. However, sex-related growth and development varies according to their differing abilities to compete for feed within the single population. Although the practice can be successful, it does not allow growth and uniformity of males and females to be controlled separately and generally does not allow the maximum potential for chick production to be achieved.

If it becomes necessary to mix both sexes early, it should never be done before 42 days (6 weeks) of age, so that males achieve the correct skeletal development. In flocks of mixed sexes, it is the female body weight in relation to target that will subsequently be used to determine overall feeding levels. Where possible, it is also advisable to grow birds from different source flocks separately, or at least for the first 6 weeks, to promote good uniformity.

Diagram 2: Management Progression

- Promote Uniform Growth
- Provide Optimum Environment:
  - Feed Distribution
  - Biosecurity
  - Temperature, Lighting, Ventilation
  - Access to Adequate Water and Feed
- Separate-sex Brooding and Rearing Recommended
- Promote Uniform Growth
  - Match Feeding Regime to Achieve Target Body Weight
  - (Frequent, Small Feed Increases)
  - Begin Fleshing Evaluation of Males and Females
- Critical Period for Monitoring and Managing Body Weight and Uniformity
- Assure Consistent Feed Intake
  - Assure Rations Meet Nutrient Requirements
- Monitor Male:Female Ratios Closely
- Follow Lighting Program
- Assess flock weight uniformity and condition before determining appropriate light and feed stimulus
- Adjust Feed Allocation for Environmental Conditions
- Transition from Grower/Developer Ration to Breeder Ration
- Begin Fleshing Evaluation of Males and Females
- Transfer to Laying House Dependent on House Type
- Monitor Body Weight
  - (Feed for Production)
  - (Manage Male and Female Weights Separately)
- Routine Culling of Underfleshed, Over-fleshed and Inactive Males
- Monitor Daily Egg Production
- Monitor Feed to Avoid Over/Underfeeding
- Follow Lighting Program
- Watch for Signs of Overmating
- Transition from Grower/Developer Ration to Breeder Ration
- Monitor Body Weight
  - Maintain Male:Female Ratios
  - Monitor Feed to Avoid Over/Underfeeding
- Adjust Feed Allocation for Environmental Conditions

Diagram 2: Management Progression
Monitoring Broiler Breeder Growth

Objective
To obtain an accurate estimate of body weight average and uniformity for each group of birds, and to ensure the feeding program is achieving its intended goals.

SAMPLE WEIGHING

Flock growth and development are assessed and managed by weighing representative samples of birds and comparing them with target body weights-for-age. Several types of scales are available which can be used to weigh birds to an accuracy of ±20 g (0.05 lb). Conventional mechanical or dial scales are more labor intensive and require records to be kept and calculations to be made manually. Higher accuracy electronic scales are available which record individual bird weights and calculate flock statistics automatically. Either type can be used successfully but only one type should be used for repeated measurements on an individual flock.

Automatic weighing systems that are placed in the house will give daily records of body weights but these must be regularly calibrated and cross-checked with manual scales.

All measurement systems require calibration and standard weights should always be available to check that scales are weighing accurately. A calibration check should be made at the beginning and end of every sample weighing.

Sample weighing should be carried out weekly starting at day old. At 0, 1 and 2 weeks (0, 7 and 14 days) of age, samples can be weighed in bulk, 10–20 birds at a time. In flocks having early growth problems, more frequent weighings are suggested. Where practicable, the total sample should not be less than 1 percent of the flock for females and 3% for males.

From 3 weeks (21 days) of age, randomly selected samples of birds should be weighed individually. Groups of 50 –100 birds per colony, or area of house, should be caught using catching frames and individually weighed. All birds captured in the sample must be weighed in order to eliminate any selective bias. If the colony or house exceeds 1,000 birds, two sample weighings must be taken from different places in the pen or house.

Birds should be weighed on the same day each week and at the same time, preferably on off-feed days or 4–6 hours after feeding. The objective is to obtain a true representation of flock growth and development by accurate sampling.

When manual scales are used, individual bird weights should be recorded on a weight recording chart (Diagram 3, page 7) as birds are weighed.

After weighing, the following parameters should be calculated for the flock:
• Average weight
• Weight range
• Weight distribution
• Coefficient of variation (CV%)

The average body weight should be plotted on the body weight-for-age graph.

Note:
Body weights that fall behind the target at any stage during the early rearing period, or signs of poor appetite development, require immediate action. Ensure birds are being fed the programmed amount.

COEFFICIENT OF VARIATION

The coefficient of variation (CV%) is a mathematical method of expressing the degree of uniformity or evenness of a flock. The precise method of calculation is as follows:

\[
\text{Standard Deviation} \times 100 = \text{CV%} \\
\text{Average Weight}
\]

Standard deviation may be calculated using an electronic calculator, or from electronic scales. The CV% method is recommended because it is a more accurate determination of what percentage of the flock needs special attention and management to prevent problems. While there are differing approaches to calculating CV%, the same approach should be used consistently throughout the rearing period. An electronic scale that automatically calculates uniformity using the CV% method may be a wise investment. If this is not possible, use the steps on page 7 to estimate CV%.
**CV% METHOD FOR UNIFORMITY CALCULATION**

Step 1 — Record Weights
Mark the weight of each individual bird on a body weight recording chart (see Diagram 3).

Step 2 — Weight Range
Calculate the weight range of the flock by subtracting the weight of the lightest bird from the weight of the heaviest bird.

Heaviest bird weight – lightest bird weight (e.g. 1452 g – 907 g = 545 g; 3.2 lb – 2.0 lb = 1.2 lb)

Step 3 — Average Weight
Calculate the average bird weight by taking the total weight of the birds weighed divided by the number of birds weighed.

Total weight/number weighed (e.g. 59.286 kg / 50 birds = 1186 g; 130.7 lb / 50 = 2.6 lb)

Step 4 — F Value for Sample Size
Use Table 1 (page 8) to determine the appropriate F value given the number of birds weighed or sample size. (e.g. 50 = 4.50)

Step 5 — Calculate
Plug the numbers from the above steps into the following equation:

\[ CV\% = \frac{\text{Weight Range} \times 100}{\text{Average Weight} \times F \text{ Value}} \]

Example

\[ CV\% = \frac{545 \times 100}{1186 \times 4.5} \]

or

\[ CV\% = \frac{1.2 \times 100}{2.6 \times 4.5} \]

\[ CV\% = 10.2 = 10 \]

Step 6 — Compare
While cross-referencing the age of the flock, compare your CV% with the values in Table 2 (page 8). If your CV% is not good, take corrective actions. Depending on the situation, these actions can include, for example, changing feeding amounts, feed distribution, feeder and drinker space, stocking density, ration changes, disease diagnosis and treatment. Corrective actions should be discussed with your Arbor Acres technical service manager and a continuing monitoring program should be established.
A second method of measuring evenness is to express it in terms of percentage of birds within the range of the average weight, ± 10% or 15%. This method gives an accurate indication of the numbers of birds close to the average weight. However, unlike CV%, it does not provide a clear picture of the number of very light and heavy birds. Table 2 illustrates the approximate relationship between CV% and ± 10% or 15% of the average weight in populations with a truncated normal body weight distribution.

Table 1: Sample Size and F Values

<table>
<thead>
<tr>
<th>Sample Size</th>
<th>F Value</th>
<th>Sample Size</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>3.94</td>
<td>75</td>
<td>4.81</td>
</tr>
<tr>
<td>30</td>
<td>4.09</td>
<td>80</td>
<td>4.87</td>
</tr>
<tr>
<td>35</td>
<td>4.20</td>
<td>85</td>
<td>4.90</td>
</tr>
<tr>
<td>40</td>
<td>4.30</td>
<td>90</td>
<td>4.94</td>
</tr>
<tr>
<td>45</td>
<td>4.30</td>
<td>90</td>
<td>4.94</td>
</tr>
<tr>
<td>45</td>
<td>4.40</td>
<td>95</td>
<td>4.98</td>
</tr>
<tr>
<td>50</td>
<td>4.50</td>
<td>100</td>
<td>5.02</td>
</tr>
<tr>
<td>55</td>
<td>4.57</td>
<td>&gt;150</td>
<td>5.03</td>
</tr>
</tbody>
</table>

To ensure good body weight uniformity, check the following factors:
- Body weight sampling procedure
- Correct mathematical calculations
- Condition of feeding and watering equipment
- Environmental conditions (e.g. temperature and RH birds are experiencing)
- Feed distribution
- Disease — especially coccidiosis and other enteric conditions
- Beak treatment
- Brooding practices
- Feeding program (e.g. avoid variable weekly increases, excessive restriction)
- Proper transition from one type of feeder to another
- Feed quality
- Adequate floor, feeder or drinker space
- Correct use of vaccine
- Avoid excessive handling
- Litter quality

Another important aspect of uniform growth is good skeletal development. Onset of sexual maturity is dependent on body composition. Flocks with uniform body weight but variable skeletal size have variable body composition. This lack of uniformity subsequently results in poor uniformity of sexual maturity after photo-stimulation.

**Monitoring Body Conformation Characteristics**

**Objective**

*To ensure consistent flock performance throughout reproductive life cycle by monitoring fleshing development visually and manually.*

**Overview**

In addition to achieving uniform growth, it is important that the body conformation be monitored. Body conformation is the amount of fleshing, muscle and fat on the bird’s skeleton. The amount of fleshing is different at different ages. Over-fleshed and under-
Fleshed females typically achieve lower peaks and fail to produce total egg numbers equal to that of an ideally fleshed flock. Over-fleshed males will have reduced mating activity, which in turn will impact fertility, as well as a higher incidence of leg problems.

Fleshing evaluations need to be conducted on both the males and females during three critical phases of life:
- 16–23 weeks (112–161 days) of age
- 30–40 weeks (210–280 days) of age
- 40 weeks (280 days) of age — depletion

There are four primary areas of the bird’s body to monitor:
- Breast
- Wing
- Pubic bones
- Abdominal fat pad

The best opportunity for evaluating the degree of fleshing in birds is when they are being handled for their weekly weighing. Make general observations of bird condition prior to capture.

**BREAST FLESHING**

During movement to or from the scale, flesh individual birds by running your free hand up the length of each bird’s breast from crop to thigh. A subjective score of over-, under- or ideally fleshed can be assigned to each bird and then averaged for the entire flock. Diagram 4 illustrates typical characteristics of over-fleshed, under-fleshed and ideally fleshed birds.

- Up to 15 weeks of age, the breast muscles should fully cover the skeleton. A cross-sectional view of the breast should look like a V. An under-fleshed bird will have a prominent keel and the cross-sectional view will look like a Y. This should never be allowed to occur. An over-fleshed bird will have more muscle on the sides of the breast making its cross-sectional view look like a heavy V or thin U.
- From 15 weeks of age, larger feed increases are given to obtain correspondingly larger increases in body weight to prepare birds to receive light stimulation. By 20 weeks, the breast should have extra muscle on the sides making the cross-sectional view look like a heavy V.
- At 25 weeks of age the cross-sectional view of the breast should look like a thin U.
- Breast development continues to 30 weeks of age. At 30 weeks of age, the cross-sectional view of the breast should be a full U.

**WING FLESHING**

The second area of the body to develop fleshing is the wing. The fleshing of the wing is monitored by squeezing the muscle located between the radius and ulna of the bird. This is the second segment from the body. The following points should be considered when monitoring wing fleshing:

- Up to 20 weeks of age, the wing should have minimal fleshing, much like the amount of meat on the tip of a small finger.
- By 25 weeks of age, the wing fleshing should have developed to feel like the tip of a middle finger.
- At 30 weeks of age, the wing fleshing is at its maximum level. It should feel like the tip of a thumb.

**PUBIC BONE SPREAD**

The spacing of the pubic (pelvic or pin) bones is measured to determine the state of sexual development of the female. Under normal situations, pin bone spacing develops as shown in Table 3 (page 10).
Table 3: Pubic Bone Spacing According to Age

<table>
<thead>
<tr>
<th>Age</th>
<th>Pin Bone Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 weeks (84 days)</td>
<td>Closed</td>
</tr>
<tr>
<td>21 days before first egg</td>
<td>1½ fingers</td>
</tr>
<tr>
<td>10 days before first egg</td>
<td>2–2½ fingers</td>
</tr>
<tr>
<td>Point of lay</td>
<td>3 fingers</td>
</tr>
</tbody>
</table>

Proper pubic bone spacing will depend on body weight, age of light stimulation and sexual development. Pin bone spacing should be monitored regularly to assess flock development throughout the period.

Abdominal Fat Development

Monitoring the abdominal fat pad can be a useful tool when managing broiler breeders. The abdominal fat pad can provide an energy reserve to support maximum egg production. However, the degree of fat deposition varies among genetic strains. When monitoring broiler breeder fat pads, consider the following points:

- In “classic” or “general purpose” types of broiler breeder strains:
  - Beginning at 24–25 weeks, significant development of the abdominal fat pad occurs.
  - The fat pad should achieve its maximum size approximately 2 weeks prior to peak production at 29–31 weeks of age.
  - The maximum fat pad volume of classic strain breeders should be enough to fill a person’s cupped hand.
- There is generally little to no abdominal fat development in properly fleshed meat yield type breeder hens prior to peak egg production.
- After peak production, it is important to avoid excessive fat pad development. If this occurs, production will decrease more quickly than normal and fertility and hatchability will be reduced.

**BROODING (0–10 DAYS)**

**Objectives**

To ensure a strong growth progression from placement through to 10 days, to achieve target body weight by 14 days, and to ensure this is maintained on a smooth growth curve through to 28 days.

To achieve successful establishment of the flock from day-old, to develop appetite and digestive system, to promote feather growth and to maintain flock uniformity.

**Overview**

Chicks must be provided with the correct temperature profile, relative humidity, air quality, good quality feed and water and appropriate feeder and drinker space. Optimal reproductive performance is dependent upon achieving high management standards in the early life stages.

**Chick Processing**

The lifetime welfare of the flock can be improved by certain procedures carried out either at the hatchery or in the first few days of life. These include treatment of beaks, toes and combs (dubbing). The necessity for any of these procedures should be routinely reviewed and appropriate procedures should be specified for each flock.

To prevent damage to females at mating, it is generally advisable to remove and cauterize the claw of the rear toe on each foot (i.e., dew claw) of male chicks at the hatchery. Trimming the comb (dubbing) of male chicks is not recommended. Leaving the male’s comb intact facilitates earlier and more effective separate-sex feeding and body weight control. This helps to maintain fertility in older flocks. Males with complete combs are less susceptible to heat stress. Complete combs can, however, be more susceptible to damage from equipment and male fighting. Despurring of male chicks is not necessary.

**Beak Treatment**

Beak trimming of both males and females is recommended to prevent cannibalism and to reduce injuries due to flock socialization and pecking trauma. However, there is a growing tendency around the world not to beak trim. Many of these flocks perform well, especially when grown under blackout or brownout conditions.

The advent of infrared beak treatment allows the tips of the chicks’ beaks to be treated without cutting the beak tissue. Since there is no wound, there is no entry point for bacterial infection and it is less stressful for the chicks. This non-invasive method uses an
infrared beam to penetrate the outer layer of the beak down to the basal tissue. Over the next several weeks, the chick’s normal pecking activity wears down the hard outer layer. All the birds should have rounded beak tips within four weeks.

If infrared beak treatment is not used, it is essential that only properly trained staff, using the correct equipment, be employed for beak trimming. It is recommended that it be done at 6–7 days of age because it can be most accurately performed at that time. The objective is to cauterize the upper and lower beak in a single action, removing the least amount of beak and minimizing immediate and future stress on the chicks. It is necessary to make the cut square (see Diagram 5) to avoid uneven growth and beak deformity in later life.

To reduce the risk of infection, great care must be taken to ensure proper cauterization during these procedures. Providing a vitamin supplement in the drinking water, for a short period both before and after the beak trimming procedure, can accelerate the healing process.

**Note:**
- Uniformity problems can be caused by variation in quality of beak trimming.
- Great care must be taken to ensure proper cauterization when beak trimming to reduce the risk of infection.

**House Preparation**

**Objective**

*Provide proper heat, ventilation and access to feed and water for the chicks to optimize growth and development.*

**Overview**

Houses and equipment should be cleaned, disinfected and set up well in advance of chick placement. At least 24 hours in advance of chick arrival, desired house and floor temperatures should be achieved with good air quality. Temperatures should be checked at chick level at feeder and drinker locations. If insufficient time is allowed for floor temperature to reach house temperature, there is a danger that chicks will become chilled. Chick behavior is the most important indicator of proper environmental temperature. Flock managers must respond quickly to changes in chick behavior.

Typically, fresh litter should be provided at a minimum depth of 10 cm (4 in). Preferred litter material is untreated softwood shavings or rice hulls. Where floor feeding is to be practiced, litter depth should not exceed 4 cm (1.5 in). Drinker height should be adjusted in response to litter subsidence.
**Brooding Area Preparation**

There are two basic options for setting up the brooding area to control temperature:
- Spot brooding
- Whole house brooding

Brooding down the center of the pen is most likely to achieve uniform chick distribution. This principle applies to both radiant and hot air systems. A typical spot brooding layout for day-old chicks is shown in Diagram 6.

Chick placements should be planned so that chicks from different aged source flocks can be brooded separately. Chicks from very young donor flocks will catch up with the others if kept separate for the first 2–3 weeks. It is good practice to allocate areas into which to place birds before the chicks arrive. Great care must be taken in allocating equal numbers of chicks to each brooder area.

When the chicks arrive, they should immediately be removed from boxes, placed in the brooding area and given access to feed and water. Feed in the gut stimulates yolk sac absorption and enhances intestinal and immune system development. Chicks given early access to feed and water have better early growth and body weight uniformity than those experiencing delayed access to feed.

Full chick boxes should never be stacked within the brooder house. Empty chick boxes should be removed from the building and destroyed as soon as possible. The requirements for vaccination and provision of competitive exclusion products are discussed in Disease Control and Vaccination (page 70).

A maximum of one day’s supply of feed should be placed on feed trays or on paper, and should be used in conjunction with the feed track to provide 20–25 g per chick placed to avoid problems associated with stale food. Small amounts of feed should be given frequently (i.e., 5–6 times per day), to encourage eating.

To ensure that chicks achieve target body weight, starter feed in crumble form should be provided for the first 3 weeks. Body weight targets during early rearing stages can only be achieved by ad libitum feeding from day of placement. Flocks that fail to achieve target weight tend to lose uniformity. Subsequently, future body weight targets are difficult to achieve and uniformity deteriorates further. This requires not only good management, but high quality feed (see supplement for complete nutritional recommendations). Daily feed intakes should be recorded, so that a smooth transition can be achieved from ad libitum to controlled feeding.

It is good practice to monitor chick-feeding activity. The extent of crop fill is a good indication of feeding activity. By 24 hours after placement, more than 80% of chicks should have full crops. By 48 hours after placement, more than 95% of chicks should have full crops. Successful levels of crop fill will maintain body weight uniformity of the flock and will yield better 7-day body weights. If these levels of crop fill are not being achieved, then something is preventing the chicks from feeding and action to resolve this is required.

If there is any evidence that birds are not growing to target body weight, then the age at which constant day length will be achieved can be delayed. Twice weekly weighing of birds should be undertaken to monitor results where target body weights are not being achieved.

To encourage even distribution of chicks, make sure light intensity is uniform.

**Temperature and Humidity**

**BROODING TEMPERATURES**

Floor temperatures at feed and water locations should be at required level, with good air quality, 24 hours before arrival of chicks. Recommended floor temperatures at feed and water locations are provided in Table 4 (page 13).
Chick behavior should be routinely and attentively observed during the brooding period — the best indicator of correct environmental temperature (see Diagram 7). Uneven chick distribution indicates incorrect temperature or drafts. Thermometers should be placed at bird height throughout the house to validate automated systems.

Brooding rings may be used to limit early chick movement. The area contained by the rings should be expanded gradually from 3 until 5–7 days of age. Thereafter, they should be removed.

For the first 24–48 hours, illumination should be continuous, depending on chick condition and behavior. Afterwards, light duration and intensity should be controlled (see Lighting, page 40).

The only house illumination necessary will be in the form of circles of light 4–5 m (13–16.5 ft) diameter per 1,500 chick capacity. The light should be bright, 80–100 lux (7.4–9.3 foot candles). The remainder of the house should be darkened or dimly lit. The illuminated area of the house should be increased in proportion to the stocked area.

When using “whole house” brooding, it is less easy to use chick behavior as an indicator of proper environmental temperature because there are no obvious heat sources (see Diagram 8). Often, chick vocalization may be the only indication of distress. Given the opportunity, chicks will congregate in areas where environmental temperature is closest to their requirements. Some care is needed in interpreting chick behavior (see Diagram 8).

**Table 4: Recommended Brooding Temperatures**

<table>
<thead>
<tr>
<th>Age (Days)</th>
<th>Floor Temperature at Location of Feed &amp; Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–3</td>
<td>33°C, 91°F</td>
</tr>
<tr>
<td>4</td>
<td>32°C, 90°F</td>
</tr>
<tr>
<td>5</td>
<td>31°C, 88°F</td>
</tr>
<tr>
<td>6</td>
<td>30°C, 86°F</td>
</tr>
<tr>
<td>7</td>
<td>29°C, 84°F</td>
</tr>
<tr>
<td>14</td>
<td>26°C, 79°F</td>
</tr>
<tr>
<td>21</td>
<td>23°C, 73°F</td>
</tr>
<tr>
<td>28-on</td>
<td>21°C, 70°F</td>
</tr>
</tbody>
</table>

*At relative humidity range of 50–70%, set controllers to achieve these temperatures. At all stages, chick behavior should be monitored to ensure chicks are experiencing proper temperature. If subsequent behavior indicates chicks are too cold or too hot, the house temperature should be adjusted appropriately.

**HUMIDITY**

At the end of the incubation process, relative humidity (RH) in the hatcher will be high (approx. 80%). In a chicken house, RH levels can be quite low (<25%), particularly when they are located at high altitude, utilize whole house heating (especially when equipped with nipple drinkers), or when rearing occurs during cold weather conditions. Equipping houses with bell-type drinkers (which have open water surfaces) or spot brooders (which produce moisture as a byproduct of combustion) can result in higher RH levels (>50%). To limit transfer shock from the incubator, RH levels experienced by the chicks during the first 3 days of life should ideally be around 70%.
RH within the parent rearing house should be monitored daily. If it falls below 50% during the first week of life, chicks will begin to dehydrate and biological performance can be negatively affected. In such cases, action should be taken to increase RH. Very low humidity conditions (<40%) are most prevalent in high altitude growing conditions; however, even at relatively low altitudes, RH can become quite low during cold weather conditions.

If the house is fitted with high pressure spray nozzles (i.e., >1000 PSI foggers) for cooling in hot climates, these can be “pulsed” to increase RH during brooding. High pressure fog should be properly “pulsed” to prevent chicks and litter from becoming wet. Chicks kept at appropriate humidity levels are less prone to dehydration, respond better to respiratory vaccinations and generally make a better, more uniform start. Care should be taken to adjust house temperatures accordingly or chicks may become chilled due to the evaporative cooling effect of the fog.

As the chick grows, the ideal RH falls. High RH from 18 days onward can cause wet litter and its associated problems. As body weight increases, RH levels can be controlled using ventilation and heating systems.

**INTERACTION BETWEEN TEMPERATURE AND HUMIDITY**

All animals will lose heat to the environment by evaporation of moisture from the respiratory tract and through the skin. At high RH, less evaporative loss occurs, increasing the animals’ apparent temperature. The temperature experienced by the animal is dependent on dry bulb temperature and RH. High RH increases apparent temperature at a particular dry bulb temperature, whereas low RH decreases apparent temperature. The temperature profile in Table 4 (page 13) assumes RH in the range 50–70%. If humidity conditions are lower than this range, the dry bulb temperature will need to be increased. Conversely, if humidity conditions are higher than this range, a lower dry bulb temperature will be required.

Carefully observing bird behavior and quickly responding by making appropriate adjustments to the environmental control system are the critical components to successfully rear chickens — the ultimate sensor for environmental condition status is chick behavior. At all stages, chick behavior should be monitored to ensure chicks are experiencing proper temperature.

**Note:**

- When RH falls below 50% during brooding, action to increase RH is required to prevent chicks from becoming dehydrated.
- Excessive chick noise is a sign of incorrect temperature.
- If chicks are too warm or cold during the first 10 days, they will not start well.

**HIGH AMBIENT TEMPERATURES**

Chickens can acclimatize and function well at higher ambient temperatures — provided consideration is given to stocking density, air speed/ventilation and humidity. Evaporative cooling pads, high pressure fogging and/or the operation of in-house fans are used to reduce house temperature (see Housing and Environment, page 37).

**Ventilation**

Chicks must be kept at the correct temperature with an adequate fresh air supply. It is good practice to establish a system of minimum ventilation during brooding. This should replenish oxygen and remove carbon dioxide and noxious gases produced by the chicks and possibly the heating system. The minimum ventilation requirements are given in Ventilation (page 38).

**Note:**

Poor air quality due to under-ventilation at brooding may cause damage to the lung surface, making birds more susceptible to respiratory disease.
Stocking Density
0–28 Days (0–4 Weeks)

Bird floor space allowance at placement, 20 birds/m\(^2\) (0.55 ft\(^2\)/bird), should be progressively increased so that by 28 days (4 weeks) birds are stocked at 6–7 birds/m\(^2\) (1.5–1.75 ft\(^2\)/bird) (see Table 5).

**Table 5: Stocking Densities**

<table>
<thead>
<tr>
<th></th>
<th>Rearing 0–140 days (0–20 weeks)</th>
<th>Production 140–448 days (20–64 weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td></td>
<td>birds/m(^2) (ft(^2)/bird)</td>
<td>birds/m(^2) (ft(^2)/bird)</td>
</tr>
<tr>
<td></td>
<td>3–4 (2.7–3.6)</td>
<td>6–7 (1.5–1.75)</td>
</tr>
<tr>
<td><strong>Males and Females</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>birds/m(^2) (ft(^2)/bird)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.9–5.1 (2.1–2.75)</td>
<td></td>
</tr>
</tbody>
</table>

*Higher number is for open-sided housing; lower number is for black-out housing.

Feeding and Drinking Space

**Male and Female Feeders (0–10 weeks):** An allowance of 5 cm (2 in) of track or pan feeder space per bird, or 1 chick feeder lid per 80–100 birds should be provided in the first 2–3 days. First feed should be given on feeder trays or paper occupying up to 25% of the brooding area. Feed should be given in crumb or mash form for the first 3 weeks. Please refer to nutritional recommendations contained in the supplements for more detailed feed recommendations. The 5 cm (2 in) feed space allowance is suitable up to 35 days, 10 cm (4 in) to 70 days.

**Female Feeders (>10 weeks):** From 10 weeks through depletion, females require 15 cm (5.5 in) for track and 10 cm (4 in) for pans (see Table 6).

**Male Feeders (>10 weeks):** From 10–20 weeks, males require 15 cm (5.5 in) for track and 10 cm (4 in) for pans. After 20 weeks, provide 18 cm (7 in) for both track and pan feeders (see Table 6).

**Table 6: Feeding Space**

**FEMALES**

<table>
<thead>
<tr>
<th>Age</th>
<th>Chick Feeder Lids</th>
<th>Feeding Space</th>
<th>Pan Feeder</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–10 days</td>
<td>1 lid/80–100 chicks</td>
<td>5 cm (2 in)</td>
<td>5 cm (2 in)</td>
</tr>
<tr>
<td>10 days–7 weeks</td>
<td>5 cm (2 in)</td>
<td>5 cm (2 in)</td>
<td></td>
</tr>
<tr>
<td>7–10 weeks</td>
<td>10 cm (4 in)</td>
<td>10 cm (4 in)</td>
<td></td>
</tr>
<tr>
<td>&gt;10 weeks</td>
<td>15 cm (6 in)</td>
<td>10 cm (4 in)</td>
<td></td>
</tr>
</tbody>
</table>

**MALES**

<table>
<thead>
<tr>
<th>Age</th>
<th>Chick Feeder Lids</th>
<th>Feeding Space</th>
<th>Pan Feeder</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–10 days</td>
<td>1 lid/80–100 chicks</td>
<td>5 cm (2 in)</td>
<td>5 cm (2 in)</td>
</tr>
<tr>
<td>10 days–7 weeks</td>
<td>5 cm (2 in)</td>
<td>5 cm (2 in)</td>
<td></td>
</tr>
<tr>
<td>7–10 weeks</td>
<td>10 cm (4 in)</td>
<td>10 cm (4 in)</td>
<td></td>
</tr>
<tr>
<td>10–20 weeks</td>
<td>15 cm (6 in)</td>
<td>15 cm (6 in)</td>
<td></td>
</tr>
<tr>
<td>&gt;20 weeks</td>
<td>18 cm (7 in)</td>
<td>18 cm (7 in)</td>
<td></td>
</tr>
</tbody>
</table>
If more than one feeder track is used, tracks should operate in opposite directions. Feed distribution time can be reduced by placing a satellite bin (dummy hopper) containing sufficient feed to fill half of the track, halfway around the feeder loop. Feed depth, distribution time and cleanup time should be monitored routinely at several points.

Good quality water is essential for growth and development. Refer to Table 23 (Health and Hygiene section, page 69) for characteristics which define acceptable water quality. Chicks should have unlimited access to water for the first weeks of life. However, under the feed restriction system utilized for pullets and cockerels, a water restriction program may be necessary to maintain good litter quality both in grow and lay (refer to Water Management, page 55).

Adequate drinking space for 1,000 day-old chicks is provided by 5–6 standard bell drinkers each measuring 40 cm (15.7 in) diameter, plus 10–15 mini supplementary drinkers each measuring 15–20 cm (5.5–8.0 in) diameter. Drinkers should be positioned strategically to ensure that chicks do not have to travel more than 1 meter (3 ft) for access to water in the first 24 hours. Water should be clean and fresh. At brooding temperatures, bacteria can multiply very rapidly in open water. Supplementary drinkers should be replaced gradually from 3–4 days onward. From 21 days, drinking space is as defined in Table 7.

### Table 7: Drinking Space

<table>
<thead>
<tr>
<th></th>
<th>Rearing Period</th>
<th>Lay Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic circular or trough drinkers</td>
<td>1.5 cm/bird</td>
<td>2.5 cm/bird</td>
</tr>
<tr>
<td>Nipples</td>
<td>1.0/8–12 birds</td>
<td>1.0/6–10 birds</td>
</tr>
<tr>
<td>Cups</td>
<td>1.0/20–30 birds</td>
<td>1.0/15–20 birds</td>
</tr>
</tbody>
</table>

Nipple or cup systems, plus supplementary drinkers, can be used very successfully from placement.

### Key Points for Brooding

- Prepare, clean and disinfect houses and equipment well in advance of chick arrival.
- Ensure house reaches correct temperature and RH, with good air quality, 24 hours before chicks arrive.
- Ensure chicks have immediate access to fresh water and feed.
- Use chick behavior as an indicator of satisfactory brooding temperature.
- Replenish feed frequently during the brooding period.
- Monitor crop fill to ensure chicks are feeding.
- Check and adjust feeders and drinkers at least twice a day.
- Check the chicks at regular intervals throughout the day.
- Beak trimming should be performed by trained, competent personnel and be properly supervised.

### Note:

If any abnormality in chick behavior should occur or if mortality exceeds 1% by 7 days, all management factors should be rechecked and arrangements made for a veterinary examination as soon as possible.

#### REARING FROM 10 DAYS – 15 WEEKS

### Objective

*Achieve and maintain uniform growth.*

### Overview

Rapid growth and development of the broiler parent occurs in the first 15 weeks. Good control of body weight gain will be based on progressively increased feed quantity. During this stage, small changes in the quantity of feed consumed can have large effects on body weight. Therefore, monitoring body weight is important to make sure birds are responding to the feed.

Recommended feeding programs to achieve body weight targets are provided as supplements. These supplements are only guides to the amount of feed required at specified energy densities. Changes to quantities of feed required should be calculated based on your company’s feed energy levels. Appropriate
increases in feed quantity are necessary on a weekly basis. Birds should be managed to achieve uniform growth and adequate fleshing.

Both sexes may be graded during this period; however, always keep in mind that it is more productive and efficient to prevent problems with uniformity than to have to take corrective actions to improve it. Grading involves dividing the birds into groups by weight in order to feed different amounts of ration. Never do any grading beyond 10 weeks of age.

At 5–6 weeks of age, one should consider installing perches or slat sections in the house. This will help birds become accustomed to jumping up — later encouraging use of nests and promoting familiarization with navigating slats.

**Feeding Management**

Install feeders with adequate feeder space so all birds can eat simultaneously (see Table 6, page 15). This provides uniform feed distribution and prevents overcrowding at feeders. Good feed distribution will allow all birds to have access to feed within 3 minutes. Run mechanical feeders continuously until birds have consumed their entire day’s feed allotment. During periods of excessive heat, change time clocks so birds are fed during very early morning hours when temperatures are coolest.

Floor feeding, either with spinner feeders or by hand, scattering high-quality pellets into litter, is an alternative to conventional feeding systems. This method offers certain advantages, including rapid and even distribution of feed, increased flock uniformity, improved litter condition and reduced leg damage. As with all feeding systems and techniques, good management practice is required to allow the full potential of floor feeding. The following points should be considered when feeding on the floor:

- From 2–6 weeks, the floor feeding area should be gradually expanded using good quality pellets 2.5 mm in diameter and 3–4 mm in length.
- After 6 weeks, good quality pellets 4 mm in diameter and 5–7 mm in length should be used.
- High intensity light (min. 20 lux; 2.0 foot candles) should be provided for the feeding period.
- Litter depth should not exceed 4 cm (1.5 in) and good litter condition must be maintained.
- To minimize stress of the changeover during lay, birds should be fed on the hen feeders 3 weeks prior to onset of lay. Male exclusion devices (i.e., grids or restrictive grill) should be removed from the feeders for the first few days after the change from floor feeding.

Pan feeders are commonly used in many areas. With good understanding of the operational guidelines and routine management, birds can be fed even on a daily schedule. They can also be used with alternate days feeding programs.

Avoid ordering feed amounts that are too large for size of the flock. Typically, the ideal situation is for feed not to remain on the farm for more than a week. Feed bins should always remain covered and in good condition to prevent water from seeping in. Clean all feed spills promptly.

Check feed scale accuracy regularly. Use a standard weight and check them daily before use. Monitor the nutrient levels, microbiological load and overall quality of feed ingredients and finished feed regularly to ensure birds consistently receive good quality feed. Save a sample of feed from each delivery and store it in a cool, dry place. If a problem develops, the feed can then be analyzed, if not previously done.

Be present at time of feeding to make sure the system operates to supply enough feed for all birds. Make necessary adjustments when problems are detected. As the flock increases in age and body weight, feed increases must keep pace with the greater nutrient requirements of correspondingly heavier birds. As a guideline, never give pullets more feed/bird/day than you would at peak hen feed consumption during the laying period.

**FEEDING SCHEDULES**

Ideally, birds should be fed every day. However, meat-type birds must have their feed restricted below what they would consume ad libitum, and daily feed volumes are often too small to be carried around the entire feed circuit. This can create logistical problems in achieving uniform feed distribution. Feed must be
evenly distributed to minimize competition and maintain body weight and flock uniformity. Consequently, alternative feeding schedules have been derived which allow the accumulation of sufficient feed on the ‘feed day’ to provide uniform feed delivery. The change over to everyday feed should be gradual with progression from 4–3, to 5–2, to 6–1 as appropriate. The most frequently used alternative feeding schedules are shown in Table 8.

The signs of poor feed distribution generally appear between 4 and 8 weeks of age. If grading is practiced, the switch from daily feeding should not occur before grading. The change to or from daily feeding needs to be gradual.

In those areas where everyday feeding has not been mandated by law and traditional feeding equipment is already in place, several feeding programs are used: skip-a-day, 5–2, 4–3, 2–1 and 6–1. The 4–3 program has become popular in recent years because it leads to smoother weekly feed increases. The manager’s experience concerning feed quantity should be used to obtain best results. Always remember, when switching from skip-a-day to daily rationing, feed efficiency improves and birds will tend to gain weight more efficiently.

**Suggested Procedures to Alleviate Body Weight Problems**

If average body weight differs from target body weight by more than 90 g (0.20 lb), reweigh a sample of birds. If the trend is valid, take the corrective action indicated below. These principles apply to both males and females.

**UNDERWEIGHT PRIOR TO 15 WEEKS**

Insufficient body weights before 15 weeks of age will result in:
- Poor body weight uniformity
- Small frame size
- Decreased feed efficiency from 16–22 weeks of age

To correct this problem:
- Remain on starter feed longer.
- Initiate the next scheduled feed increase and increase the amount of the next scheduled feed increase until body weight is brought gradually back to target.
- As a rule of thumb, for every 50 g (0.10 lb) underweight, a bird will require an additional 13 kcal ME/day beyond the normal feed increase to recover in 1 week.
- See Diagram 9 (page 19) for an example of such corrective action.

**OVERWEIGHT PRIOR TO 15 WEEKS**

Flocks that are overweight before 15 weeks of age will result in:
- Poor uniformity
- Large frame size
- Decreased feed efficiency during lay

To correct this problem:
- Do not reduce feed lower than the current feeding level.
- Decrease the amount of next feed increase.
- Delay the next feed increase.
- See Diagram 10 (page 19) for an example of such corrective action.

**Table 8: Examples of Feeding Schedules**

<table>
<thead>
<tr>
<th>FEED SCHEDULE</th>
<th>MON</th>
<th>TUE</th>
<th>WED</th>
<th>THU</th>
<th>FRI</th>
<th>SAT</th>
<th>SUN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Every Day</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>6–1</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>5–2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>4–3</td>
<td>3</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Skip-a-day</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>7</td>
<td>3</td>
</tr>
</tbody>
</table>

3=Feed Day    7=Non-Feed Day
Diagram 9: Females Underweight at 4 Weeks Example

- Immediately feed next scheduled increase
- Increase the amount of scheduled feed increase
- Remain on starter feed longer to gradually bring weight back to target

Diagram 10: Females Overweight at 4 Weeks Example

- Decrease amount of next feed increase
- Delay next scheduled feed increase
Section 2
Management Into Lay (15–30 weeks)

Management from 15 Weeks to Light Stimulation
- Female Management Considerations
- Male Management Considerations
- Mating Up
- Sample Weighing Males

Separate-sex Feeding
- Female Feeding Equipment
- Male Feeding Equipment

Management of Females Pre-peak Period – Photo-stimulation to 30 Weeks
- Management of Females from Photo-Stimulation to 5% Production
- Management of Females from 5% Hen-Day Production to Peak Egg Production
- Key Points for Bringing Females into Production
- Feed Consumption Trends
- Egg Weight and Feed Control

Key Points for Egg Weight and Feed Control

Management of Males from Photo-stimulation to 30 Weeks
- Male Feeding
- Over-mating
- Monitoring Male Condition
- Key Points for Managing Males in Production

Management of Females After Peak Production
- Female Weight Control
- General Guidelines for Post-Peak Feed Reduction
- Key Points for Controlling Female Body Weight

Management of Males After Peak Production
- Male Weight Control
- Spiking Programs
MANAGEMENT FROM 15 WEEKS TO LIGHT STIMULATION

Objectives
To minimize variation in sexual maturity.
To prepare the females for the physiological demands of sexual maturity.
To ensure males develop optimal physical condition and are able to sustain reproductive fitness throughout the laying period.

Female Management Considerations
The period 15 weeks to photo-stimulation is crucial in influencing onset of egg production, early egg size, hatching egg yield, absolute feed requirements pre-peak and potential peak production. During this period, increasing feed quantities are used to accelerate uniform growth and to achieve proper weekly incremental weight gain.

Continue increasing feed amounts weekly to sustain good growth. At this stage, resultant increases in body weight initiate physiological changes leading to sexual maturity. Feed quantity increases allowing good body weight gains will promote optimal reproductive performance. Weekly incremental body weight increases will ensure a smooth transition into sexual maturity and egg production.

Inadequate nutrient supply as birds reach sexual maturity is a frequent cause of loss of uniformity. The flock manager must note and compensate for energy changes between rations (e.g. grower, prebreeder, breeder). Birds may be changed from a grower to a prebreeder feed or directly to a breeder feed. A prebreeder feed, initiated at 18 weeks of age, is preferred only when the flock has not been properly gaining weight.

PROBLEMS ASSOCIATED WITH IMPROPER GROWTH

If weekly incremental weight gains are not made in line with the feeding program, development of sexual maturity will be affected. If body weights are depressed beyond 17 weeks, future reproductive performance may be reduced due to impaired uniformity of sexual maturity. Failure to meet required weekly incremental gain beyond 19 weeks is a common cause of poor performance. Impaired growth and ovarian development will cause:
• Delayed onset of lay
• Poor initial egg size
• Increased incidence of cull eggs
• Reduced fertility
• Increased susceptibility to broodiness
• Loss of uniformity of body weight and sexual maturity

Flocks that are fed excessively and thus exceed target body weights in this period will commonly exhibit:
• Early onset of lay
• Increased egg size and double yolks
• Reduced hatching egg yield
• Increased feed requirements through lay
• Reduced peak and total eggs
• Reduced fertility throughout life
• Increased levels of mortality

Male Management Considerations
Attention to male management requirements must be given the same priority as that of females. Therefore, recommendations and observations made for female management in this period are equally relevant to the male population. As with females, from 15 weeks, the aim should be to follow the target body weight profile and bring males to uniform and coordinated sexual maturity with the females.

If the smooth transition of body weight gain and flock body weight uniformity does not follow the target body weight profile, uniformity of sexual maturity is likely to be disrupted in the 15 week to photo-stimulation period.

Target body weight should be redrawn forward if flock body weight deviates by more than ± 5% at 15 weeks. The profile should be redrawn on the body weight graph, parallel to the standard curve.

When out-of-season flocks are housed in open-sided houses, males are likely to become sexually mature ahead of females. Adjustments may be required, therefore, to ensure sexual maturity synchronization. This may be achieved by:
• Delaying male photo-stimulation
• Delaying mixing of males and females
• Reduction of initial male:female ratio
• Introducing males gradually

Failure to make adjustment(s) can lead to increased female mortality attributable to male aggression.

Mating Up

During the 20–23 week period, males and females are mixed and additional management techniques are necessary. To maintain males and females in optimum reproductive condition throughout the reproductive period, attention must be paid to mating up procedures, management of male to female ratio and equipment.

Males and females are generally ready to be mated up at 20–23 weeks. If variation exists in sexual maturity within the male population, males beginning to show secondary sexual characteristics should be mixed with females and immature males should be allowed extra time to develop before introduction. A practical approach would be to mix 6% males at 22 weeks and by 29 weeks add the remaining 2.5–3.0%.

MATING RATIO

At mating, selected males should be uniform in body weight, be free of physical abnormalities, have strong straight legs and toes, be well-feathered with a good upright stance and good muscle tone. In addition, secondary sexual characteristics (i.e., face and comb color, wattle and comb growth) should indicate that selected males are equally advanced and uniform in sexual condition (See Diagram 11).

In order to maintain fertility persistence, each flock will require an optimum number of sexually active males. Table 9 indicates typical ranges of male to female ratios throughout the laying period. The number of males to be removed may be calculated according to Table 9 and the mating ratio reviewed weekly. These mating ratios are only a guide and should be adjusted according to local circumstances and flock performance. It is essential that substandard and sexually inactive males be removed. A guide to recognizing sexually inactive males is given in Monitoring Male Condition (page 31).

![Diagram 11: Mature Male and Immature Male](image)

<table>
<thead>
<tr>
<th>Weeks of Age</th>
<th>Number of Males/100 Females*</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-22</td>
<td>6.0-8.5</td>
</tr>
<tr>
<td>29</td>
<td>8.5-9.0</td>
</tr>
<tr>
<td>30-end</td>
<td>8.5</td>
</tr>
</tbody>
</table>

*In open-sided houses, ratios 1% higher will be needed.

Male sexual development is more responsive to photo-stimulation than females. Examine the flock twice weekly for signs of surplus males and over-mating from 25 weeks on (frequently observed around 26–27 weeks of age). Females “hiding” from the males beneath equipment, in nest boxes or refusing to come down from the slatted area are signs of over-mating. If this occurs, accelerate removal of males, taking out 1 male/200 females until the problem is corrected.

Sample Weighing Males

After mating up, monitoring male body weight is more difficult. This is because of the difficulty in catching representative samples of males spread throughout the house. The problem can be largely overcome, if, prior to mating, 20–30% of the selected males that are within ±5% of the mean body weight are marked. Markings must be discreet (e.g. leg bands, spray marks using colored paint) so they do not attract attention from other males or interfere with mating behavior. During sample weighing, only marked males should be weighed. Ideally, 50% of the 20% marked should be weighed. Average body weight and uniformity are then calculated and compared with target body weight and records for previous weeks. Feed allocation should then be calculated accordingly.
Caution should be used when referring to body weight averages and uniformity when using automatic weighing systems in the house. Recording of male weights with such equipment is often inaccurate because of insufficient sample size. Insufficient sample sizes in this situation are due to greater reluctance of roosters to step onto the scale platform.

Regardless of the information gained by weighing, the manager must handle and evaluate male body conformation weekly to ensure males are consuming correct feed allocation. Males which are losing fleshing and/or with poor muscle tone are indicative of underfeeding. The underfeeding problem may be attributable to poor feed distribution and not the allocation per se.

**SEPARATE-SEX FEEDING**

After mating up, males and females should be fed from separate feeding systems. This allows effective control of body weight and uniformity for each sex. Separate-sex feeding takes advantage of differences in head and comb size between males and females. The technique requires skilled management and appropriate equipment that is properly adjusted and maintained.

**Female Feeding Equipment**

Irrespective of the type of feeding system utilized, feed should be dispensed such that all birds have access to feed within 3 minutes. Satellite bins (dummy hoppers) will aid in reducing feed distribution time; however, they require skilled management.

Trough type feeding systems are most common around the world. Females should have a minimum of 15 cm (6 in) of feeding space per bird. The most effective system of restricting male access involves fitting grids (also referred to as grills or toast racks), which exclude males because of their greater head width and/or comb height (see Diagram 12). Minimum internal grid width is 43–45 mm (1 3/4–1 9/16 in). Width of the grid wire can reduce feeding space by 5–10%. The objective is to allow all females free access to their feed and to restrict access by the majority of males.

Further restriction of males from the female feeders can be achieved by utilizing a 57 mm (2 1/4 in) height horizontal wire or plastic pipe in the apex of the grid and allowing the internal grid width to be increased by 2–5 mm. The use of horizontal fittings has the additional advantage of strengthening the grid. The grid width should be 45–47 mm (1 3/4–1 9/16 in). The use of undubbed males, in combination with a grid and a horizontal wire (or bar or pipe) ensures that almost 100% of the males cannot obtain feed from female feeders. There is a danger that narrow grid widths (43 mm and under; 1 3/4 in) will prevent a significant number of the females from feeding and cause reduced performance.

**Diagram 12: Separate-sex Feeding System**

Pan feeders are an alternative to trough feeders and provide good feed distribution if properly managed. When pans are used, they should be spaced so birds feeding in adjoining pans do not obstruct access. Hens require about 5 cm (2 in) less feeder space when pans are used. The control pan must cycle frequently so that the other pans do not become empty. Pan feeders must be checked frequently to make sure that all pans are receiving feed and lines remain charged.

Refer to Table 6, page 15 for specific feeder equipment space recommendations.

Using a grid can prevent male access to pan feeders or hanging hoppers. With hanging hoppers, efforts should be made to reduce movement of hoppers to a minimum.

Daily checks should be made for damage, displacement or irregularity of gaps in the female feeder grid.

Check ventilation, especially during feeding hours. Temperature in the feeding area can increase 4°C (7°F) during feeding. In hot weather, extra fans should be set to operate during this period and/or the sensors moved to monitor this area more closely.
Male Feeding Equipment

Successful separate-sex feeding is dependent upon good management of male feeding equipment and uniform feed distribution. Three types of feeders are generally used for males:

- Automatic pan-type feeders
- Hanging hoppers
- Suspended feeder track

All three types are managed similarly. Ideally, after feeding, raise feeders to deny access, add the next day’s allocation of feed, and lower again at feeding time.

Regardless of the male feed system used, keep in mind the following:

- It is essential that each male has a minimum feeding space of 18 cm (7 in) and that feed distribution is uniform.
- When using undubbed males, proper feeder adjustments should be made to allow male access.
- When manually filled hanging hoppers are used, it is important that the same feed quantity be delivered to each hopper and that hoppers are not tilted.
- Suspended feeder track has proved very successful for males, as feed can be leveled, thus ensuring each male has access to the same feed quantity.
- It is beneficial to delay male feeding until female feeders are filled.
- It is essential that feeder height be correctly adjusted to limit access by females, but allow all males equal access. Correct male feeder height is dependent on male size and feeder design (i.e., trough or pan depth). Feeder height should be in the range of 50–60 cm (20–24 in) above litter. Care should be taken to avoid buildup of litter beneath male feeders. Ensure correct feeder height by routine observation and adjustment.
- Avoid giving too much feeding space to males, as more aggressive males will over-consume and male body weight uniformity will deteriorate — leading to a decline in reproductive performance. As male numbers decline, the number of male feeders should be reduced to maintain a feeding space of 18 cm (7 in).
- Checks should be routinely made during feeding time to ensure sexes are feeding separately.

Note:
Poorly managed feeding equipment and uneven feed distribution are major causes of depressed reproductive performance.

MANAGEMENT OF FEMALES
PRE-PEAK PERIOD – PHOTO-STIMULATION
TO 30 WEEKS

Two phases require different management:

- Photo-stimulation to 5% production
- 5% production to peak egg production

Management of Females from Photo-Stimulation
To 5% Production

Objective
To stimulate and support egg production in females using feed and light.

MANAGEMENT CONSIDERATIONS

Females should be grown with a feeding program that will achieve a desired body weight profile and with the recommended lighting program until the flock has come into production (See Lighting, page 40). Regular feed increases (i.e., at least weekly) are essential for appropriate body weight gain, fleshing and timely onset of lay. Lighting programs should be implemented exactly on schedule to support and stimulate females over this period.

The spacing of the pin (pubic or pelvic) bones is measured to determine the state of sexual development of the female. For specific advice on monitoring pin bone spacing, see Pubic Bone Spread, page 9.

Note:
Problems with feed, water or disease at this stage can have devastating effects on the onset of production and on subsequent reproductive performance of the flock.
Management of Females From 5% Hen-Day Production to Peak Egg Production

Objectives
To promote and support female reproductive performance as measured by early egg size, egg quality, level of peak egg production and persistency of lay.

Overview
Females must be gaining weight during early lay to maximize egg production and hatchability. Birds supplied with more feed than required for egg production will develop an abnormal ovarian structure and gain excess weight — resulting in poor egg quality (e.g., excessive double-yolk eggs) and low hatchability. Increased mortality due to peritonitis or prolapse is symptomatic of overfeeding during this period.

Birds should be fed to meet the increased demands of egg production and growth. Ideally, it would be preferable to measure changes in egg production, body weight and condition on a daily basis and adjust feed daily. In practice, however, the number and frequency of feed increases depends on capability of the management system to observe and react in a responsive way to changing levels of egg production and other variables. The decision on how much feed is required at each stage depends on observation and measurement of:

- Body weight
- Body condition
- Feed quantity
- Feed cleanup time
- Egg mass (i.e., egg production percent x egg weight)
- Operational house temperature
- Dietary energy density
- Environmental temperature

MANAGEMENT CONSIDERATIONS

The procedure for determining the pattern of feed increase is primarily based on body weight uniformity and fleshing at 20 weeks. These characteristics will determine the amount of feed allocation for the first pre-production feed increase. If flock CV%<10, the first feed increase should be at 5% production (see Table 2 , page 8 for further details if using uniformity values). If flock CV%>10, the first feed increase should be delayed to 10% production.

Thereafter, feed increases follow actual production levels and egg size.

The maximum metabolizable energy (ME) intake at peak production is provided in the supplements. The difference in feed quantity allocated prior to first egg and that given at peak allows a feed allocation schedule to be established. Feed amounts up to and at peak can then be adjusted for each individual flock depending on body weight, growth, egg production, egg weight, ambient temperature and feed energy density. Monitoring of body weight gain, daily egg production and egg weight are vital. Uniform flocks will come into production rapidly and feed amounts must be appropriately adjusted to support birds at this stage. Small but frequent feed increases to the peak feed amount should be used to prevent excessive weight gain.

Responsive management of birds coming into production requires frequent observation of important production parameters as shown in Table 10.

Table 10: Frequency of Observation of Important Production Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight</td>
<td>At least weekly</td>
</tr>
<tr>
<td>Rate of body weight gain</td>
<td>At least weekly</td>
</tr>
<tr>
<td>Uniformity</td>
<td>At least weekly</td>
</tr>
<tr>
<td>Egg production</td>
<td>Daily</td>
</tr>
<tr>
<td>Increase in egg production</td>
<td>Daily</td>
</tr>
<tr>
<td>Egg weight</td>
<td>Daily</td>
</tr>
<tr>
<td>Change in egg weight</td>
<td>Daily</td>
</tr>
<tr>
<td>Feed cleanup time</td>
<td>Daily</td>
</tr>
<tr>
<td>Bird condition (fleshing, color)</td>
<td>At least weekly</td>
</tr>
<tr>
<td>House temperature (min. and max.)</td>
<td>Daily</td>
</tr>
</tbody>
</table>

Weekly and trend body weight and egg weight data are used in combination to determine feed increases. For example, if egg weight and/or body weight are/is judged to be deviating significantly from the expected profiles, feed increases should be delayed or advanced as appropriate. Feed increases beyond recommended peak feed amounts will be required in
high-producing flocks (i.e., flocks exceeding performance objectives supplements).

Environmental temperature is a major factor influencing energy requirement of the bird. For further information, see Nutrition, page 52.

Management requirements vary for each flock depending on their condition, performance and environment. The most appropriate program should be determined by using the principles described above, and should take into consideration available equipment and facilities.

The following example shows how a feeding program might be devised for a particular flock progressing in egg production — taking into account flock history, environmental temperature, feed energy density and management constraints.

**Table 11: Example of a Feeding Program as Females Progress in Egg Production**

<table>
<thead>
<tr>
<th>Hen Day %</th>
<th>Feed Increase</th>
<th>Feed Amount (g/day/Bird)</th>
<th>Daily Energy Intake (kcal/day/Bird)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to Production</td>
<td>Feed to Body Weight</td>
<td>121*</td>
<td>347*</td>
</tr>
<tr>
<td>5</td>
<td>2.0</td>
<td>123.0</td>
<td>352</td>
</tr>
<tr>
<td>10</td>
<td>2.0</td>
<td>125.0</td>
<td>358</td>
</tr>
<tr>
<td>15</td>
<td>2.0</td>
<td>127.0</td>
<td>364</td>
</tr>
<tr>
<td>20</td>
<td>2.5</td>
<td>129.5</td>
<td>371</td>
</tr>
<tr>
<td>25</td>
<td>2.5</td>
<td>132.0</td>
<td>378</td>
</tr>
<tr>
<td>30</td>
<td>2.5</td>
<td>134.5</td>
<td>385</td>
</tr>
<tr>
<td>35</td>
<td>2.5</td>
<td>137.0</td>
<td>393</td>
</tr>
<tr>
<td>40</td>
<td>3.0</td>
<td>140.0</td>
<td>401</td>
</tr>
<tr>
<td>45</td>
<td>3.0</td>
<td>143.0</td>
<td>410</td>
</tr>
<tr>
<td>50</td>
<td>3.0</td>
<td>146.0</td>
<td>418</td>
</tr>
<tr>
<td>55</td>
<td>3.0</td>
<td>149.0</td>
<td>427</td>
</tr>
<tr>
<td>60</td>
<td>4.0</td>
<td>153.0</td>
<td>438</td>
</tr>
<tr>
<td>65</td>
<td>5.0</td>
<td>158.0</td>
<td>453</td>
</tr>
<tr>
<td>70-75</td>
<td>5.0</td>
<td>163.0</td>
<td>467</td>
</tr>
</tbody>
</table>

*Flocks can consume 115–135 g of feed per female prior to 5% hen day production. Feeding program should be adjusted accordingly.

- First feed increased for production should be at 5% production.
- Feed amounts up to and at peak will vary depending on egg production, egg weight, body weight, condition, uniformity, eating-up time and ambient temperature.
- Uniform flocks will come into production rapidly and feed amounts should be adjusted accordingly.
- Flocks peaking at levels beyond the performance objectives will require further feed increase above 70–75% production.
- If the feed energy density used differs from that of the example, feed intake must be adjusted proportionally to achieve the same caloric intake.
Key Points for Bringing Females into Production

- Grow females with a feeding program and monitor body weight to make sure feed is achieving desired results.
- Stimulate egg production from 5% hen-day production by giving programmed feed and light increases.
- Define the program of feed increases based on production increases, feed amount prior to production, energy level, ambient temperature and expected maximum feed amount.
- Use small but frequent feed increases. Ovarian response is more orderly if feed is given in gradually increased amounts.
- Monitor average body weight, uniformity and body weight gain at least weekly.
- Weigh eggs and record weights daily from no later than 10% hen-day production.
- Respond to inadequate or excessive gains in egg weight, production and/or body weight by advancing or delaying feed increases.
- Respond to changes in feed cleanup time.

Feed Consumption Trends

Feed consumption time (feed cleanup time) is simply the time required for the flock to eat its daily feed allotment. The time begins when feeder starts to operate. The time ends when there is only dust left in the feeder.

Feed cleanup time is a good management tool to confirm the flock is getting adequate energy. Many factors affect feed cleanup time including: age, temperature, feed amount, physical feed characteristics, feed nutrient density and quality. When the amount of feed being offered is excessive, birds will take longer to consume it. Conversely, if there is not enough feed, birds will consume it more quickly.

Egg Weight and Feed Control

Objective

To use egg weight to determine whether nutritional input is adequate for achievement of optimum egg production.

Overview

Daily egg weight trend acts as a sensitive indicator of adequacy of total nutrient intake. Feed intake is adjusted according to deviations from the expected egg weight profile.

PROCEDURES

A sample of 120–150 eggs should be weighed in bulk. These must be taken from eggs collected directly from the nest at the time of the second collection. Double-yolked, very small and abnormal eggs (e.g. soft shelled) are rejected. Average egg weight is obtained by dividing the bulk weight by the number of eggs weighed. The daily weight is then plotted against the standard profile. It is important that the graph scale be large enough to make daily variation clearly observable.

In flocks receiving the correct quantity of feed, egg weight will normally increase parallel to the standard egg weight profile. Egg weight at a given age is dependent on body weight and sexual maturity and can be above, below or on standard. If the flock is being underfed, egg size will not increase over a 4–5 day period as it should. This is corrected by bringing forward the next planned feed increase. If anticipated peak feed quantity has been reached, then feed should be increased by 5 g/bird/day (1.1 lb/100 birds/day).

Average daily egg weight will fluctuate on a daily basis due to sampling variation and environmental influences. The effect of fluctuation in egg weight is minimized if the midpoints between consecutive daily weights are joined on the graph to produce both the trend and projected profiles (see Diagram 13, page 29).
MANAGEMENT OF MALES FROM PHOTO-STIMULATION TO 30 WEEKS

Objective
To manage male body weight and the male-to-female ratio to maximize fertility.

Overview
Target body weight-for-age is achieved by monitoring male body weight and adjusting feed quantity. Control of male body weight over this period can be difficult as males become progressively excluded from the female feeders as their head width increases.

The development and establishment of successful mating requires removal of surplus males by observation of flock behavior and condition of females.

Male Feeding
After mating up, the achievement of production objectives for males and females is more likely if separate-sex feeding equipment and techniques are employed. Males are more likely to be excluded from the female feeders if they are left undubbed (i.e., comb intact).

Average body weight and body weight gains should be monitored weekly and the amount of feed placed in the male feeder regulated, so as to achieve the required male growth rate. Daily feed allowance can vary considerably, e.g., 100–160 g feed/male/day (22–35 lb/100 males/day), depending upon the amount of feed being taken from the feeders by either sex.

Males require a minimum of 18 cm (7 in) of feeding space per bird and feeding points should be spread evenly in a line throughout the length of the house. As the flock ages, male numbers will decline and the number of male feeders should be reduced over the life of the flock to maintain proper feeding space. See the supplements for specific nutrient recommendations.

Key Points for Egg Weight and Feed Control
• Adjust feed intake based on deviations from target egg weight profile.
• Weigh bulk samples of eggs and record daily from no later than 10% hen-day production.
• Monitor trends in daily egg weight by plotting on a large-scale graph.
• Respond promptly to falling trends in daily egg weight by increasing feed allowance.

Diagram 13: Daily Egg Weights

Note:
Responding to egg weight shortfall beyond 75% hen-day production is not recommended, since it is likely that excessive body weight gain would occur.
Note:

Poor male exclusion from female feeders, and vice-versa, reduces the precision of feed allocation to males and females. Problems will be encountered if the following are inappropriate:

- Grid width and height
- Precision of grid installation
- Corner and satellite bin security
- Feeder height
- Feeding equipment condition

Feeders exclusion entails mutual exclusion of each sex from the other’s feeder and eliminating all opportunities for stealing feed from the feeding systems. This requires ongoing attention and should be checked twice weekly. Close observation of the flock must be made from the point at which males become excluded from the females’ feeders. Typically, this will be at 27–32 weeks of age for dubbed and 22–24 weeks of age for undubbed males. At this time, a feed increase will be required to maintain growth. The size of this increase will vary from flock to flock, but an initial increase of 5–10 g feed/male/day (1.1–2.2 lb/100 males/day) followed by a mid-week sample weighing to monitor progress is recommended. It is very important that neither males nor females experience a reduction in nutrient availability in this pre-peak period.

Failure to detect when the males are excluded from the females’ feeders is a common cause of male body weight shortfall and has serious implications for fertility. Proper male growth and maintenance cannot be achieved with inadequate nutrient intake (see supplements). Care should be taken to adjust male feed amounts once all males have become excluded from the female feeder. Monitoring this situation properly requires routine weighing of males using proper sample procedure — including making a distinction in body weights measured for original versus spike males (if spiking is practiced).

Males stealing female feed, particularly when the flock is between 50% hen-day egg production and peak, may significantly reduce peak performance levels. Flock managers must be aware of factors which indicate when a shortfall in female body weight is occurring (e.g. change in daily egg weight or bird condition).

Males and females are encouraged to use their own feeders if males are fed later than females. This is best achieved by lowering male feeders after distributing female feed.

Note:

Feed distribution and equipment problems, which can seriously depress egg and semen production, may be remedied more quickly if flock attendants are present at feeding time. Feeding behavior should be observed on a regular basis.

Over-mating

A surplus of males leads to over-mating, interrupted mating and abnormal behavior — increasing the risk of female mortality due to male aggression. Where over-mating occurs, flocks will exhibit reduced fertility, hatchability and egg numbers.

In the early stages after mating-up, it is quite normal to observe some displacement and wear of the feathers at the back of the female’s head and of the feathers on the back at the base of the tail. When this condition progresses to the removal of feathers, this is a sign of over-mating. If the mating ratio is not reduced, the condition will worsen with de-feathering of areas of the back, scratching and tearing of the skin. This leads to welfare problems, loss of female condition, increased female mortality and reduced egg production. A surplus of males is also indicated when they show excessive injuries and feather damage from fighting.

When surplus males are present, competition for females prevents the maintenance of the optimum number of matings. Surplus males must be removed quickly or a significant loss in persistency of male fertility will result. The flock should be examined twice weekly for signs of over-mating from 27 weeks. When over-mating is observed, the removal of males should be accelerated, initially taking out an additional 1 male/200 females. After 29 weeks of age, a typical target ratio is 8.5–9.0 males/100 females.

Note:

Monitor male to female ratio carefully and appropriately adjust the number of males in the flock to prevent over-mating.
Monitoring Male Condition

Male numbers will be reduced throughout the life of the flock as non-working and substandard males are removed. It is good practice to monitor male condition weekly. As males are dispersed within the flock, they are more difficult to manage than females. Good routines are essential in order to recognize changes in the condition of the males. Characteristics requiring close attention are:

- Underfeeding: This is most common from 35 weeks onwards, but can occur earlier. Males will suddenly appear dull and listless, showing reduced activity and less frequent crowing. If these symptoms are missed and the condition progresses, the comb and wattles become flaccid and there is a loss of muscle tone. Later, there will be a loss of fleshing, loss of face color (e.g. purplish appearance instead of red) and molting. In addition, vent color will become less red. This last stage is serious and a significant number of birds will not recover. On observing any combination of these symptoms, feed allowance should be increased by 3–5 g/bird/day (0.7–1.1 lb/100 males/day) immediately. Cleanup time, feeding space per bird and feeder security should be checked. The accuracy of weekly average weight gain data must be verified and a sample reweighed if in doubt. Prompt action is essential (see Sample Weighing, page 23 and Monitoring Body Conformation, page 8).

- Overweight Males: If body weight control is poor, a sub-population of heavy males with excessive breast development may occur. These males will experience more stress on their leg joints and footpads, cause excess damage to the females during mating and will have a high frequency of incomplete matings. Often females will begin to avoid mating if a considerable percentage of males are overweight. In addition, the overweight male requires more nutrition for body maintenance. If nutrition becomes marginal, overweight males will be among the first to undergo testicular regression with the attendant reductions in mating activity and fertility. Overweight males should be removed. Overfeeding is expensive and non-productive.

- Alertness and Activity: The flock should be observed at various times of the day to monitor mating activity, feeding, resting location, daytime distribution and distribution immediately prior to lights out. In addition, general behavior and posture should be noted. The majority of males should be evenly distributed over the litter (scratch) area for most of the light period and should not be on the slats or hiding under equipment. If mating activity is low, the reason for this should be determined to improve mating activity in subsequent flocks.

- Physical Condition: Face, comb and wattle color, comb and wattle condition (e.g. firm or flaccid) are important indications of physical condition. Assessment of muscle tone, fleshing and keel bone prominence should be made and a careful watch kept for deterioration of males. Condition of legs, joints and feet should be checked. Wet litter and poor slat condition causes the skin on the bottom of the feet to crack, leading to the risk of infection and discomfort that will reduce welfare and mating activity.

- Feathering: Observation of feather condition can give an indication of mating activity. Feathers particularly around the tail will be worn on males with a high mating frequency. Partial feather loss and neck molt are general indicators of poor male health and physical condition.

- Cleanup Time: Individual male behavior and variation must be observed and recorded. It is important that any changes within the flock are verified and acted upon.

- Vent Color: Intensity of redness of the vent is a useful management aid in the assessment of male activity within the flock. Males working at optimum rates will demonstrate a very red vent color. The objective is to promote and maintain this condition in all working males throughout the life of the flock. Whenever overmating is observed, males with poor vent color should be removed.
Key Points for Managing Males in Production

- Grow males to the target body weights and promote flock uniformity.
- Use separate-sex feeding with adequate, well-maintained equipment.
- Monitor average body weight and body weight gain at least weekly, and twice weekly from mating-up until the males are excluded from the females’ feeders.
- Feed into the male feeder whatever is required to achieve the target body weight gain. Any shortfall in male body weight has serious implications for fertility.
- Monitor females for signs of over-mating from 27 weeks of age.
- Whenever over-mating occurs, reduce male numbers by 1 male/200 females and readjust future mating ratios.
- Follow a weekly routine of assessment of the flock and individual males. Maintain optimum-mating ratio by removing individual males based on their condition.
- Observe and monitor alertness and activity, physical condition, feathering, cleanup time and vent color.
- Remove excessively overweight males when mating damage is occurring.

Management of Females After Peak Production

Objective
To maximize the number of fertile hatching eggs per hen.

Female Weight Control

To remain healthy and vigorous beyond 30 weeks, females must gain body weight close to an average rate in accordance with the appropriate body weight standard. If body weight gain is inadequate, total egg production will be lower as some hens will not receive adequate nutrients. If body weight gain increases too rapidly, late stage production and fertility will be lower than desired.

Failure to control body weight and fat deposition post-peak can significantly reduce persistency of lay, shell quality and female fertility and it can increase egg size after 40 weeks of age.

Female broiler breeders usually attain physical maturity and cease to grow in frame size at or prior to peak egg production. At this time, the female will continue to gain weight; however, it is due to increase in muscle mass and fat deposition only. Limiting the rate of fat accumulation, through adjustments in feed consumption, is key to maximizing egg production, post-peak egg quality and hatchability.

Shortly after peak production, maximum nutrient requirements for egg production occur. This is because egg mass continues to increase after there has been some reduction in rate of lay. Egg mass is the product of percent hen-day egg production and average egg weight (i.e., egg mass + average egg weight % hen-day egg production).

Many factors are involved in determining the exact timing of the initial feed reduction. Timing and amount of feed reduction will depend on:

- Body weight change from start of production
- Daily egg production and trend
- Daily egg weight and egg weight trend
- Flock health status
- Ambient temperature
- Feed composition and quality
- Quantity of feed (energy intake) at peak
- Flock history (rearing and pre-peak performance)
- Feed cleanup time changes*

*Feed cleanup time is defined as the consumption time elapsed from turning feeder system on until only dust remains in the trough or pan. Cleanup time is affected by feed texture. Peak egg production feed time should ideally be 4–5 hours for mash, 3–4 hours for crumbles and 2–3 hours for pellets.

After a feed reduction, if production decreases more than anticipated, restore the feeding amount to the previous level and attempt to reduce the feed level again in 5–7 days.

General Guidelines for Post-peak Feed Reduction

Under moderate temperature conditions, the following scenarios illustrate general guidelines for reducing female feed.
Scenario 1 — peak of ≤79%.
When weekly egg production trends down:
1. Reduce feed intake by 12 kcal ME/bird/day.
2. Wait 1 week, then reduce another 12 kcal ME/bird/day.
3. Wait 1 week, then begin reducing 1–3 kcal ME/bird/day every week until daily intake is ≥10% lower than peak amount.
4. If a feed intake reduction is made and egg production decreases more than anticipated, restore the previous feed allocation and attempt to reduce feed intake again in 5–7 days.
5. Make sure proper feed allotment changes are made to accommodate changes in environmental temperature.
6. Monitoring feed cleanup time will assist in determining proper feed allocation.

Scenario 2 — peak of 80–83%.
When weekly egg production trends down:
1. Reduce feed intake by 16 kcal ME/bird/day.
2. Wait 1 week, then reduce another 6 kcal ME/bird/day.
3. Follow steps 3 to 6 as in Scenario 1.

Scenario 3 — peak of ≥84%.
High-producing flocks like this one tend to be underweight and excessive feed reduction will hurt potential egg output and cause broodiness and molting.
1. Monitor feed cleanup times closely and adjust feed allotments as necessary.
2. Remain on your peak feed amount until egg production declines to 83%, then reduce feed intake by 2.5 kcal ME/bird/day on a weekly basis until daily intake is ≈10% lower than peak amount.

Flocks peaking during hot weather should have feed reduced strongly and rapidly. However, feed increases will be required as ambient temperature decreases. A flock peaking during decreasing temperatures will not need a feed reduction immediately post-peak production. A more rapid feed reduction will be required when ambient temperatures begin to rise. Again, monitor feed cleanup time to stay on top of these varying situations — you cannot escape routine monitoring if you want to produce exceptional results.

FACTORS TO CONSIDER WHEN ADJUSTING FEED ALLOCATIONS:

• Total feed reduction for the life of the flock will generally be in the range of 8–12% (average of ≈10%) of the peak feed amount per hen.
• Make feed change decisions based on changes in body weight, environmental temperature, feed cleanup time and female body condition.
• When evaluating feed reductions, always monitor feed cleanup time before and after a new batch of feed is delivered. If the feed cleanup time does not change, the females have enough feed. If the feed amount is reduced and feed cleanup time drops as well, wait 2 weeks before making another feed reduction.
• If egg production drops abnormally, restore feed allocation to the previous amount. If egg production does not return, it is unlikely the feed reduction caused the lowered egg production.
• If egg production is not reaching normal levels, feed should not be increased beyond the typical peak feed amount unless female body condition indicates a feed shortage is the problem. If body weights are increasing normally, additional feed will hurt rather than help production.

Key Points for Controlling Female Body Weight

Reduce feed allocations beginning shortly after peak weekly production has been achieved depending on:
• Rate of lay
• Female body condition
• Body weight relative to target
• Feed quantity
• Environmental temperature
• Feed consumption time
• Egg size relative to target

Make feeding decisions weekly, or more often, in response to observations of the factors listed above.

Monitor female fleshing on a regular basis to maintain optimum flock performance.
**MANAGEMENT OF MALES AFTER PEAK PRODUCTION**

**Objective**
To maximize hatching egg fertility through control of male feeding and body condition.

**Male Weight Control**

Management principles and procedures for males in the post-peak period are similar to those used in the pre-peak period. Adjusting feed quantity to achieve a gradual but constant increase in weight as the male ages controls body weight and body condition.

Males should be weighed frequently to ensure this is achieved. Each male weighed should be evaluated to determine if it is maintaining ideal body condition for breeding. Changes in flock feed quantities should be made based on the sample evaluated. A sample size that is too small can mislead the flock manager.

After 30 weeks of age, male weekly body weight gain should be approximately 15 g/week (0.03 lb), when averaged over a 3-week period. Body weight data should be used with other husbandry information to make feed allocation decisions. Male feed amounts can vary greatly depending on feeder exclusion. Assuming no feed stealing, post-peak male feed allowance is normally in the range of 350–440 kcal ME/bird/day — depending on feed energy density, environmental temperature and age. Male feed allocations should continue to increase throughout his life. From 40 weeks of age, males generally require one small feed increase every 2 weeks to achieve average body weight gain of 15–20 g per week.

Litter condition and slat construction have a major effect on male footpad health and, ultimately, on his ability to mate. If litter becomes wet, compacted, or nonexistent, additional litter must be added to give males and females a comfortable area to walk and mate. When male or female footpads become swollen and painful, reduced mating and lower fertility will occur.

**Spiking Programs**

With proper male management, males initially housed with the hens should be sufficient to maintain good life-of-flock fertility. However, to assist in maintaining optimum-mating ratios, flocks can be “spiked” with younger males during the post-peak period. If this is done, it is imperative to:

- Conduct lab analysis and clinical examinations on spiking males to ensure no pathogens are introduced into the flock.
- Make sure spiking males are mature enough to avoid being dominated by older hens and males. Don’t spike males that are ≤3.85 kg (8.5 lb).
- Place spiking males as a group in the center of the house only after lights are out and the house is dark.
- Observe to make sure spiking males find feed and water. Pen slow learners with ready access to feed and water.
- Weigh spiking males (marked with colored leg bands or paint on wings) separately from older males so actual body weight trends can be monitored.

Another option commonly used is to “intra-spike” — moving proportion of the males between houses or within large houses. Moving 25–30% of 10% is the usual procedure. The “intra-spiking” procedure removes the risk of introduction of new pathogens.
Section 3

Environmental Requirements

**Housing and Environment**
- Site Layout and House Design
- Controlled Environment Housing
- Open-sided Housing

**Ventilation**
- Negative Pressure Ventilation
- Tunnel Ventilation
- Natural Ventilation

**Equipment and Facilities**
- Perches
- Feeding Space
- Separate-sex Feeding Equipment
- Drinking Space and Availability of Water
- Egg Handling and Storage
- Emergency Equipment

**Lighting**
- Controlled Environment/Blackout Rearing – Controlled Environment Laying
- Controlled Environment/Blackout Rearing – Open House Laying
- Open House Rearing – Open House Laying
- Artificial Lights and Light Intensity
- Seasonal Variations
Housing and Environment

Objectives

To provide a protected environment in which temperature, humidity, day length and light intensity can be controlled for the lifetime of the flock.

To ensure that the control is at levels that are optimum for good reproductive performance and do not compromise health and welfare. Birds must be allowed individual access to feed and water.

Overview

Broiler hatching eggs are produced commercially in a range of climates throughout the world. Climate and economics dictate the type of housing system (e.g., open-sided, controlled environment) chosen for the parent stock. The technical specification of the housing system must be defined so that the birds are maintained under appropriate and, where possible, optimal environmental conditions. These specifications should take into account bird welfare, performance targets, materials available and financial constraints. Other important factors to consider are the ease and effectiveness of environmental control and house maintenance.

Site Layout and House Design

The site layout and house design should be planned with biosecurity of vehicle and staff access in mind. Facilities must be provided for staff accommodation, changing of clothing and, where possible, a showering option. (see Biosecurity, page 64).

House design should also include consideration of:

Climate: Extremes of temperature and humidity may dictate which type of housing is most suitable (i.e., open or closed) and the degree of environmental control required.

Local Planning Regulations and Laws: These may stipulate important constraints in design (e.g., height, color, materials, etc.) and should be consulted at the earliest opportunity.

Biosecurity: The size, relative situation and design of houses should be such as to minimize the transmission of pathogens between and within flocks. A policy of one-age, one-site should be adopted.

Number of Birds Required: The number of hatching eggs required per week determines the number of parent stock to be housed. The number and size of houses is influenced by stocking density, feeding and drinking space and capacity of ventilation/cooling systems.

Management Preference: Flock management is more successful when controlled environment or black-out housing is used throughout the production cycle but, at a minimum, during the rearing period. The type of housing used during the laying period is dependent on climate and latitude.

Local Topography and Prevailing Winds: These natural features have particular importance for open-sided housing. They can be exploited to minimize entry of direct sunlight and for optimal ventilation or cooling. The existence of sites nearby, which present an airborne disease risk, must also be taken into account.

Power Availability and Costs: Controlled environment housing requires a reliable source of power to operate electrical ventilation, heating, lighting and feeding equipment.

Floors: Concrete floors with a smooth, hard finish are essential for ease of cleaning and effective disinfection. An area of concrete or gravel extending to a width of 1–3 m (3–10 ft) around the house will inhibit entry of rodents (see Biosecurity, page 65).

Drainage: Appropriate disposal of rainwater and cleanout water aids biosecurity.

Water: A clean, fresh supply of water is required (see Water Quality, page 69).

Access: Suitable access must be provided for bird, feed and egg transporters.
Controlled Environment Housing

Controlled environment housing has advantages over open-sided housing, especially during rearing, since it limits variation due to environmental influences, facilitates control of sexual maturity and body weight, and assists in the production of uniform flocks.

Controlled environment house design should include the following considerations:

Flock Size: The flock size selected must be manageable so that all the daily feed allowance can be distributed evenly and be accessible to all birds within a maximum of 3 minutes.

Lighting: Light should be evenly distributed throughout the house. Light intensity should be controllable, especially in the rearing period (see Lighting, page 40).

Light Control: Light intensity must not exceed 0.4 lux (0.04 fc) in a darkened house (see Lighting, page 40). Accurate measurements of light intensity require the use of a light meter.

House Temperature: Ambient temperature will be influenced by level of insulation, wind-proofing, ventilation capacity and the presence of supplementary heating or cooling. Daily temperature fluctuations should be kept to a minimum so temperature is in the range of 18–22°C (64–72°F) after birds are 3 weeks old.

Insulation: Adequate insulation must be in place to prevent house temperature fluctuations.

Wind Exclusion: Wind exclusion and light control are both achieved by the same design features.

Heating Equipment: Closed houses will require supplementary heating to maintain house temperature in the desired range and to achieve correct brooding temperature (see Table 4, page 13). A partial list of available heating equipment types includes spot brooders, water/oil ‘central heating,’ whole house/space heater or combinations thereof. Actual equipment specifications will depend on local climate and house design.

Table 12: Evaporative Cooling Systems in Common Use

<table>
<thead>
<tr>
<th>Cooling System</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-pressure fogging</td>
<td>100–200psi (7–14 bar), droplet sizes &gt;30 microns may cause wet litter at high humidities.</td>
</tr>
<tr>
<td>High-pressure fogging</td>
<td>400–600psi (28–41 bar), droplet sizes of 10–15 microns minimal residual moisture giving extended humidity range.</td>
</tr>
<tr>
<td>Cooling pads</td>
<td>Air is drawn through a water-soaked filter by tunnel ventilation.</td>
</tr>
</tbody>
</table>

Diagram 14: High Pressure Fogging

Diagram 15: Pad Cooling in Controlled Environment Housing
Open-sided Housing

Where open-sided housing is used, particular attention must be paid to the lighting program (see Lighting, page 40). A combination of controlled environment rearing and open-sided laying facilities allows more control than open-sided housing from day-old to depletion.

Open-sided houses rely on the free-flow of air through the house for ventilation. Houses should be constructed to a specified width, i.e., 9–12 m (30–40 ft), and a minimum height to the eaves of 2.5 m (8 ft), to ensure adequate air flow.

While more difficult to manage, under many practical conditions, natural ventilation through open-sided houses will provide birds with an appropriate environment. This is not the case, however, in temperature extremes. Air flow is controlled by varying curtain height. Circulation fans can be used to supplement natural ventilation and enhance temperature control within the house. Translucent curtain materials allow the use of natural light during daylight hours. Black curtains are used in situations where it is necessary to exclude daylight (e.g. to provide blackout conditions during rearing).

VENTILATION

Objectives
To properly ventilate poultry houses for optimal performance by:
- Removing excess heat and moisture
- Providing oxygen while removing harmful gases
- Reducing dust and improving air quality
- Providing the ability to grow birds in a light controlled environment

Overview
The ventilation system must be capable of supplying adequate fresh air and removing gaseous and airborne byproducts. It also contributes to temperature and humidity control, especially in warm conditions, and should provide an environment that is uniform at bird level, and draft free. Ventilation requirement depends on the metabolic rate of the bird, which is determined by body weight, egg production and growth rate. Where there are problems with ammonia levels (from poor litter condition), the ventilation rate will have to be increased.

Negative Pressure Ventilation

Negative pressure ventilation utilizes electric fans to blow air out of the house, thereby creating negative pressure within the house. Type, size and spacing of air inlets are very important.

Negative pressure ventilation systems are used to satisfy minimum ventilation requirements during cold weather. These systems normally have fans positioned on one side or end of the building. Fans are controlled primarily by time clocks with thermostatic overrides. Modern house controllers will help maintain a more consistent environment than time clocks and thermostats. A minimal quantity of air is exchanged to remove moisture, CO₂, dust and ammonia while introducing clean air with higher oxygen levels.

In cold climates, proper environmental conditions can be achieved by using brooder stoves or space heaters in conjunction with a negative pressure ventilation system.

The negative pressure ventilation system should provide an air exchange rate of 0.011–0.017 m³/min (0.4–0.6 cubic feet per minute [cfm]) of air per kg of body weight (0.2–0.3 cfm/lb). This rate of air exchange can be provided by using one 10,000 cfm fan per 460 m² (5,000 ft²) of building space controlled by a 5–10 minute cycle timer with emergency thermostatic controls. Maintaining a static pressure of 0.13–0.25 cm (0.05–0.10 in) will cause the air to enter the building at a speed that facilitates good air mixing.

When using a negative pressure ventilation system, air enters the building through air intake vents located around the house perimeter on the top of the sidewalls. The proper static pressure is achieved by matching the amount of air openings (vents) with fan capacity. One 1 m (36-inch) fan requires a total 1.4–1.9 m² (15–20 ft²) of air inlet space.

Tunnel Ventilation

Tunnel ventilation is used during hot weather. A tunnel ventilation system uses air inlets on one end of the house combined with fans on the opposite end. Air travels the length of the house, removing heat and contaminants, and cooling the birds by a ‘wind chill’ effect.
The objective of a tunnel ventilated house is to maintain a temperature of less than 30°C (85°F) and move air across the birds at a rate of 122 m/min (400 ft/min). This air movement alone will provide a wind chill effect on the bird of approximately 5–7°C (10–12°F).

During hot, dry weather, evaporating water using foggers or pad cooling systems in conjunction with a tunnel ventilation system can help keep birds comfortable.

The number of fans required to obtain a desired air velocity can be calculated by using the cross sectional area of the house multiplied by the air velocity divided by fan speed.

One of the most important and most commonly overlooked issues with any ventilation system is maintenance. Not performing routine basic tasks such as checking fan speeds, cleaning air inlets and monitoring water supply to cooling pads can substantially reduce ventilation efficiency. This will cause a reduction in bird performance.

In all cases, flock management must include monitoring bird activity and behavior. Birds will clearly indicate whether they are too cold or too hot. When such problems are observed, the environment should be modified accordingly.

**Natural Ventilation**

When the outside temperature is 5°C (9°F) lower than the desired temperature, it is possible to naturally ventilate the house by opening sidewall curtains.

It is important that the poultry house be positioned so the long axis is east/west in orientation to minimize solar heat effects. Curtains should be fastened to the sidewall at the bottom and opened from the top. This will minimize wind or drafts blowing directly on birds. Every effort should be made to open curtains on both sides of the building to provide cross ventilation. If there is light wind or the wind is changing directions, curtains on each side of the building should be opened the same amount. If wind is coming consistently from one side of the building, that curtain should be opened less than the downwind side to minimize drafts on birds.

Several steps can be taken to minimize impact of hot weather:

- Reduce flock density.
- Insulate or cool the roof to prevent radiant solar heat from reaching birds.
- Increase the number and size of circulating fans — a fan will circulate air over an area three times its diameter wide and 10 times its diameter long.
- Strategically position fans to move hot air out of the house and to provide air movement to birds.
- Use a tunnel ventilation system with evaporative cooling.

**EQUIPMENT AND FACILITIES**

Operation of an efficient parent operation requires careful attention to equipment and facilities.

**Perches:** It is good management practice to install perches during the rearing period in order to train and stimulate females in nesting behavior. Sufficient numbers of perches to provide 3 cm/bird (1 1/4 in), sufficient for 20% of the birds to roost, should be placed in the females’ rearing pens from 4–6 weeks of age.

**Feeding Space:** Proper nutritional management depends on feeder space and feed distribution time. Feeding space per bird is determined by bird size and will increase as the bird ages (see Table 6, page 15). Good feed distribution will allow all birds to have access to feed within 3 minutes.

**Separate-sex Feeding Equipment:** Details of separate-sex feeding equipment are provided in Separate-sex Feeding, page 24.

**Drinking Space and Availability of Water:** Drinker requirements are influenced by ambient temperatures. In very high temperatures extra drinking space may be required. A reserve supply of water is recommended in case of emergency. General recommendations for drinking space are given in Feeding and Drinking Space, page 15.

**Egg Handling and Storage:** Information about nests, mechanical egg collection, storage and handling is provided in Care of Hatching Eggs (page 57).
Emergency Equipment: In planning a production unit, alarm systems to warn of equipment failures should be included. Alarms should warn of power failure and temperature extremes. Backup systems should be available where feasible (e.g. standby generators). Substantial commercial losses and welfare issues can develop where appropriate backup is not provided.

LIGHTING

Objective
To achieve good uniformity in sexual maturity and optimal reproductive performance by proper photo-stimulation (day length and light intensity).

Overview
Achieving optimal reproductive performance in Arbor Acres’ parent stock depends on successfully managing photo-stimulation:

- Day length and light intensity play key roles in developing the reproductive system.
- The differences in day length and light intensity between the rearing and laying environments control and stimulate ovarian and testicular development.
- Responses to increases in day length and light intensity are dependent on age, body weight, good flock uniformity and appropriate cumulative nutrition.
- Breeder females differ in their sensitivity to lighting programs. Ask your Arbor Acres representative about the characteristics for the particular strain you are using.
- Inappropriate lighting programs will result in over- or under-stimulation of flocks.

There are three common combinations of lighting environments throughout the world due to differing facility types in the rearing and production periods:

- Controlled environment/Blackout rearing – Controlled environment laying
- Controlled environment/Blackout rearing – Openhouse laying
- Open house rearing – Open house laying

Controlled Environment/Blackout Rearing – Controlled Environment Laying

Both rearing and laying houses should be light-proofed. All light will be from an artificial source. Satisfactory results from these systems depend on the degree of light control. Care should be taken to avoid light leakage through air inlets, fan housings, doorframes, etc. In practical terms, this means achieving a light intensity of <0.4 lux (0.04 foot candles) during the dark period. Regular checks should be made to verify light proofing effectiveness.

Note:
Birds are very sensitive to day length. Any light leakage should be corrected immediately to maintain control of day length.

Birds should be on a constant day length of 8–9 hours prior to 10 weeks and preferably by 3 weeks of age. Light intensity should be in the range 10–20 lux (0.9–1.8 foot candles), but can be reduced further if bird welfare is compromised because of pecking and cannibalism. Day length should not be increased during the remainder of the rearing period.

Age at the first pre-lay light increase depends on flock uniformity around 21 weeks. Uneven flocks require later and more gradual light stimulation to avoid over-stimulation of lightweight birds. This will help avoid problems such as broodiness and prolapse. Recommended light increases are given in Table 13, page 41.

Males reared to the Arbor Acres’ body weight profile and lighting program will not require increases in day length or intensity ahead of females. Achieving target body weight profile with good uniformity will ensure sexual maturity synchronization (see Management into Lay, Section 2, page 21–34).

LIGHT INTENSITY

It is vital that light intensity and day length are increased together. It is the combination of increasing day length and light intensity that stimulates sexual maturity and subsequent laying performance. Target light intensity in the laying house should be 60 lux (6 fc) at bird height but a range of 30–60 lux (3–6 fc) within the house is acceptable. Egg numbers and male activity may be improved by increasing laying house light intensity to 100–150 lux (10–15 fc).
Key Points

- Maximize response to increases in day length and light intensity by achieving the correct cumulative nutrition, proper body weights and good flock uniformity.
- Problems such as broodiness and prolapse may result from over-stimulation of uneven flocks.
- Ensure that houses are light-proofed to an intensity of less than 0.4 lux (0.04 foot candles) during dark periods.

Controlled Environment/Blackout Rearing – Open House Laying

Controlled environment housing during rearing permits greater control over day length and resolves production problems associated with out-of-season flocks, (i.e., delay in egg production, high female body weight and poor uniformity, high feed consumption). When blackout systems are used for in-season flocks, care should be taken to avoid over-stimulation when birds are transferred to open laying houses.

The frequency of abnormal eggs, prolapse, broodiness, egg peritonitis, etc., can be limited by:

- Following the lighting programs shown in Table 14 (page 42)
- Ensuring birds accumulate sufficient nutrition
- Achieving body weight targets with good uniformity

Ensure males and females are synchronized in terms of sexual maturity by rearing them on the same lighting program.

Birds should be on constant day length by 70 days and preferably by 21 days of age and reared on 10–20 lux (1–2 fc). Constant day length should be 8–9 hours until the flock is photo-stimulated in the open-sided laying house. In latitudes where problems associated with over-stimulation (i.e., prolapse, broodiness or high pre-peak mortality) persist, it may be necessary to rear on a constant day length of 10 hours.

**Table 13: Lighting Program for Controlled Environment/Blackout Rearing – Controlled Environment Laying**

<table>
<thead>
<tr>
<th>Age</th>
<th>Hours of Light</th>
<th>Light Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>80–100 lux (8–10 fc) in brooding area; 10–20 lux (1–2 fc) in house</td>
<td>80–100 lux (8–10 fc) in brooding area; 10–20 lux (1–2 fc) in house</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>30–60 lux (3–6 fc) in brooding area; 10–20 lux (1–2 fc) in house</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>30–60 lux (3–6 fc) in brooding area; 10–20 lux (1–2 fc) in house</td>
</tr>
<tr>
<td>10 days–20 wks</td>
<td><strong>10–20 lux (1–2 fc)</strong></td>
<td><strong>10–20 lux (1–2 fc)</strong></td>
</tr>
<tr>
<td>21</td>
<td>147</td>
<td>60 lux (6 fc) target</td>
</tr>
<tr>
<td>22</td>
<td>154</td>
<td>30 lux (3–6 fc)</td>
</tr>
<tr>
<td>23</td>
<td>161</td>
<td>10–20 lux (1–2 fc)</td>
</tr>
<tr>
<td>24</td>
<td>168</td>
<td>8</td>
</tr>
<tr>
<td>25</td>
<td>175</td>
<td><strong>8</strong></td>
</tr>
<tr>
<td>26</td>
<td>182</td>
<td><strong>10–20 lux (1–2 fc)</strong></td>
</tr>
<tr>
<td>27</td>
<td>189</td>
<td><strong>10–20 lux (1–2 fc)</strong></td>
</tr>
</tbody>
</table>

*Constant day length should be achieved by 21 days (3 weeks) at the latest.
**If feather pecking occurs, light intensity may be reduced.

Further stimulation may be required beyond 15-hour day length if egg production is not increasing satisfactorily. Two further increases of half an hour should be sufficient. There is generally no benefit in exceeding 16-hour day length.
The first pre-lay light increase should be given at 21–24 weeks (147–168 days) depending on female strain in use. This is the age at which either the flock should be transferred to open laying houses (i.e., rear and move), or the time when the blackout curtains should be opened (i.e., day-old to depletion). Target light intensity of the artificial light used during production should be 60 lux (6 fc) but a range of 30–60 lux (3–6 fc) within the house is acceptable. Egg numbers and male activity may be improved by increasing artificial light intensity to 100 lux (10 fc). Birds will become photo-refractory when submitted to long days for extended periods. There is no need to go to more than 16 hours of light.

![Table 14: Lighting Programs for Controlled Environment/Blackout Rearing – Open House Laying](image)

Example: When the natural day length at 154 days (22 weeks) will be 13 hours, rearing day length should be 9 hours constant day from 10 days to 153 days. At 154 days (22 weeks), day length should be increased to 13 hours (all natural light). Subsequent increase in day length would be a combination of artificial and natural light.

*Constant day length should be achieved by 21 days (3 weeks) at the latest; however, if problems are occurring with early body weight gain, especially with males, constant day length may be achieved by 28 days. Some strains may be stimulated at 147 days. Please consult your Aviagen technical services representative for details.

**If feather pecking occurs, light intensity may be reduced.
Open House Rearing –
Open House Laying

Where open-sided houses are used, both in rearing and production, the program adopted should allow for seasonal changes in natural daylight hours and light intensity. In open-house rearing, there are four situations that can arise:

- Natural light increasing from 0–22 weeks.
- Natural light increasing, then decreasing from 0–22 weeks.
- Natural light decreasing from 0–22 weeks.
- Natural light decreasing, then increasing from 0–22 weeks.

These changes in natural day length patterns are illustrated in Diagram 16. For each month of placement, different shading/colors indicate the pattern of increasing or decreasing hours of daylight during rearing. For example, a flock placed at the start of October (Northern Hemisphere) or April (Southern Hemisphere) will have decreasing natural daylight up to 10–12 weeks, then increasing natural daylight.

The basic principle behind the lighting programs given in Table 14 (page 42) is the use of artificial light to counteract the influence of naturally occurring changes in day length. The objective is to control the onset of lay throughout the year and thus try to avoid large fluctuations in age at first egg.

Artificial Lights and
Light Intensity

It is important that light intensity provided by the artificial lighting system is sufficient to ensure photo-stimulation. The target light intensity is 60 lux (6 fc), but a range of 30–60 lux (3–6 fc) in the house is acceptable. Egg numbers and male activity may be improved by increasing artificial light intensity in the layer house to 100 lux (10 fc). During times of the year when flocks have been reared in high intensity natural light, high levels of artificial light in the laying house are essential to ensure satisfactory reproductive performance. Seasonal effects are the result of changing patterns of day length and light intensity light during rearing.

In open-sided houses, seasonal effects can be significantly reduced if intensity of light entering the house can be reduced. The use of black plastic horticultural netting has proven successful. This netting reduces light intensity entering the house, while allowing adequate ventilation. The netting is removed at first pre-lay light increase. Painting the inside of rearing houses with black paint also produces successful results provided the birds are subsequently moved to laying houses. Any anticipated problems associated with high internal house temperatures can be countered by painting the outside of the roofs white.
Diagram 17: Natural Daylength Hours at Latitude 10°, 30°, 50° North or South

Table 15: Lighting Programs: Open House Rearing – Open House Laying

<table>
<thead>
<tr>
<th>Flock Age</th>
<th>Hours of Light During Brooding/Rearing</th>
<th>In-season Hatch Dates</th>
<th>Out-of-season Hatch Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weeks</td>
<td>Days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>Supplement</td>
<td>23 Hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Natural Daylight</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>to Provide:</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>23 Hours</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>19 Hours</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Reduce to Natural Daylight</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
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<td></td>
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<tr>
<td>7</td>
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<td></td>
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<td>8</td>
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<td></td>
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<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 days-21 weeks</td>
<td>10-53 days</td>
<td>Natural Daylight</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>

**Option 1**
Natural Daylight to 153 Days

**Option 2**
Natural Daylight to 84 Days then hold constant

Flock Age

Coming into lay, natural daylight and supplemental light should be used to increase light by:

<table>
<thead>
<tr>
<th>Weeks</th>
<th>Days</th>
<th>Hours of Light During Brooding/Rearing</th>
<th>In-season Hatch Dates</th>
<th>Out-of-season Hatch Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>154</td>
<td>2-3 Hours**</td>
<td>3-4 Hours**</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>168</td>
<td>1 Hour</td>
<td>1 Hour</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>182</td>
<td>1 Hour</td>
<td>1 Hour</td>
<td></td>
</tr>
</tbody>
</table>

Note:
Maximum 17 hours by 182 days (24wks)
Maximum 17 hours by 182 days (24wks)

* These months are difficult to define. The degree of seasonal effect in these months will depend on latitude. Slight variations in lighting programs and body weight may be necessary. These should be discussed with your technical services manager.

** The size of the first light increase and subsequent number of increments will depend on the difference between the rearing day length (10–153 days) and 17 hours. The difference will vary with season and latitude.
Seasonal Variations

Seasonal changes are gradual and a precise definition of whether certain months of the year are in- or out-of-season is difficult to establish. Some months are neither one nor the other. Latitude will also influence seasonal effects (see Diagram 17, page 44). In order to simplify a complex picture, the months in which the birds are placed are classified as in-season, or out-of-season in Table 16.

**OUT-OF-SEASON FLOCKS**

Age at onset of lay for flocks hatched between March and August in the Northern Hemisphere, and September to February in the Southern Hemisphere will be retarded due to natural daylight patterns and light intensity. Compared to in-season flocks, out-of-season flocks will come into production later and tend to have lower peaks and less predictable reproductive performance throughout lay. To counteract these effects, it is necessary to grow females to the heavier out-of-season body weight targets. By easing the degree of body weight restriction for out-of-season flocks, maturity can be advanced. First light increase should be given at 21 weeks (147 days). The amount of the first light increase should be 3–4 hours.

**IN-SEASON FLOCKS**

In-season flocks should be grown to the target body weight profile and the first light increase given at 22 weeks (154 days) (see Table 15, page 44).

<table>
<thead>
<tr>
<th>Northern Hemisphere</th>
<th>Southern Hemisphere</th>
</tr>
</thead>
<tbody>
<tr>
<td>September</td>
<td>March</td>
</tr>
<tr>
<td>October</td>
<td>April</td>
</tr>
<tr>
<td>November</td>
<td>May</td>
</tr>
<tr>
<td>December</td>
<td>June</td>
</tr>
<tr>
<td>January*</td>
<td>July*</td>
</tr>
<tr>
<td>February*</td>
<td>August*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Northern Hemisphere</th>
<th>Southern Hemisphere</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>September</td>
</tr>
<tr>
<td>April</td>
<td>October</td>
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<tr>
<td>May</td>
<td>November</td>
</tr>
<tr>
<td>June</td>
<td>December</td>
</tr>
<tr>
<td>July*</td>
<td>January*</td>
</tr>
<tr>
<td>August*</td>
<td>February*</td>
</tr>
</tbody>
</table>

* These months are difficult to define. The degree of seasonal effect in these months will depend on latitude. Slight variations in lighting programs and body weight may be necessary. These should be discussed with your Technical Service Manager.
Section 4

Nutrition and Water

Supply of Nutrients

• Energy Supply
• Protein and Amino Acids
• Major Minerals
• Trace Minerals
• Added Vitamins

Feeding Programs and Diet Specifications

• Starter Period
• Growing Period
• Transition to Sexual Maturity
• Laying Stage
• Temperature Effect on Feed Requirements
• Male Nutrition

Feed Manufacturing

• Management Practices
• Raw Materials
• Feed Processing
• Feed Hygiene (heat treatment)
• Finished Feed

Water Management
Specific nutrient recommendations are published as separate supplements for each broiler breeder strain. For a copy of current nutrient recommendations for males and females, contact your technical service manager.

**Objective**

To supply a range of balanced diets that meet broiler parent stock requirements at all stages of their development and production, to maximize reproductive performance and chick quality.

Maintaining good uniformity and achieving good body weight are largely a reflection of how one feeds parent stock. Feed composition, feeding management and husbandry must be considered together when assessing parent stock performance. Economic analysis of the whole broiler production cycle reveals that very small improvements in breeder or chick performance will more than cover costs of improving breeder feed. High-quality breeder diets are economically justifiable.

**SUPPLY OF NUTRIENTS**

**Objective**

To optimize the reproductive performance of males and females by providing them with rations meeting specific nutrient requirements throughout their life cycle.

In practice, the supply of nutrients to broiler parents is controlled through composition of feed and level of feed intake and these must always be considered together. Daily intakes of energy, amino acids and other nutrients heavily influence flock performance. Actual nutrient intakes should be considered when changing either feed composition or feed intake level.

Guidelines for daily feed intakes, and for adjusting them according to observations of bird performance, are discussed in earlier sections of the manual and in specific supplements. These guidelines are made with reference to dietary energy levels quoted in the recommended nutrient specifications. If different feed energy levels are used, feed intake must be adjusted in proportion.

Recommended nutrient specifications are given as dietary concentrations; however, the concept of required daily nutrient intakes should be considered when making feeding decisions. This is especially important at high temperatures.

**Key points**

- Rations must be balanced based on intake of digestible nutrients. An overabundance or deficiency of even one key nutrient can negatively impact total flock performance.
- Consult your nutritionist and/or technical service manager with specific questions regarding ration nutrient modifications.

**Energy Supply**

Feed energy is conventionally expressed as apparent metabolizable energy level corrected to zero nitrogen retention (AMEn). Data on metabolizable energy (ME) contents expressed in this way are available from many sources.

Nutrient specifications, including daily energy recommendations, for each of the specific strains of breeders are supplied in separate supplements available from your technical service manager. The total daily energy need for a bird is the sum of energy required for maintenance, growth and production of egg mass. The maintenance requirement for energy is by far the largest component of total energy need. Maintenance energy need is based on body weight and is significantly affected by environmental temperature. Therefore, it is reasonable that energy requirements for specific breeder strains differ due to inherent differences in recommended body weight profile and egg production. Adjustment of energy intakes are necessarily based largely on observed body weight responses, feed cleanup time, fleshing, egg mass and environmental temperature.

Additional feed should be given only when energy appears to be the limiting factor. When a nutrient other than energy is limiting performance, the provision of additional feed may lead to excess energy intake and over-development of the ovaries. If energy supply is adequate and another nutrient is too low, then the feed must be reformulated.
The choice of dietary energy level is primarily an economic decision. Under controlled feeding, the optimum feed is the one that is least-cost per unit of energy. However, constraints other than feed cost per se are influential.

The following points should be considered in making this choice:

- The full range of energy levels may not be available in practice because of constraints on the use of fat/oil and/or availability of ingredients acting as "diluents." These constraints may include nutritional factors, as discussed above, or milling requirements for pellet quality.
- Poor quality (low digestibility) feed ingredients can make it impossible for birds to consume adequate levels of feed to meet their ME requirements. Diets that are relatively high in fiber (greater than 5%) are less digestible and can cause birds to produce excessive heat during digestion. This can be beneficial during cold weather, but highly detrimental in heat stress.
- The choice of an energy level can be influenced by milling constraints. Feed is required in a form consistent with good feeding practice. Thus, in mash feeding systems, considerations of grist and dustiness may guide ingredient use and choice of energy level. In pelleted products, pellet quality needs are often dominant.
- If feed energy levels differ from those suggested, the ratio of other nutrients to energy should be kept constant.

Once factors affecting choice of energy level are resolved, the needs of individual flocks should be considered:

- Energy contents of successive feeds should not vary widely. Changes of feed should be carefully controlled (e.g. changing from pre-breeder to breeder ration).
- When least-cost feed formulation is used, large changes in feed ingredients and energy level between deliveries given to a single flock should be avoided.

To avoid undersupplying energy, nutritionists often use relatively conservative ME values for raw materials. Thus, average ME levels fed may be greater than expected and energy oversupplied. It is important to compare actual versus expected body weight gains over time to monitor this.

### Protein and Amino Acids

Feed protein level must be sufficient to ensure requirements for all essential amino acids are met. Crude protein required varies according to the feed ingredients available.

In general, it is preferable, especially under conditions of heat stress, to feed smaller amounts of high-quality protein rather than larger amounts of low-quality protein.

Recommended amino acid levels are published as a separate supplement and target those eight amino acids most likely limited in practical feeds. Levels are expressed as total and available amino acids. Available amino acids are based on true fecal digestibility. Formulating diets on available amino acid levels gives better control over variation in finished feed amino acid levels.

### Major Minerals

The major minerals, calcium and phosphorus, are critical for proper skeletal development, metabolic functions, reproductive performance and shell quality.

Laying hens require 4–5 g of calcium/hen/day to maintain calcium balance. In practice, this requirement is satisfied by making the change from grower, developer or pre-breeder rations to Phase 1 Layer ration (2.80–3.25% calcium) at 5% egg production.

To maintain optimal shell quality, consider supplementing 1.0 g Ca/bird/day in the form of a large particle-sized limestone (diameter 3.2 mm; 1/8 in) or oyster shell. This is particularly true when feeding pelleted diets. In the latter situation, finely ground limestone is often used in the diet to minimize pellet die wear. When birds are fed early in the day, the smaller particle-sized limestone in the feed is rapidly absorbed and excreted via the kidney long before the egg shell is laid down during the evening. Thus, provision of a larger particle calcium source during the afternoon hours can improve shell quality by ensuring calcium is present in the gut during shell formation. One effective way to provide this supplement is to evenly broadcast it on the house litter area. Supplemental calcium sources should not be allowed to build up in the litter since excessive calcium intake can be detrimental to shell quality. If build-up of the calcium supplement in the litter does occur,
discontinue additional supplementation until the flock has consumed that remaining in the litter. If mash feeds are used, large particle-sized limestone or oyster shell can easily be incorporated into the diet.

Calcium tetany of broiler breeder hens is occasionally seen with mortality appearing from 25–30 weeks of age. Hens are found paralyzed or dead in the nest in the morning with active ovaries and an egg in the shell gland with a partially formed shell. No other pathology may be observed post-mortem. Occurrence of this condition is rare when calcium feeding recommendations are followed.

Excessive levels of available phosphorus throughout lay reduce shell quality and have a negative impact on hatchability. High levels of phosphorus have been used as part of the prevention and control of Sudden Death Syndrome (SDS) during early lay. SDS of broiler breeders occurs from 25–30 weeks of age with birds dying suddenly in the breeder house. At post-mortem, there is an enlarged flaccid heart, congested lungs and pericardium in some birds. SDS usually responds to potassium supplementation in the drinking water. Aviagen stock has a low susceptibility to SDS; therefore, the effects on shell thickness are given priority in setting available phosphorus levels. Recommendations are not made for total phosphorus, as these will depend on the feedstuffs in use.

**Trace Minerals**

Consult the most recent recommended nutrient specifications for recommended trace mineral levels in the premix. Chelated trace elements generally have higher availability. Some anions, especially chloride, should be taken into account when considering feed mineral balance. An anion imbalance can cause increased gut motility, resulting in loose droppings, increased water intake and decreased nutrient digestibility.

**Added Vitamins**

Vitamins are critical in all aspects of growth and reproductive performance. Consult the most recent recommended nutrient specifications for recommended vitamin levels. Under stressful conditions, disease outbreaks and other situations, birds can show a positive response to higher vitamin levels. The goal should be to remove or reduce stress factors, rather than depend on permanent use of excessive vitamin supplementation for optimal performance.

Cereal type should be taken into consideration when establishing certain supplemental vitamin levels. Accordingly, separate recommendations have been made for vitamin A, nicotinic acid, pantothenic acid, pyridoxine (B6) and biotin in maize- and wheat-based feeds.

Vitamins are sensitive to many factors, including heat, oxidation, feed conditioning pressure and sheer, moisture and time. Quality control measures should be put in place to ensure finished feed vitamin levels meet recommended nutrient specifications. Several strategies can be employed to accomplish this goal, including:

- Use separate vitamin and trace mineral supplements and exclude choline chloride from supplements. The choline recommendation is given as a minimum specification in complete feed and not quoted as a premix component.
- Feed formulas should be adjusted to account for estimated vitamin degradation during a given feed conditioning process.

Vitamin E is one of the most expensive vitamins. However, as it has several biological functions impacting immune and reproductive systems, supplementary levels higher than those necessary to avoid deficiency are beneficial. The recommendation is 100 IU vitamin E/kg feed, to ensure a level of 200µg tocopherol/g yolk. Research has shown this level to enhance immune systems of newly hatched chicks. There may be situations (e.g. disease outbreaks) in which higher levels of vitamin E may prove beneficial.

**FEEDING PROGRAMS AND DIET SPECIFICATIONS**

**Objective**

To combine feed formulation and feeding management to achieve target body weights and good uniformity throughout the life of the breeder flock.

Feed specifications and feeding management must always be considered together. Different feed specifications may be used with equal success provided they lead, together with the feed management procedures, to the required bird performance.
The main factors influencing feed specifications include available feed ingredients, ingredient costs, feed milling logistical constraints, feed processing technology and bird management procedures. Several different feeding strategies can lead to successful reproductive performance. Most of the variation in feeding programs is in the rearing period and the two main approaches successfully and widely used are:

**Four-stage rearing program:** This consists of two starter feeds, a grower feed and a pre-breeder feed up to onset of lay (sometimes referred to as starter, grower, developer and pre-breeder). This program is often used with high stocking densities — everyday feeding and feed cost constraints are limiting. Additionally, this system is used in areas where wheat is the predominant cereal grain and where floor feeding is practiced.

**Key Points**

- Good early growth control is essential. Though only one starter feed is absolutely necessary, two-stage starter feed programs have been found beneficial in many cases due to the higher amino acid concentration in the Starter-2 feed.
- Feeding management and feed composition must be guided by closely monitoring and observing flocks.

**Starter Period**

Starter feed preferably should be provided as a sieved crumble. In a four-stage rearing program, the Starter-1 feed will be fed for about 21 days with special emphasis on early growth and uniformity. The Starter-2 feed, introduced when feed restriction starts, provides a transition to lower amino acid specifications in the grower period.

In a two-stage rearing program, the starter feed will also be fed for about 21 days. A grower feed will follow immediately behind the starter in the two-stage rearing program. This grower feed will generally contain higher protein and amino acid specifications than the grower in a four-stage rearing program.

Care should be taken to avoid presenting mash feed with large particle-sized grain to chicks. Individual chicks will select these large pieces, to the exclusion of the crumbles and consequently develop nutrient deficiencies (e.g. rickets).

During changes from Starter-1 to Starter-2 or from starter to grower feed, body weight should be monitored carefully. This is especially important when the change involves a different feed form.

If problems are consistently experienced in achieving target body weights by 28 days, the actual nutrient profile of the starter ration should be reevaluated.

**Growing Period**

During the growing period, daily growth rates and nutrient intakes are lower. However, it is very important to maintain good feed quality in this period, concentrating on the use of feed ingredients with consistent nutrient profiles.

Energy levels are highly influenced by prevailing economic circumstances. However, if higher energy levels and smaller feed volumes are fed during the growing period, there is a risk that these smaller feed volumes cannot be distributed throughout the house rapidly enough and flock uniformity will suffer. It may be necessary to lower the grower feed energy level to support good flock uniformity, particularly in situations where daily feeding is mandated.

**Transition to Sexual Maturity**

The use of a pre-breeder feed from 18 weeks of age is recommended in a four-stage rearing program. In a two-stage rearing program, the nutritional requirements at this stage are met by the higher specification grower feed.

Sufficient amino acids and other nutrients are required for proper reproductive tissue develop-
ment. Provision of extra vitamins in the pre-lay and early lay periods will increase body tissue levels before egg production commences and may provide a benefit in early hatchability. Pre-breeder feed energy level should be similar to the breeder feed.

Sudden changes in feed ingredients and feed texture that may reduce feed intake, even transiently, should be avoided. Dietary transitions (e.g. from grower to pre-breeder) should not correspond with any movement of birds between houses or other major management events (e.g. vaccination).

Laying Stage

Feed compositions given in the recommended nutrient specifications supplements will support target levels of production in properly reared and uniform flocks. Performance during the laying stage is often affected by feeding and management practices applied in earlier stages. Increasing feed allowances because of poor egg production should be undertaken with caution and a clear understanding of the flock’s nutritional status.

In most flocks, using more than one breeder feed may not be nutritionally necessary. Slightly reduced daily requirements of amino acids are normally fully covered by feed intake reductions post-peak. Calcium requirement increases in older birds. This can be satisfied by providing a calcium supplement in the laying house instead of providing additional calcium in the feed. Phase feeding of phosphorus may be required if higher levels are used in the earlier stages of lay to control SDS. Otherwise, available phosphorus levels should be kept at the recommended level. An economic case can be made for a Breeder-2 ration with lower protein/amino acid and available phosphorus levels, and a higher calcium concentration. This is particularly true when supplemental calcium is not provided apart from the feed and when egg weights are too heavy.

Over-sized eggs are often associated with overfeeding. Therefore, it is prudent to evaluate the complete nutrition and feeding program if this is a problem.

Temperature Effect on Feed Requirements

Environmental temperature is a major factor influencing energy requirement of the bird. As temperature varies from 20°C (68°F), energy intakes of the laying hen should be adjusted as follows:

- Increased by approximately 30 kcal (0.126 MJ) per bird per day if temperature is decreased from 20—15°C (68—59°F).
- Reduced by approximately 25 kcal (0.105 MJ) per bird per day if temperature is increased from 20—25°C (68—77°F).
- The influence of temperatures above 25°C (77°F) on energy requirement is not as straightforward as the effect of cold. At temperatures above 25°C (77°F), feed composition, feed amount and environmental management should be controlled to reduce heat stress.

These temperature-dependent energy intake modifications will vary according to bird age (e.g. pullets versus hens). Please consult your Aviagen nutritionist for more complete details.

Male Nutrition

Objective

To meet the nutritional needs of male broiler breeder parents for optimal reproductive performance.

Key Points

- Separate control of male feed intake is essential for successful broiler breeder production.
- Some research indicates that using specific male breeder rations during the reproductive period improves semen characteristics (e.g. motility, concentration). However, insufficient data exists to clearly demonstrate that such diets improve natural mating reproductive performance. In addition, the use of separate male breeder diets creates logistical challenges (e.g. long residence time of feed at farm due to small usage rate; increased risk of feed delivery errors).
- Concern has been raised about the effects of feeding layer ration levels of calcium to males. However, research to date indicates such calcium levels are not detrimental to males. The widespread industry practice of feeding males the same feed females receive further demonstrates the practice is not harmful.
- A separate male diet with its lower protein and amino acid levels may be beneficial in situations where males tend to develop excessive breast muscle on amounts of hen feed needed to maintain their body weights on the suggested weight profile.
- Good antioxidant status is important for sperm quality.
FEED MANUFACTURING

Objective
Carry out best manufacturing practices to ensure that parent stock receive rations with adequate nutrient fortification, while minimizing potential contaminants.

Management Practices

Proper nutrition can only occur when sound management practices are followed in the feed manufacturing process. Breeding stock can be fed successfully on mash, crumbled or pelleted feed. It is vital that broiler breeders receive rations with adequate nutrient fortification, while minimizing potential feed contaminants.

To ensure nutritionally balanced feed formulations are properly manufactured, a thorough quality control program should be in place at the feed manufacturing establishment. While not a complete list, some key points to consider regarding feed manufacturing and delivery include:

• Feed processing techniques should be documented and consistently followed on a feed-batch and production-run basis.
• Feed ingredients used must be free of contamination (e.g. chemical residues, microbial toxins, pathogens).
• Record-keeping systems should be present to ensure that raw materials are as fresh as possible — within practical limitations.
• Feed ingredients should be stored under appropriately controlled conditions.
• Ingredient and finished feed storage facilities must be protected from contamination by insects, rodents and wild birds — all of which are potential pathogen vectors.
• Appropriate sampling and testing procedures must be in place to ensure ingredients used in rations, as well as the finished feeds themselves, are of consistent quality. Make sure feed and raw material samples are stored properly in a cool, dry place for future analytical needs.
• Feed fats/oils should be of consistent and good quality. Feed-grade fats/oils should be appropriately stabilized with an anti-oxidant (e.g. ethoxyquin) to prevent oxidation. Products of fat/oil oxidation (e.g. peroxides) are very detrimental to birds. Fish oils have been shown to depress performance. Fats/oils containing trans-isomer fatty acids should be avoided. The latter can be formed, for example, in over-cooked vegetable oils or in fat/oil sources containing partially hydrogenated oils.
• As moisture content increases, energy density of the ingredient or finished feed declines. To avoid under- or over-supplying energy to birds, monitor moisture content of key ingredients (e.g. corn, sorghum, wheat, soybean meal) and adjust energy values accordingly. In addition, monitor moisture content of finished feed if feed conditioning is performed. If unaccounted for, variation in moisture content of key ingredients and finished feeds will cause corresponding variation in bird growth and reproductive performance.
• Feed deliveries should be scheduled to prevent feed from residing in farm feed bins for excessive periods of time (i.e., >10 days). By using appropriate mold inhibitor compounds (e.g. propionic acid-based mold inhibitors), the risk of mold growth and subsequent mycotoxin production can be reduced. The time period for feed to go from the feed plant to actual consumption by the breeder flock should be as short as possible. This is especially important under conditions of high temperature and humidity, which will accelerate overall feed quality degradation.

Raw Materials

Many feed ingredients are suitable for feeding to parent stock. Supply and price will usually determine the choice. However, a few general guidelines may be given:

• When comparing cereal sources, maize has been found to give performance advantages in the laying period when compared to wheat. Birds fed maize-based rations consistently have improved egg shell quality compared with hens fed wheat-based feeds. This leads to improved yield of hatching eggs, less bacterial contamination and improved hatchability.
• Feed fats should be used at modest levels at all stages, and at minimum levels unless good quality fat can be assured. In general, a minimum inclusion of 0.5-1.0% added fat is recommended to reduce dustiness.
Feed Processing

The feed form utilized is highly dependent on available feed ingredients and feed compounding facilities. There are three primary feed forms used:

- **Mash**: A good quality mash extends cleanup time, allowing all birds to eat a reasonable feed amount which can support good uniformity. However, mash feed can be problematic due to inconsistent supply of nutrients caused by segregation of light from heavy feed ingredients as the feed is dropped, transported by truck and augered from bin to bin. We recommend you do not feed mash feed during the starter period due to chicks selectively picking out larger particles (e.g. large particles of corn) and, consequently, consuming a very imbalanced diet. High levels of fibrous ingredients can make mash bridge in farm bins.

- **Crumble**: A good quality crumble will increase cleanup time compared to pellets with a lower chance of diet segregation compared to mash.

- **Pellets**: A good quality pellet is preferred if cleanup time (e.g. at high environmental temperatures) is a concern. If floor-feeding is applied, a good quality pellet is essential.

Feed Hygiene (heat treatment)

All feed must be considered a potential source of bacterial infection for breeders, particularly coliforms and salmonellae, and should be decontaminated if microbial pathogen control is required. There are currently two reliable methods of feed decontamination. The first is treatment with adequate heat in a retention vessel at atmospheric pressure for sufficient time to kill the organism. Commonly, this is around 86°C (191°F) for six minutes for parent stock feed. This will generally reduce the total viable bacterial counts to less than 10 organisms/gram.

An equally reliable method of feed decontamination involves a pressurized expansion pelleting process that will condition the mash at 96°C (205°F) for two minutes followed by feed compression at a pressure of approximately 8 bar (120 psi), producing an end-feed temperature of approximately 113°C (235°F) for 3–4 seconds.

Pelleting alone will not completely eliminate harmful bacteria from feed (although it may reduce the con-
tamination below detectable levels in tests of finished feed). Care must be taken not to recontaminate feed. Critical control points for the prevention of recontamination include the pellet cooler, storage bins and feed transportation. Treatment with organic acids (e.g. propionic acid) is frequently necessary as a further precaution. Further information on heat treatment of feed for Salmonella control can be obtained from your local technical service manager.

When feeds are heated, attention must be paid to vitamin loss and possible destruction of other feed components (e.g. enzymes). Vitamin levels recommended in the nutrient specification supplements will cover losses from conventional feed conditioning and pelleting. However, more severe heat treatment may increase the need for vitamin supplementation. There may also be changes in nutritional value due to feed structural changes.

**Finished Feed**

While not complete, Table 17 (page 54) describes the effects of over- or undersupply of several key nutrients.

**Insoluble Grit:** It is good management practice to offer 5 mm granite grit from 42 days (6 weeks) of age at a rate of 0.5 kg (1 lb)/100 birds/month. This assists in the breakdown of litter material or feathers which birds may consume. Impaction problems could result from the ingestion of such material without the presence of insoluble grit in the gizzard.

**WATER MANAGEMENT**

Various factors (e.g. diet, temperature and humidity) can impact water requirements. Therefore, daily water needs vary and cannot be precisely defined. Consumption should be recorded daily. Unusual or extreme variations can indicate possible health problems, which should be fully investigated.

Water should be delivered to parent stock at temperatures of 10–12°C (50–54°F). Very cold or very warm (30°C/86°F) water reduces intake. In hot weather, flushing water lines ensures water is as cool as possible.

At temperatures over 21°C (70°F), water requirement increases by approximately 6.5% per 1°C (2°F) rise. Water over-consumption can occur in growing birds, particularly in the later rearing period (6–22 weeks).

During both the growing and production phases, a water restriction program can help maintain good litter quality, improve feed digestion, lower the humidity and promote overall enteric health.

During rearing, on feed days, water should be available for a continuous 3–4 hour period. Start ½–1 hour before feeding and end 1–2 hours after feed is consumed. Also provide water for two or three 20–30 minute periods in the afternoon. On off-feed days, supply water early in the morning for 30–60 minutes and also provide water for 20–30 minutes three or four times per day.

During egg production, provide water continuously for a period of 30 minutes before feeding until 1–2 hours after feed is consumed. Provide 30 minutes of water in the afternoon. Provide another 30 minutes prior to dark.

Birds’ crops should be soft and pliable after the watering period. If water consumption is inadequate, crops will be hard and may become impacted — possibly leading to necrosis.

If temperatures are ≥30°C (86°F), provide water at least 20 minutes of every hour. At temperatures ≥32°C (90°F), provide unlimited access to water.
Section 5

Care of Hatching Eggs

Nest Management

- Conventional Nests (Manual Egg Collection)
- Mechanical Nests (Mechanical Egg Collection)
- Reducing Floor and Slat Laying

Egg Collection and Hatching Egg Selection

- Egg Collection
- Selecting Hatching Eggs

Hatching Egg Disinfection and Storage

- Disinfection of Hatching Eggs
- Egg Storage
The production of good-quality day-old chicks from hatching eggs involves effective collection, disinfection, cooling, storage and incubation of eggs. Each step should be properly taken so that embryonic development is not compromised. Best hatchability is achieved when eggs are kept in clean conditions, and at the correct temperature and humidity, from the time laid until hatched.

**NEST MANAGEMENT**

**Objective**

*Nests provide a sanitary environment for eggs to be laid and proper nest management should maximize the percentage of eggs laid in nests.*

The design of the nests should encourage hens to lay in them. Hens are more likely to use nests that are clean, dry, dimly lit and secluded. Nest boxes should be easily accessible, but high enough so they will not become contaminated with floor litter, or provide a refuge for females avoiding the males.

Provision of perches during rearing assists in training the females to use nests when they come into lay (see Equipment and Facilities, page 39). Nest litter, pads and/or liners must be clean and dry. Floor litter should be clean and dry so hens’ feet are clean upon entering the nests.

**Conventional Nests**

*(Manual Egg Collection)*

Install nests prior to moving birds into the laying house or by 22 weeks of age in brood/grow/lay houses. If nest fronts can be closed, open the top row of nests at 21 to 22 weeks of age. At onset of lay, open the bottom row of nests.

Nest boxes are usually assembled in 2- or 3-tier units allowing 1 nest/4 birds. The nest dimensions should be approximately 30 cm (12 in) wide x 35 cm (14 in) deep x 25 cm (10 in) high. The design should allow for good ventilation with freedom from drafts. The perch rail for the lower tier of nests should not be more than 45 cm (18 in) above the litter. The bottom tier perch rail should extend to a minimum of 10 cm (4 in) beyond the second tier rail.

Train the birds to the nests as follows:
- After the first egg is laid, place all eggs produced the first 5–7 days into the nests to attract hens to nests.
- Walk the building perimeter hourly, driving all birds off walls and out of corners.
- Pull the egg trolley/cart through the building frequently to allow birds to become familiar with the routine.
- Remove all floor eggs frequently throughout the life of the flock.

Remove all hens and close nests after the last egg collection to prevent birds from roosting in nests, which leads to increased fecal contamination of nest material. Open nests after dark so they are available to birds at first light in the morning.

**Mechanical Nests**

*(Mechanical Egg Collection)*

Before a new flock is placed, ensure that all nest pads are properly installed. Run the belt a full cycle at least four times per day at normal egg gathering times to acclimate the flock to the system. Nest belts and pads should be kept clean and a regular routine of cleaning should be practiced. From first egg until depletion, check 25% of the pads daily. Remove and clean all obviously dirty, worn and torn pads. If belt brushes are used, they should be cleaned or replaced after the first and last run of each day. When belt cleaners/sanitizers are used, care must be taken to ensure the belt is dried before it comes in contact with eggs.

Mechanical nests will reduce labor required to collect eggs. However, as with any automated system, effectiveness should be carefully monitored. Routines should be established to ensure maximum numbers of eggs are laid in nests. Equipment must be maintained to minimize losses due to mechanical damage of eggs during collection and grading. Manufacturers should be consulted for details of house design and nest layout.

Hen-to-nest ratios should be a maximum of 5.5 hens/nest for a nest box approximately 30 cm (12 in) wide x 35 cm (14 in) deep x 25 cm (10 in) high. Consult manufacturers’ recommendations for other
mechanical nest types. European design mechanical nests require a sloping, slatted area extending to approximately 100 cm (40 in) in front of the nest, and should be 35 cm (14 in) above litter height at the front edge.

Light intensity must be a minimum of 60 lux (5.5 foot-candles) in houses equipped with automatic egg collection systems (see Lighting for complete recommendations, page 40).

Train the birds to nest as follows:
• Pick up all floor eggs.
• During the remainder of the morning, walk the scratch (litter) area to drive birds onto slats. Avoid walking on slats so that the birds can use the nests undisturbed.
• In the afternoon, walk the building perimeter and scratch area.

Reducing Floor and Slat Laying

Risk of floor and slat eggs will increase if hens find nests unattractive or if there are too many females per nest. Following are suggested measures to help reduce the incidence of floor and slat laying:
• Introduce perches in rearing.
• Maintain stocking densities and hen-to-nest ratios at recommended levels uniformly throughout the house. Several factors influence the distribution of birds within a house:
  – Non-uniform cooling or heating throughout the house. If cooling systems are not maintained and managed properly, birds may migrate to cooler areas of the house, placing increased pressure on hen-to-nest ratios.
  – Inadequate female feeder space, distribution and/or feeder location
  – Drinker location, space and availability
• Incorporate a suitable perch rail in nest box design.
• Uniform distribution of light of greater than 60 lux (5.5 foot-candles).
• Light the birds in synchrony with achievement of target body weight gains.
• Effective management of early mating ratios. Over-mating can predispose slat/floor egg laying.
• Set feeding times to avoid the peak of egg laying activity. Feeding time should be either within 30 minutes of ‘lights on’ or 5–6 hours after ‘lights on’ to prevent birds from feeding when most eggs are likely to be laid.
• Floors should be walked slowly, so as to not disturb hens in nests.
• Eggs should not be allowed to accumulate in areas other than nests. Accumulation in undesirable areas encourages other hens to lay in the same location.
• Eliminate excessive shadows under male feeders, which can also encourage floor laying.
• Slat heights of 60 cm (24 in) or greater predispose hens to floor laying. As mentioned previously, maintaining 35–40 cm (14–16 in) above litter height at the front edge will help minimize this risk factor.
• Unstable perches and slats around nests may discourage hens from using these nests and should be repaired or replaced.

EGG COLLECTION AND HATCHING EGG SELECTION

Objective
To ensure eggs are collected, sorted, cleaned and stored properly for optimal production of good quality chicks.

Egg Collection

Individuals gathering and packing eggs should wash and sanitize their hands regularly. Gather eggs a minimum of four times per day. Birds will have a different lay pattern based on the time of first light, feeding time and the flock age. Egg gathering times should be matched to flock lay pattern:
• Each of the first two egg gatherings should yield approximately 30% of total daily egg production.
• Each of the final two egg gatherings should yield approximately 15–20% of total daily egg production.
• If the percentage of eggs gathered at one egg gathering exceeds 30%, the number of dirty and cracked eggs will be increased.

Eggs should be collected frequently, disinfected and cooled as soon as possible after lay. Frequent collections reduce accidental egg damage in nests caused by hens. Manual collections should be made at least four times daily. Time collections so there are never more than 30% of the total eggs in any one collection.
Eggs should be collected onto clean setter trays or clean fiber trays, preferably the former. Floor and dirty eggs must be collected and stored separately from clean eggs. Dirty eggs should not be incubated and should be handled and stored separately.

Sort nest eggs by category as they are being collected: hatching, undersized, double yolks, dirty and cracked eggs. Floor eggs should be collected separately from nest eggs and kept separate from hatching eggs. Sorting in this manner will allow ease of recording at end of day. It is preferable to set only clean eggs laid in nests. Remove small amounts of fecal material or litter with a plastic or wood scraper, a clean, dry cloth, or with your thumbnail. It is not recommended to use sandpaper. Sandpaper destroys the egg cuticle and pushes dirty material into the eggshell pores, greatly increasing the potential for exploding eggs during incubation, and subsequent hatchery contamination. Be sure to clean dirty eggs in an area away from clean eggs to prevent cross contamination. Store and set clean eggs and previously dirty eggs in separate incubators.

Selecting Hatching Eggs

The flock manager is responsible for ensuring non-hatching eggs are removed from those used for incubation. Producers may select eggs based on exterior shell quality, shape, size, color and cleanliness. It is important to remove cracked, thin-shelled, misshapen, pimpled and dirty eggs.

Hatching egg size requirements will differ. A minimum egg weight of 50 g (2 oz/dozen) is recommended. However, when eggs as small as 47 g (2 oz/dozen) are hatched, the resultant small chicks can be grown successfully if grown separately 1–2 days longer with extra care. If a chick weight over 38 g (1.3 oz) is required, minimum egg size target should be approximately 55 g (2.3 oz/dozen). In general, chick size will be 68% of egg size with good incubation conditions and the 42-day broiler weight will be affected by at least 7–10 g (0.02 lb) for every gram (0.4 oz/dozen) change in egg size.

The egg selection process has a direct impact on chick quality by determining uniformity of hatch and amount of dehydration. Consistency of egg selection is important to maintain quality.

HATCHING EGG
DISINFECTION AND STORAGE

Disinfection of Hatching Eggs

As the egg cools, its contents contract and any bacteria on the shell will be drawn through the egg pores to the interior. Therefore, if eggs are disinfected, it should be conducted immediately after collection, while the eggs are still warm. The disinfection process must not cause eggs to cool due to the aforementioned risk of drawing bacteria into the egg.

Hygienic conditions must be maintained throughout all egg handling procedures. Egg storage areas and vehicles used for transport must be kept clean at all times and disinfected regularly. Disinfected eggs are very vulnerable to bacterial recontamination if egg storage areas are not subjected to an effective, ongoing sanitization program. Eggshells must not become wet after disinfection, as this allows airborne bacteria access through the shell pores. Regular fogging of the egg storage area with an approved disinfectant will reduce the bacterial load, but must be undertaken in such a way as to avoid wetting eggs.

Disinfected eggs are frequently recontaminated by:
- Dirty water in humidifier reservoirs
- Dirty fan blades, grills and air inlets for coolers
- Airborne dust drawn from egg-handling area into storage area
- Failure to close doors to egg-storage areas

Different methods are available for hatching egg disinfection, some of which are outlined below:
- There are two common methods of sanitizing hatching eggs: fumigation with formaldehyde and spraying with a quaternary ammonia/hydrogen peroxide solution.
- Fumigating the eggs with formaldehyde is probably the best method for disinfecting the eggshell surface, but in many countries government regulations limit formaldehyde use. Formaldehyde is a known carcinogen and should be used with caution. The following points should be considered when fumigating eggs with formaldehyde:
  - Always follow government regulations when using formaldehyde fumigation.
Arbor Acres

• Use rubber gloves, goggles and mask for personal protection.
• Fumigate the eggs as soon as they are gathered at the farm.
• Formaldehyde fumigation is most effective at temperatures above 21-24°C (72–75°F) with a relative humidity of 60–75%.
• Use fans to evenly distribute the gas in large rooms.
• At the end of fumigation, exhaust all of the gas in the room with fans for 40 minutes.

• The following points should be considered when using hatching egg spray disinfectants:
  – Store hatching egg spray at room temperature.
  – Some disinfectants (e.g. quaternary ammonium compounds) may affect hatchability. Test all disinfectants before using.
  – Do not fumigate wet eggs as it can be toxic to the embryos.
  – See Table 19 for recommended preparation of a commonly used hatching egg spray disinfectant.
• Hatching egg spray has been proven to be an effective replacement for formaldehyde.

• Either method should first be used when the eggs are still on the farm.
• Many hatcheries repeat the sanitation procedures when the eggs arrive at the hatchery and/or at the time of pre-setting the eggs in the hatchery.
• Table 18 summarizes the effectiveness of different methods of disinfection.

### Table 18: Relative Effectiveness of Disinfection Procedures

<table>
<thead>
<tr>
<th></th>
<th>Formalin</th>
<th>In-line Washer</th>
<th>Dipping</th>
<th>UV Light</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kills bacteria</td>
<td>44</td>
<td>44</td>
<td>44 '</td>
<td>4</td>
</tr>
<tr>
<td>Safe for embryo</td>
<td>44 '</td>
<td>4 '</td>
<td>4</td>
<td>44</td>
</tr>
<tr>
<td>Safe for operator</td>
<td>8</td>
<td>44</td>
<td>44</td>
<td>4</td>
</tr>
<tr>
<td>No cuticle damage</td>
<td>44</td>
<td>8</td>
<td>4 '</td>
<td>44</td>
</tr>
<tr>
<td>Egg shell dry</td>
<td>44</td>
<td>8</td>
<td>8</td>
<td>44</td>
</tr>
<tr>
<td>Temperature extremes</td>
<td>44</td>
<td>8</td>
<td>4 '</td>
<td>44</td>
</tr>
</tbody>
</table>

44 = Good 4 = Acceptable 8 = Poor

- Cannot be used between 12–96 hours of incubation.
- High embryo mortality associated with bacterial rots in older flocks.
- Usage and solution changes require careful monitoring.
- Depends on chemical used. Quaternary ammonium products are usually acceptable; hydrogen peroxide is not suitable.
- Tank temperature and dip duration require careful monitoring.
- Ultraviolet light does not destroy staphylococcus effectively. Effectiveness is improved when combined with fumigation at some point prior to setting.

### Table 19: Hatching Egg Solution for 19 Liters of Solution (5 Gallons)

<table>
<thead>
<tr>
<th>Hatching Egg Solution for 19 Liters of Solution (5 Gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen peroxide (H₂O₂) is available in 50% or 30% solutions. For a 50% solution, use 385 mL (14 oz); for 30%, use 650 mL (22 oz)</td>
</tr>
<tr>
<td>30 mL (1 oz) of quaternary ammonium compound (12.2% active ingredient)</td>
</tr>
<tr>
<td>The remainder of the solution should be clean water.</td>
</tr>
</tbody>
</table>

### Table 18: Relative Effectiveness of Disinfection Procedures

<table>
<thead>
<tr>
<th></th>
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<tr>
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<td>44 '</td>
<td>4 '</td>
<td>4</td>
<td>44</td>
</tr>
<tr>
<td>Safe for operator</td>
<td>8</td>
<td>44</td>
<td>44</td>
<td>4</td>
</tr>
<tr>
<td>No cuticle damage</td>
<td>44</td>
<td>8</td>
<td>4 '</td>
<td>44</td>
</tr>
<tr>
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<td>44</td>
<td>8</td>
<td>8</td>
<td>44</td>
</tr>
<tr>
<td>Temperature extremes</td>
<td>44</td>
<td>8</td>
<td>4 '</td>
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Egg Storage

Objective
To provide a consistent egg storage environment that maximizes hatchability.

Always collect, pack and set eggs with the large end up. Cool eggs to 19–20°C (67–68°F) after collection. Avoid air currents blowing directly over stored eggs. If eggs are to be stored in cardboard boxes, cool the eggs before packing them.

Storage rooms should be well insulated and lined with an impervious material, and include a heater/cooler system — all of which can be easily sanitized. The area must be large enough to accommodate anticipated egg volumes and to meet egg spacing requirements. The egg storage room ceiling should be approximately 1.5 m (5 ft) above the stored eggs.

The egg storage room should be only used for egg storage. Maintain the egg holding room temperature on the farm at 18°C (64°F) with a relative humidity of 75%. Eggs held for an extended period of time should be kept slightly cooler (16°C, 61°F). If this is done, the cooler temperatures should ideally be provided from day of production. Once established, temperatures and humidity should be maintained at steady levels throughout.

The ideal egg storage time for optimal hatchability is 3–5 days for breeders <50 weeks old and 2–4 days for breeders >50 weeks old. Ensure thermometers and relative humidity measuring devices are calibrated a minimum of once a month.

Clean and disinfect the egg holding room routinely and provide continuous air movement. When condensation forms on the eggs (“sweating”), disease-producing organisms are able to penetrate shell pores more easily. Prevent sweating by maintaining correct temperature and humidity conditions throughout the time eggs are held (on farm, during transportation and at the hatchery). If eggs are cooled to 18°C (64°F) and then moved to a warmer room, they may sweat. To prevent this, see Table 20, which outlines the maximum percent relative humidity target in relation to room temperature — beyond which eggs will begin to sweat.

Table 20: Condensation Table
Egg Temperature 18°C (64°F)

<table>
<thead>
<tr>
<th>Room Temperature °C</th>
<th>Room Temperature °F</th>
<th>% Relative Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>70</td>
<td>83</td>
</tr>
<tr>
<td>24</td>
<td>75</td>
<td>71</td>
</tr>
<tr>
<td>27</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>29</td>
<td>85</td>
<td>51</td>
</tr>
<tr>
<td>32</td>
<td>90</td>
<td>43</td>
</tr>
<tr>
<td>35</td>
<td>95</td>
<td>38</td>
</tr>
<tr>
<td>38</td>
<td>100</td>
<td>32</td>
</tr>
</tbody>
</table>

When poor egg handling occurs due to improper temperature, humidity and length of storage, both hatchability and chick quality will suffer. The associated lower hatch is usually seen as higher early embryonic deaths. Prolonged storage will affect hatchability and also lengthen incubation time. Generally, hatching time is delayed 30 minutes and hatch is affected 1% for every day eggs are held beyond 4 days.

The incubator room should be controlled to maintain a temperature of 27°C (80°F). If eggs are held at 18°C (65°F), they will sweat if the incubator room is at RH >42%. This is a problem because the recommended minimum RH for the incubator room is 50%. Therefore, eggs should be set into incubators directly from the egg holding room. The eggs may sweat for a short period of time; however, since the internal egg temperature is increasing in the incubator, exterior contamination will not be pulled into the egg interior. Pre-warming of eggs outside of the incubator will result in non-uniform hatches since the internal egg temperatures often vary by as much as 4.5°C (8°F) between eggs near the outside of the racks and those in the center.
The Relationship Between Management and Disease Expression
- Inspection of Birds
- Hygiene Management

Biosecurity
- Farm Location/Construction
- Preventing Diseases Transmitted by Humans
- Preventing Diseases Transmitted by Animals

Site Cleaning
- Cleaning the House
- Cleaning Water and Feed Systems
- Repairs and Maintenance
- Disinfection
- Formalin Fumigation
- Cleaning External Areas
- Evaluation of Farm Cleaning and Disinfection Efficiency
- Water Quality

Dead Bird Disposal
- Disposal Pits
- Incineration
- Composting
- Rendering

Disease Control and Vaccination
- Disease Control
- Vaccination Programs
- Types of Vaccines
- Specific Vaccination Programs

Health Monitoring Programs
- Sampling for the Presence of Disease
- Monitoring the Effectiveness of Vaccination Programs
Objectives

To achieve hygienic conditions within the poultry house environment and minimize adverse disease effects.

To attain optimal performance and welfare and provide assurance on food safety issues.

The Relationship Between Management and Disease Expression

The incidence and severity of many diseases is affected by the degree of stress experienced by birds within the production process. The management systems described in this manual are designed to maximize production by minimizing stress in broiler parents. Where it may prove impossible to exclude a pathogen in a particular situation, the commercial effects of a disease may be minimized by reducing stress derived from other sources.

Many factors interact to increase the symptoms seen as a result of infection. When defining control measures for disease, it is important to consider the possible occurrence of stress factors such as:

- Poor feed management and body weight control are stress factors that can precipitate problems of staphylococcal arthritis/tendinitis.
- Precocious development (over-stimulation) is associated with peritonitis, increased double yolked eggs and *E. coli* septicemia at point of lay.
- Poor litter management can cause problems with coccidiosis, staphylococcal arthritis/tendinitis and poor egg hygiene.
- Stocking density, biosecurity, vaccination and control of immunosuppressive infections (e.g. Marek’s Disease, Reovirus, Infectious Bursal Disease [IBD], Chicken Anemia Virus [CAV]), can markedly affect severity of other diseases.

Inspection of Birds

It is essential to inspect birds routinely to identify emerging disease symptoms or welfare problems. All flocks should be inspected at least twice per day by an experienced flock manager. The flock manager should pass within viewing distance (i.e., approximately 3 m (10 ft) of each bird). Light intensity should be sufficient to ensure all birds are clearly visible.

Hygiene Management

Strict operation of a comprehensive program of hygiene management is essential for maximum productivity and good health status of parent flocks. Such a hygiene program must include detailed attention to:

- Site biosecurity
- Site cleaning
- Disposal of dead birds

Biosecurity

Objective

Prevent the introduction of disease organisms into the flock.

Farm Location/Construction

- It is best to build the farm in an isolated area, at least 2.5 km (1.5 miles) from the nearest poultry or other facility that may contaminate the farm.
- Build the farm away from major roadways that may be used to transport poultry.
- Fence the farm perimeter to prevent unwanted visitors.
- Test the water source for mineral, bacterial and chemical contamination.
- The design and construction of the houses should be in a manner that does not provide openings for wild birds and animals to enter the building. All openings should be covered with 2.0 cm (.75 in) plastic coated poultry wire. It is preferable to have a concrete foundation and floor to prevent rodents from burrowing into the house.
- It is especially convenient for conventional houses to be facing the east-west direction.
- Clear and level an area 15 m (50 ft) around all houses so grass can be cut quickly and easily. Gravel or pebbles are easier to maintain than grass.

Preventing Diseases Transmitted by Humans

- Minimize the number of visitors to the poultry farm by locking entry gates and posting no trespassing/no visitors signs.
- If supervisory personnel must visit more than one farm per day, they should visit the youngest flocks first. Always visit flocks with disease problems last. If a serious problem is suspected, e.g. avian
influenza (AI) or Viscerotropic Velogenic Newcastle Disease (VVND), stop all visits at once.

- All people entering the farm should follow a biosecurity procedure. The requirement that all workers and visitors shower and use clean farm clothes is one of the best procedures to prevent cross contamination between facilities.
- Maintain a record of visitors, including name, company, purpose of visit, previous farm visited and next farm to be visited.
- When entering and leaving each poultry house, workers and visitors must wash and sanitize their hands and boots.
- Tools and equipment carried into the house are a potential source of disease. Only necessary items should enter the house and then only after proper cleaning and disinfection.

**Preventing Diseases Transmitted by Animals**

- Whenever possible, place the farm on an “all in/all out” placement cycle. Multiple-age chickens on the same site provide an ideal reservoir for disease organisms.
- Downtime between flocks will reduce contamination of the farm. Downtime is defined as the time between depopulation and placing the next flock. A minimum downtime of 4 weeks between flocks is recommended.
- Keep all vegetation cut 15 m (50 ft) away from buildings to provide an entry barrier to rodents and wild animals.
- Keep all equipment, building materials and trash picked up to reduce cover for rodents and wild animals.
- Clean up feed spills as soon as they occur.
- Store wood shavings and rice hulls for use as litter material in bags or inside a storage building or bin.
- Keep wild birds out of all buildings.
- Keep waterfowl away from the breeder farm, as they can be the source of avian influenza viruses. Ideally, breeder farms should not be built near small or large bodies of water.
- Presence of other livestock within the breeder farm must be discouraged.
- Maintain an effective rodent control program. Baiting programs are most effective when followed continuously.
- Use an integrated pest management program, including mechanical, biological and chemical controls.

**SITE CLEANING**

**Objectives**

To clean and disinfect the poultry house so all potential poultry and human pathogens are removed and to minimize numbers of residual bacteria, viruses, parasites and insects. This will greatly reduce the risk of any effect on health, welfare and performance of the subsequent flock.

**Cleaning the House**

House Design: The house and equipment should be designed to enable easy, effective cleaning. The poultry house should incorporate concrete floors, washable (i.e., impervious) walls and ceilings, accessible ventilation ducts and no internal pillars or ledges. Earth floors are impossible to clean and disinfect adequately. An area of concrete or gravel extending to a width of 1–3 m (3–10 ft) surrounding the house can discourage the entry of rodents and provide an area for washing and storing removable items of equipment.

Planning: A successful cleanout requires that all operations are effectively carried out on time. Cleanout is an opportunity to carry out routine farm maintenance and this needs to be planned into the cleaning and disinfection program. A plan detailing dates, times and labor, and equipment requirements should be drawn up prior to depleting the farm to ensure all tasks can be successfully completed.

Insect and Rodent Control: Insects and rodents are significant disease vectors and must be destroyed before they migrate into other farm areas or to other farms. As soon as birds have been removed from the house, and while it is still warm, the litter, equipment and all surfaces should be sprayed with a locally recommended insecticide. Alternatively, the house may be treated with an approved insecticide within 2 weeks prior to depletion. A second treatment with insecticide should be undertaken before fumigation. A thorough rodent baiting must also be carried out in order to eliminate as many rodents as possible before they are forced to look for food and shelter in other locations.

Remove Dust: All dust, debris and cobwebs must be removed from fan shafts, beams and exposed areas of unrolled curtains in open-sided houses, ledges and stonework. This is best achieved by brushing so dust falls on to the litter.
Pre-spray: A knapsack or low-pressure sprayer should be used to spray detergent solution throughout the inside of the house, from ceiling to floor, to dampen down dust before removal of litter and equipment. In open-sided houses, the curtains should first be closed.

Remove Equipment: All equipment and fittings (drinkers, feeders, perches, nest-boxes, dividing pens, etc.) should be removed from the building and placed on the external concrete area. It may not be desirable to remove automatic nest boxes and alternative strategies may be required.

Remove Litter: The aim should be to remove all litter and debris from within the house. Trailers or rubbish skips should be placed inside the house before they are filled with soiled litter. The full trailer or skip should be covered before removal, to prevent dust and debris blowing around outside. Vehicle wheels must be brushed and spray-disinfected on leaving the house.

Litter Disposal: Litter must be removed to a distance of at least 3.2 km (2 miles) from the farm, and disposed of in accordance with official regulations in one of the following ways:
- Spread on arable crop land, and plowed in within 1 week
- Buried in a ‘landfill’ site
- Stacked and allowed to heat (i.e., compost) for at least 1 month before being spread on livestock grazing land

To avoid the risk of contamination of a clean farm and/or prevent exposure of a new flock to disease organisms present in the previous flock, litter must not be stored on the farm or spread on land adjacent to the farm.

Washing: First, check that all electricity in the house has been switched off. A hot water pressure washer with foam detergent should be used to remove remaining organic matter, dirt and debris from the house and equipment. Use of hot water facilitates removal of organic matter and improves efficiency of disinfection and/or fumigation procedures. Make sure the detergent used is compatible with the disinfectant used. Many different industrial detergents are available. Manufacturers’ instructions should be followed when using detergents.

After washing with detergent, the house and equipment should be rinsed with clean fresh water using a pressure washer. After washing, excess floor water must be properly drained from the house and away from the farm to prevent recontamination. All equipment that has been removed to the external concrete area must be soaked and washed. After equipment is washed, it should be stored under cover.

Inside the house, particular attention should be paid to the following places when washing:
- Fan boxes
- Fan shafts
- Fans
- Ventilation grills
- Tops of beams
- Ledges
- Water pipes

In order to ensure that inaccessible areas are properly washed, it is recommended that portable scaffolding and portable lights be used.

The outside of the building must also be washed and special attention given to:
- Air inlets
- Gutters
- Concrete pathways

In open-sided housing, the inside and outside of curtains must be washed. Any items that cannot be washed (e.g. polythene, cardboard) must be destroyed.

When washing is complete, there should be no dirt, dust, debris or litter present. Proper washing requires time and attention to detail.

Staff facilities should be thoroughly cleaned at this stage. The egg storage room should be washed out and disinfected. Humidifiers should be dismantled, serviced and cleaned prior to disinfection. Occupational and environmental regulations must be followed when using chemicals for washing and disinfection purposes.

Cleaning Water and Feed Systems

All equipment within the house must be thoroughly cleaned and disinfected. After cleansing, it is essential that equipment be stored under cover.
The procedure for cleaning the water system is as follows:

- Drain pipes and header tanks.
- Flush lines with clean water.
- Physically scrub header tanks to remove scale and bio film deposit. Drain to the house exterior.
- Refill tank with fresh water and add an approved water sanitizer.
- Run the sanitizer solution through the drinker lines from the header tank, ensuring there are no air locks.
- Fill the header tank to normal operating level with additional sanitizer solution at appropriate strength. Replace lid. Allow disinfectant to remain for a minimum of 4 hours.
- Drain and rinse with fresh water.
- Refill with fresh water prior to chick arrival.

Bio films will form inside water pipes and regular treatment is needed to prevent decreased water flow and bacterial contamination of drinking water. Bio films begin as aggregations of lipopolysaccharide (LPS) capsules from bacteria. Pipe material will influence rate of bio film formation. The use of vitamin and mineral treatments in drinking water can increase bio film and aggregation of materials.

Physical cleaning of the inside of pipes to remove bio films is not always possible. Between batches of chickens, bio films can be removed by using high levels (140 ppm) of chlorine or peroxygen compounds. These need to be flushed completely before birds drink. High local water mineral content (especially calcium or iron) may lead to an increased need for acid scrubbing. Metal pipes can be cleaned the same way, but corrosion can cause leaks. Water treatment should be considered for high-mineral waters. Evaporative cooling and fogging systems can be sanitized at cleanout using an approved sanitizer.

The procedure for cleaning the feed system is as follows:

- Empty, wash and disinfect all feeding equipment (i.e., feed bins, track, chain, hanging feeders).
- Empty bulk bins and connecting pipes and brush out where possible. Clean out and seal all openings.
- Fumigate wherever possible.

**Repairs and Maintenance**

A clean, empty house provides the ideal opportunity for structural repairs and maintenance.

Once the house is empty, attention should be given to the following tasks:
- Repair cracks in the floor with concrete/cement.
- Repair pointing and cement rendering on wall structures.
- Repair or replace damaged walls and ceilings.
- Carry out painting or whitewashing where required.
- Ensure all doors shut tightly.
- Repair or replace ventilation equipment.
- Replace non-working lights or light fixtures.

**Disinfection**

Disinfection should not take place until the whole building (including external area) is thoroughly clean and all repairs are complete. Disinfectants are ineffective in the presence of dirt and organic matter. Disinfectants approved by governments for use against specific poultry pathogens of both bacterial and viral origin are most likely to be effective. Manufacturers’ instructions must be followed at all times.

Most disinfectants have no effect against coccidial oocysts. Where selective coccidial treatments are required, compounds producing ammonia should be used by suitably trained staff. These are applied to all clean internal surfaces and will be effective even after a short contact period of a few hours.

**Formalin Fumigation**

Where formalin fumigation is permitted, fumigation should be undertaken as soon as possible after completion of disinfection. Surfaces should be damp. The houses should be warmed to 21°C (70°F). Fumigation is less effective at lower temperatures and at relative humidities of less than 65%.

Doors, fans, ventilation grills and windows must be sealed. Manufacturers’ instructions concerning fumigant use must be followed. After fumigation, the house must remain sealed for 24 hours with NO ENTRY signs clearly displayed. The house must be thoroughly ventilated before anyone enters.

After litter has been spread, all fumigation procedures described above should be repeated.

Fumigation is hazardous to animals and humans. Protective clothing (i.e., respirators, eye shields and gloves) must be worn. At least two people must be present in case of emergency.
For special situations, some floor treatments can be used following the dosages and indications suggested in Table 21 below.

**Cleaning External Areas**

It is vital that external areas are also cleaned thoroughly. Ideally, poultry houses should be surrounded by an area of concrete or gravel, 3 m (10 ft) in width. Where this does not exist, the area must:
- Be free of vegetation
- Be free of unused machinery/equipment
- Have an even, level surface
- Be well drained, free of any standing water

Particular attention should be paid to cleaning and disinfection of the following areas:
- Under ventilator and extractor fans
- Access routes
- Door surrounds

All external concrete areas should be washed and disinfected as thoroughly as the inside of the building.

**Evaluation of Farm Cleaning and Disinfection Efficiency**

It is essential to monitor the efficiency and cost of cleaning out and disinfection. Effectiveness is evaluated by undertaking total viable bacterial counts (TVC). Table 22 indicates the suggested standards to be achieved. Monitoring trends in TVCs will allow continuous improvement in farm hygiene and comparison of different cleaning and disinfection methods.

*Note:
When disinfection has been carried out effectively, the sampling procedure should not isolate any salmonella species.*

**Table 21: Common Floor Treatments for Poultry Houses**

<table>
<thead>
<tr>
<th>Compound</th>
<th>Application Rate</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boric Acid</td>
<td>As necessary</td>
<td>Kills darkling beetles</td>
</tr>
<tr>
<td>Salt (NaCl)</td>
<td>0.25</td>
<td>Reduction of Clostridium counts</td>
</tr>
<tr>
<td>Sulphur Powder</td>
<td>0.01</td>
<td>Lowers pH</td>
</tr>
<tr>
<td>Lime (Calcium Oxide/Hydroxide)</td>
<td>As necessary</td>
<td>Disinfection</td>
</tr>
</tbody>
</table>

**Table 22: Evaluation of Cleaning and Disinfection**

<table>
<thead>
<tr>
<th>Sample Site</th>
<th>Recommended No. of Samples</th>
<th>TVC* Target</th>
<th>Maximum</th>
<th>Salmonella Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support poles</td>
<td>4</td>
<td>5</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>Walls</td>
<td>4</td>
<td>5</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>Floors</td>
<td>4</td>
<td>30</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>Feed hopper</td>
<td>1</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Nest boxes</td>
<td>20</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Crevices</td>
<td>2</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Drains</td>
<td>2</td>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

*Total viable counts in colony forming units/cm²*
**Water Quality**

Good quality water is an essential nutrient and a critical component of a sound parent stock management program.

Water should be clear with no organic or suspended matter. It should be monitored to ensure potability or freedom from pathogens. In particular, water should be free from Pseudomonas species and have no more than one coliform/mL in any one sample. Consecutive samples must not contain coliforms in more than 5% of samples. *Escherichia coli* should not be present.

Water composition standards are given in Table 23. These are unlikely to be exceeded if water comes from a source treated and supplied for human consumption. Water from wells, however, may have excessive nitrate levels and high bacterial counts, due to run-off from fertilized fields. Where bacterial counts are high, the cause should be established and rectified as soon as possible. Chlorination to give a minimum of 3 ppm chlorine at the drinker level can be fully effective. Ultraviolet light can also be used to disinfect water. Manufacturers’ guidelines should be followed in establishing this procedure.

Hard water or water with high levels of iron (>3mg/L) can cause blockages in drinker valves and pipes. Sediment will also block pipes and, where this is a problem, water should be filtered using a 40–50 micron (µm) filter. Water containing high levels of iron can support bacterial growth and should not be used to wash or sanitize eggs.

**Dead Bird Disposal**

**Objective**

To dispose of dead birds in a manner that avoids environmental contamination, cross-contamination with other poultry, becoming a food source to other animals or vermin, and being a nuisance to neighbors.

**Disposal Pits**

Burying in pits is one of the traditional methods of disposal.

**Advantages:**
- Inexpensive to dig and tend to produce a low amount of odor

**Disadvantages:**
- Can be a reservoir for diseases
- Require adequate drainage
- Illegal in some areas due to potential ground water contamination

**Incineration**

Incineration is another traditional method of disposal. If incinerators are used, be sure there is sufficient capacity for future farm needs. When operating, be sure carcasses are completely burned to a white ash.

**Advantages:**
- Does not contaminate ground water
- Does not produce cross-contamination with other birds when grounds are properly maintained
- There is very little byproduct ash to remove from the farm

**Disadvantages:**
- Tends to be more expensive
- May produce air pollution
- In many areas, air pollution regulations limit incinerator use

**Composting**

Composting has become one of the preferred alternatives for on-farm disposal.

**Advantages:**
- Economical
- If designed and managed properly, will not contaminate ground water or air

---

**Table 23: Maximum Acceptable Levels of Minerals and Bacteria in Drinking Water**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Maximum Acceptable Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dissolved solids</td>
<td>300-500 ppm</td>
</tr>
<tr>
<td>Chloride</td>
<td>200 mg/L</td>
</tr>
<tr>
<td>pH</td>
<td>6-8</td>
</tr>
<tr>
<td>Nitrates</td>
<td>45 ppm</td>
</tr>
<tr>
<td>Sulphates</td>
<td>200 ppm</td>
</tr>
<tr>
<td>Iron</td>
<td>1 mg/L</td>
</tr>
<tr>
<td>Calcium</td>
<td>75 mg/L</td>
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<tr>
<td>Copper</td>
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<tr>
<td>Magnesium</td>
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<tr>
<td>Manganese</td>
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<tr>
<td>Zinc</td>
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</tr>
<tr>
<td>Lead</td>
<td>0.05 mg/L</td>
</tr>
<tr>
<td>Fecal coliforms</td>
<td>0</td>
</tr>
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</table>
CONSTRUCTING A COMPOSTER
(See Diagram 18)
• Build a 2.5 m (8 ft) high building with 3.7 m² (40 ft²) of floor space per 10,000 birds breeder capacity.
• The building should have a concrete floor and roof that protects compost from rain.
• Divide building into a minimum of two bins with no more than 3.4 m² (36 ft²) per bin.
• The sidewalls should be constructed of 5 cm x 20 cm (2 in x 8 in) planks that will hold the weight of the compost and also allow air into the compost for aerobic fermentation.

OPERATING A COMPOSTER
• Place a 15 cm (6 in) layer of floor litter on the bottom of the composter.
• Cover this with a 15 cm (6 in) layer of slat litter.
• Dig a 13 cm (5 in) trough in the litter and add 8 cm (3 in) of clean shavings in the trough.
• Place the birds on the shavings along the trough so that they are touching, but keep them at least 15 cm (6 in) away from the edges of the composter.
• Mist the birds with water and cover with 13 cm (5 in) of one part floor litter and one part unused litter.
• The composter requires no further treatment and the composting process should be complete within 30 days.
• Under normal conditions, the temperature of the compost should increase rapidly and reach a peak operating temperature of 57–66°C (135–151°F) within 2–4 days. Because insects, bacteria and other pathogens are killed at temperatures above 46°C (115°F), 55°C (131°F) and 60°C (140°F) respectively, composting effectively destroys these organisms.
• Product from the composter can be used as a soil amendment or fertilizer. Most producers will remove compost from the farm at the same time litter is removed.

Diagram 18: Poultry Compost Facility

Rendering
Some producers dispose of dead birds by hauling them to a rendering plant.

Advantages:
• No on-farm disposal of dead birds
• Requires minimal capital investment
• Produces minimal environmental contamination

Disadvantages:
• Requires freezer units to keep the birds from decomposing during storage
• Requires intense biosecurity measures to prevent personnel from tracking diseases from the rendering plant or other farms to your farm
• Decomposed carcasses will likely contain biogenic amines which can be detrimental to poultry — despite proper rendering

DISEASE CONTROL AND VACCINATION

Disease Control
Objective
To minimize the adverse effects of disease on health and welfare of broiler parent stock and their progeny.

Good management and high standards of hygiene will prevent or minimize the risk of many poultry diseases. One of the first signs of a disease challenge is a decrease in water or feed intake. It is, therefore, good management practice to keep daily records of feed and water consumption. If a problem is suspected, immediate action should be taken by sending birds for post mortem examination and seeking the assistance of a poultry veterinarian. Early appropriate treatment of a disease incident may minimize the adverse effects on bird health, welfare and reproductive performance. Additionally, it will help minimize the effects on progeny health and quality.

Records are an important means of providing objective data for investigating flock problems. Vaccinations, batch numbers, medications, observations and disease investigation results should all be recorded in flock records.
Vaccination Programs

Objective

To provide birds with exposure to a mild or inactivated form of the infectious organism (antigen), which will promote a good immunological response. This will actively protect the bird from subsequent field challenge and/or clinical symptoms and provide passive protection, via maternally derived antibody, to progeny.

Common diseases, including Marek’s Disease, Newcastle Disease (ND), Avian Encephalomyelitis (AE), Chicken Anemia (CAV), Infectious Bronchitis (IB), Infectious Bursal Disease (IBD, also known as Gumboro Disease), should be routinely considered when a vaccination program is prepared. However, vaccination requirements vary. A suitable program should be devised by licensed poultry veterinarians who will use their detailed knowledge of disease prevalence and intensity in a specific country, area or site.

Dyes, vaccine titers and elimination of clinical signs of disease can be used to assess effectiveness of vaccines and vaccine delivery. Excessive vaccination may lead to poor titers and/or wide CV of titers. Overly aggressive vaccination and handling programs can be very stressful on growing chickens — especially from 5–15 weeks of age. Hygiene and maintenance of vaccination equipment is important. It should be noted that titers are not always correlated with protection. The field situation should be considered in evaluating a vaccination program’s effectiveness.

Vaccination can help prevent disease but is not a direct replacement for good biosecurity. Protection against each individual disease should be assessed in devising control strategy. Good biosecurity policies provide adequate protection against some diseases, rendering vaccination unnecessary. Vaccines used in vaccination programs should be limited to only those that are absolutely necessary. Such programs will be less expensive, less stressful and provide greater opportunity to maximize overall vaccine response. Vaccines should be obtained from reputable manufacturers.

Vaccine administration technique has a direct influence on vaccination success. Training of personnel is critical to achieve desired results.

Key Points

- A suitable vaccination program should be designed by a local and certified poultry veterinarian in conjunction with the production/breeder manager.
- Strict implementation of a comprehensive health and biosecurity program is essential for maximum productivity and good welfare and health status of the breeder flocks.
- The severity of infection with many poultry diseases can be exacerbated by the level of stress caused by other factors.
- It is essential to inspect birds routinely to identify early emerging disease or welfare problems.
- Immediate removal of any dead or culled birds from the poultry house is essential to prevent build-up of pathogenic microorganisms and possible disease transmission to healthy birds.

Types of Vaccines

Vaccines for poultry are in two basic forms: live or killed. In some vaccination programs, they may be combined to promote maximum immunological response. Each type of vaccine has specific uses and advantages.

Killed Vaccines: These are composed of inactivated organisms (antigens), usually combined with an oil emulsion or aluminium hydroxide adjuvant. The adjuvant helps increase the response to antigen by the bird’s immune system over a longer period of time. Killed vaccines may contain multiple inactivated antigens to several poultry diseases. Killed vaccines are administered to individual birds by injection either subcutaneously or intramuscularly. Killed bacterins (i.e., salmonella, coryza, cholera) can be very reactive in birds, and therefore, it is critical that vaccine administration be done carefully.

Live Vaccines: These consist of infectious organisms of the actual poultry disease. However, the organisms will have been substantially modified (attenuated) so that they will multiply within the bird but will not cause disease. Some vaccines are exceptional in that they are not attenuated, and therefore, require care before introduction into a vaccination program (e.g. AE vaccine, some coccidiosis vaccines).

In principle, when several live vaccinations to a specific disease are given, the most attenuated is normal-
ly given first, followed by less attenuated strains. This principle is commonly utilized for ND live vaccination when pathogenic field challenge is anticipated.

Occasionally, non-attenuated live vaccines are used in poultry vaccination programs. They are administered either via a route which the pathogen would not normally enter (e.g. the wing web route with fowl pox) or by exposure to the vaccine during the period when disease does not occur (e.g. CAV exposure to birds during rearing).

Live vaccines are usually administered to the flock via drinking water, spray or eye drop application. Occasionally live vaccinations are given by injection (e.g. Marek’s Disease vaccine).

Live bacterial vaccines have been uncommon. Salmonella and mycoplasma vaccines are now available and may have a place in some production systems. Some competitive exclusion products may help protect parent stock from salmonella, and possibly other infections, early in life or after antibiotic treatment.

Combined Live and Killed Vaccinations: The most effective method of achieving high and uniform antibody levels to a disease is by the use of one or more live vaccines containing the specific antigen, followed by injection of the killed antigen. The live vaccines ‘prime’ the bird’s immune system and facilitate a very good antibody response when the killed antigen is presented. This type of vaccination program is routinely used for many diseases (e.g. IB, ND and IBD). It ensures active protection of the bird and provision of high and uniform levels of maternally derived antibody. This allows passive protection for progeny.

Specific Vaccination Programs

Marek’s Disease: Marek’s Disease vaccines are all live vaccines and three different serotypes are available. All broiler parent stock should receive Marek’s Disease vaccine at day old. Usually this is a combination of cell-associated Turkey Herpes Virus (also known as HVT) and Rispens’ (CVI-988). This combination provides serotypes 3 (HVT) and 1 (Rispens’) simultaneously — the most commonly used combination in broiler breeders today.

Newcastle Disease (ND): Where field challenge with pathogenic strains is anticipated, the mild live B1 vaccine strain is usually followed by the stronger La Sota vaccine strain. La Sota vaccine is not licensed in all countries and some countries do not vaccinate against ND (e.g. Denmark, Sweden and Finland). In areas where Velogenic and Viscerotropie Newcastle Disease (VVND) is endemic, an early administration of inactivated vaccine (usually 7 days to 4 weeks) has been highly effective to protect flocks at risk.

Infectious Bronchitis (IB): H120 or other mild Massachusetts strain live vaccine viruses are normally used to prime birds for IB. H52 live vaccine virus is less attenuated and should not be given to unvaccinated birds. Variant IB isolates have emerged over the years and frequently require the use of IB vaccines, which contain the variant antigen to achieve good protection. Make sure the variant has been isolated and identified locally and that it is legal to use. For maximum protection, these variant antigens should be available in both live ‘priming’ vaccines and killed vaccines.

Infectious Bursal Disease (IBD): A wide range of live IBD vaccines are available for priming broiler parent stock. Intermediate strains should be given first. The use of stronger vaccines after the use of intermediate types helps in priming birds. The most important priming vaccine is that one given after the bird is immunologically mature (between 4 and 6 weeks of age).

ND/IB/IBD: A killed injection containing antigens to ND/IB/IBD is usually given at 18 weeks or at transfer to laying house. Some inactivated vaccines containing more antigens (e.g. Reovirus strains) are now available.

Avian Rhinotracheitis (ART) or Avian Pneumovirus (APV): Combinations of live and killed vaccines are considered to be most effective in protecting parent stock and their progeny.

Avian Encephalomyelitis (AE): A single dose of a live vaccine given in the drinking water or wing web between 8 and 12 weeks of age can give lifelong protection to the breeding bird. Killed vaccine has also occasionally been used effectively to control AE.

Chicken Anemia Virus (CAV): This vaccine is commonly administered at approximately 8 weeks of age. A single dose of a live, non-attenuated vaccine administered via the drinking water has been used to give lifelong protection to the broiler parent. A live attenuated vaccine is also available which is given by wing web injection at 9–12 weeks of age.
Reovirus Infections: Reovirus infections have been associated with a number of disease conditions, the most widespread being Viral Arthritis (VA) and some forms of the so-called malabsorption syndrome. Combinations of live and killed vaccines can be used to protect the bird, prevent vertical transmission and pass on maternally derived antibody to progeny. Care and consideration should be given when introducing live Reovirus vaccination into the overall parent stock vaccination program, especially if administered early in life. Maternal antibodies may interfere with vaccine uptake. Some live Reovirus vaccines may have the potential to induce disease, especially in young birds. A combination of two killed injections without the use of a live priming vaccination, at approximately 6 and 16 weeks has been used to protect parent stock and provide high levels of maternally derived antibody to progeny. A suitable program should be designed by a local and licensed poultry veterinarian who should take into account flock history, regional disease challenge and antibody levels.

Fowl Cholera (Pasteurella multocida) and Infectious Coryza (Haemophilus paragallinarum): These are bacterial diseases. In areas or farms where the diseases are considered to be endemic, control can be enhanced by using killed vaccines. These killed vaccines usually contain several strains of the organism to broaden protection level. Two killed antigen injections, approximately 4–6 weeks apart, are usually administered during rearing. Live pasteurella vaccines are available which confer a wide range of immunity. In many cases using a killed pasteurella product, followed by a live product, solves recurring pasteurella problems. Coryza is more common in tropical humid climates.

Egg Drop Syndrome 1976 (EDS '76): This disease is common in some world areas. Control can be enhanced by using a single, killed oil adjuvant vaccine. EDS vaccines are usually administered intramuscularly between 14 and 18 weeks of age.

Salmonella: Salmonella vaccination of parent stock can be useful where there is poor control of feed contamination and environmental challenges. Killed vaccines can decrease vertical transmission. Recently, live mutant salmonella vaccines have been used alone, or in combination with killed vaccines, to protect flocks against prevalent salmonella species.

Coccidiosis: Vaccination of broiler parents with live coccidiosis vaccines at day old in the hatchery is the method of choice for controlling this condition. Care should be taken to prevent subsequent flock exposure to substances with anticoccidial activity (except where recommended by the vaccine manufacturer). Coccidiosis can also be controlled by using anticoccidial drugs in feed. Management conditions and nutrition can significantly affect development of adequate coccidial immunity and prevention of adverse post-vaccinal reactions and/or field outbreaks.

WORM (HELMINTH) CONTROL
It is important to monitor and control the internal worm burden (helminth parasites) to which birds are exposed. Birds should routinely receive two doses of an anthelmintic drug during the rearing period where required. Monitoring efficiency of the control program through routine post-mortem examination of culled birds can determine the necessity for additional treatment at approximately 22 weeks of age.

NON-INFECTIOUS DISEASE
Some non-infectious diseases can be confused with viral infections.

Peritonitis. Although E. coli is often isolated, this does not appear to be the primary cause. Rather, poor body weight uniformity and/or excessive feeding and lighting will cause erratic ovulation defective egg syndrome (EODES) and peritonitis. This condition appears to be secondary to poor control of ovarian development. Excessive yolk material for reab- sorption through the peritoneum increases the risk of peritonitis with opportunistic invasion by E. coli and other bacteria. Treatment is largely unsuccessful but peritonitis can be prevented in subsequent flocks by improving body weight and lighting management.

Tendinitis/Arthritis with Secondary Staphylococcal Infection. Factors affecting incidence of this disease include underweight for age, excessive bird activity, poor coccidiosis control, improper beak trimming, contamination during parenteral inoculations, poor litter management, excessive and/or rough handling, lack of adequate feeder space, improper lighting programs and marginal nutrition. Slat height and condition have a direct influence on the incidence of the problem. Moving birds or faulty application of controlled feeding can precipitate problems such as staphylococcal tendinitis. This malady is often confused with Reovirus-associated tenosynovitis and arthritis.
Swollen Head Syndrome. Improper separate-sex feeding equipment may cause damage to birds’ heads. This can be mistaken for Swollen Head Syndrome associated with avian pneumovirus infection. Also, incorrectly administered killed vaccines to the back of the neck can cause head swelling.

Sudden Death Syndrome (SDS) and Calcium Tetany. This occurs in broiler parents at point of lay and can be well controlled by careful nutrition and feeding program management. Metabolic problems at point of lay can be triggered by inappropriate dietary phosphorus, potassium and calcium levels. Use of a breeder diet with a higher calcium level (approximately 3%) is not recommended until 5% hen-day production (see Nutritional Section for specific recommendations, page 48).

**HEALTH MONITORING PROGRAMS**

**Objectives**

*To confirm freedom from specific pathogens that can adversely affect the health, welfare and reproductive performance of broiler parent stock and the health, welfare and quality of the progeny.*

*To identify disease presence at an early stage so corrective measures can be implemented to minimize adverse effects to the flock or their progeny.*

**Sampling for the Presence of Disease**

Monitoring for most diseases in a population should be designed to detect a prevalence of at least 5%, with a 95% confidence level. For those population sizes, which normally apply to broiler parent flocks (i.e., >500 birds), approximately 60 samples should be taken when monitoring each flock. Traditionally, a higher level of monitoring is carried out at 20–22 weeks of age — especially for mycoplasmas and salmonella. Usually 10%, or a minimum of 100 samples, are tested at this critical time. Frequency of testing will vary with the individual disease and local regulatory or trading requirements.

**SALMONELLA**

*Salmonella pullorum* and *S. gallinarum* are strains which are specific to poultry. Control is monitored by detecting presence of specific blood antibodies using an agglutination test. This can be carried out either on the farm using whole blood or in the laboratory using serum. Many countries have official government programs for control and eradication of both *S. pullorum* and *S. gallinarum*. Both commercial and government supplies of specific antigens are available in many countries. Absence of these infections can also be monitored by hatchery microbiological surveys.

Presence of paratyphoid salmonellae is usually detected by bacteriological examination of the bird and its environment. Progeny can be monitored as it arrives from the hatchery. Many salmonellae can affect both birds and man (zoonoses). *S. Enteritidis* and *S. typhimurium* are of particular importance and can readily be transmitted vertically to broiler progeny. Specific commercial ELISA tests for *S. enteritidis* and *S. typhimurium* are available and can be used in a manner similar to the agglutination test for *S. pullorum* and *S. gallinarum* to detect specific antibody in serum. Cull birds, cloacal swabs, fresh fecal droppings, litter, drag swabs and dust samples have all been used to monitor flocks for salmonella. Hatchery samples include dead-in-shell, cull chicks, hatcher tray papers (where available), chick box liners, meconium and hatchery fluff. Samples can be pooled, usually in tens, to facilitate practical laboratory processing.

**MYCOPLASMOSIS**

Blood samples taken from parent flocks should be monitored routinely for both *Mycoplasma gallisepticum* and *M. synoviae* using the rapid serum agglutination test (RSPA) or specific, single or combined commercial ELISA tests. Positive test results by RSPA/ELISA should be confirmed by HI, culture or PCR. Many things (e.g. recently given killed vaccine) can cause false positive reactions on the plate test and ELISA.

**EGG DROP SYNDROME 1976 (EDS ’76)**

Specific haemagglutination inhibition or ELISA tests can be used to verify absence of EDS ’76, where required. Where drinking water for poultry is drawn from surface water supplies where wild birds (especially waterfowl) have access, chlorination should be undertaken. This will also give protection against Avian Influenza.
OTHER DISEASES

Serological monitoring for presence of other diseases can be carried out routinely, or as is more common, following clinical signs and/or a drop in production. Serological monitoring for diagnostic purposes can include diseases against which flocks have been previously vaccinated (e.g. ND, IB and Avian Rhinotracheitis). Field challenge is suggested when a higher than normal antibody response occurs in the flock.

TRADE BETWEEN COUNTRIES

Certification of freedom from specific avian pathogens is required when products from a flock, either eggs or day-old chicks, are traded between countries. The specific requirements will vary from country to country. Government veterinary advisers should be consulted for requirements of trade between countries.

Monitoring the Effectiveness of Vaccination Programs

Objective:
To monitor vaccination program effectiveness by assessing specific antibody levels at various ages throughout the life of the flock.

For CAV and AE, serological testing one month after vaccination is useful for determining whether one should revaccinate flocks which have not sero-converted before onset of lay. IBD titers and titers CV% of parent stock may be used to predict timing of broiler vaccinations for IBD.

Vaccination programs provide both active protection to parent stock and passive protection to progeny by providing high, uniform levels of maternally derived antibodies. However, it is important to monitor their effectiveness.

Monitoring vaccination programs is achieved by measuring the level of specific antibodies in individual birds and by assessing the range of response in the number of birds sampled. Usually, a minimum of 18 blood samples per group is used. Various quantitative tests, including haemagglutination inhibition test, agar gel diffusion test and ELISA test, have been used to quantify antibody response in vaccinated flocks. The ELISA test is considered to be more specific, sensitive and repeatable and can be automated to enhance serological testing efficiency.

Routine testing after killed vaccination around onset of lay can allow maternal antibodies to be predicted for the total period of lay. Cross-reactions in mycoplasma serology are commonly seen in birds for a 2-week period after the use of killed vaccines, so sampling during this time period should be avoided.