POULTRY INDUSTRY MANUAL

FAD PReP

Foreign Animal Disease Preparedness & Response Plan

National Animal Health Emergency Management System

USDA

the Center for Food Security & Public Health
IOWA STATE UNIVERSITY®

United States Department of Agriculture • Animal and Plant Health Inspection Service • Veterinary Services

MARCH 2013

Poultry Industry Manual

The *Foreign Animal Disease Preparedness and Response Plan (FAD PReP)/National Animal Health Emergency Management System (NAHEMS) Guidelines* provide a framework for use in dealing with an animal health emergency in the United States.

This FAD PReP Industry Manual was produced by the Center for Food Security and Public Health, Iowa State University of Science and Technology, College of Veterinary Medicine, in collaboration with the U.S. Department of Agriculture Animal and Plant Health Inspection Service through a cooperative agreement.

The FAD PReP Poultry Industry Manual was last updated in March 2013. Please send questions or comments to:

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Poultry Industry Manual

Information provided here is meant to be used as a preparedness resource rather than a comprehensive document. Several key APHIS documents complement this "FAD PReP Poultry Industry Manual" and provide further details when necessary. This document references the following APHIS documents:

- APHIS APHIS Foreign Animal Disease Framework documents
- FAD PReP/National Animal Health Emergency Management System Guidelines:
    - Biosecurity (2011)
    - Cleaning and Disinfection (2011)
    - Disposal (2012)
    - Personal Protective Equipment (2011)
    - Mass Depopulation and Euthanasia (2011)
    - Vaccination for Contagious Diseases (2011)
- FAD PReP Standard Operating Procedures (SOP):
    - Biosecurity
    - Cleaning and Disinfection
    - Disposal
    - Personal Protective Equipment
    - Mass Depopulation and Euthanasia
    - Vaccination for Contagious Diseases
- HPAI Response Plan: The Red Book, USDA-APHIS, September 2012
- VS Guidance 12001.1 Policy for the Investigation of Potential Foreign Animal Disease/Emerging Disease Incidents (FAD/EDI)

These documents and many others are available on the USDA-APHIS National Center for Animal Health and Emergency Management website at *http://www.aphis.usda.gov/animal_health/*

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THE IMPERATIVE FOR FOREIGN ANIMAL DISEASE PREPAREDNESS AND RESPONSE

WHY FOREIGN ANIMAL DISEASES MATTER

Preparing for and responding to foreign animal diseases (FADs), like highly pathogenic avian influenza (HPAI) and foot-and-mouth disease (FMD), are critical measures to safeguard our nation's animal health, public health, and food supply.

There are significant potential consequences of an FAD outbreak in the United States. In addition to the economic impact, the social and psychological impact on both producers and consumers could be severe. The FMD outbreak in the United Kingdom had an estimated impact of between $12–18 billion. Studies have estimated a likely national welfare loss between $2.3–69 billion[1] for an FMD outbreak in California, depending on delay in diagnosing the disease[2].

CHALLENGES OF RESPONDING TO AN FAD EVENT

An FAD outbreak will be challenging for all stakeholders. For example, there will be disruptions to interstate commerce and international trade. Response activities are complex, and significant planning and preparation must be conducted before an outbreak. Outbreaks can become large and widespread. Large, geographically dispersed and diverse teams will need to be assembled rapidly and must react quickly. The response effort must have the capability to be rapidly scaled up, involving many times more resources, personnel, and countermeasures. As such, responding to an FAD—large or small—may be a very complex and difficult effort.

LESSONS LEARNED FROM PAST FAD OUTBREAKS

Past outbreaks both in the United States and in other countries offer important lessons that can be applied to preparedness and response efforts. To achieve successful outcomes in future FAD response, it is vital to identify, understand, and apply these lessons learned:

- Provide a unified State-Federal-Tribal-industry planning process that respects local knowledge.
- Ensure the unified command sets clearly defined and obtainable goals.
- Have a unified command that acts with speed and certainty to achieve united goals.
- Employ science-based and risk-management approaches that protect public health and animal health, stabilize animal agriculture, the food supply, and the economy.
- Ensure guidelines, strategies, and procedures are communicated and understood by responders and stakeholders.
- Acknowledge that high expectations for timely and successful outcomes require the:
  - Rapid scale-up of resources and trained personnel for veterinary activities and countermeasures, and
  - Capability to quickly address competing interests before or during an outbreak.
- Rapid detection and FAD tracing is essential for the efficient and timely control of FAD outbreaks.

1. Carpenter TE, O'Brien JM, Hagerman AD, & McCarl BA. 2011. "Epidemic and economic impacts of delayed detection of foot-and-mouth disease: a case study of a simulated outbreak in California." J Vet Diagn Invest. 23:26-33.
2. Estimates based on models may vary: Ekboir (1999) estimated a loss of between $8.5 and $13.5 billion for an FMD outbreak in California. Ekboir JM. 1999. "Potential Impact of Foot-and-Mouth Disease in California: the Role and Contribution of Animal Health Surveillance and Monitoring Services." Agricultural Issues Center. University of California, Davis.

FAD PREP MISSION AND GOALS

The significant threat and potential consequences of FADs and the challenges of and lessons learned of effective and rapid FAD response have led to the development of the Foreign Animal Disease Preparedness and Response Plan, also known as "FAD PReP." The mission of FAD PReP is to raise awareness, expectations, and develop capabilities surrounding FAD preparedness and response. The goal of FAD PReP is to integrate, synchronize, and deconflict preparedness and response capabilities as much as possible before an outbreak, by providing goals, guidelines, strategies, and procedures that are clear, comprehensive, easily readable, easily updated, and that comply with the National Incident Management System.

In the event of an FAD outbreak, the three key response goals are to: (*1) detect, control, and contain the FAD in animals as quickly as possible; (2) eradicate the FAD using strategies that seek to stabilize animal agriculture, the food supply, the economy, and protect public health; and (3) provide science- and risk-based approaches and systems to facilitate continuity of business for non-infected animals and non-contaminated animal products.* Achieving these three goals will allow individual livestock facilities, States, Tribes, regions, and industries to resume normal production as quickly as possible. They will also allow the United States to regain FAD-free status without the response effort causing more disruption and damage than the disease outbreak itself.

FAD PReP DOCUMENTS AND MATERIALS

FAD PReP is not just one, standalone FAD plan. Instead, it is a comprehensive US preparedness and response strategy for FAD threats. This strategy is provided and explained in a series of different types of integrated documents, as illustrated and described below.

FAD PReP Suite of Documents and Materials

Note: APHIS=Animal and Plant Health Inspection Service, NAHEMS = National Animal Health Emergency Management System, SOP = standard operating procedures.

Strategic Plans—Concept of Operations

- *APHIS Foreign Animal Disease Framework documents:* These documents provide an overall concept of operations for FAD preparedness and response for APHIS, explaining the framework of existing approaches, systems, and relationships.
- *National Center for Animal Health Emergency Management (NCAHEM) Stakeholder Coordination and Collaboration Resource Guide:* This guide describes key stakeholders with whom NCAHEM collaborates.
- *NCAHEM Incident Coordination Group Plan:* This document explains how APHIS headquarters will organize in the event of an animal health emergency.

NAHEMS Guidelines

- These documents describe many of the critical preparedness and response activities, and can be considered as a competent veterinary authority for responders, planners, and policy-makers.

Industry Manuals

- These manuals describe the complexity of industry to emergency planners and responders and provide industry a window into emergency response.

Disease Response Plans

- Response plans are intended to provide disease-specific information about response strategies. These documents offer guidance to all stakeholders on capabilities and critical activities that would be required to respond to an FAD outbreak.

Critical Activity Standard Operating Procedures (SOPs)

- For planners and responders, these SOPs provide details for conducting 23 critical activities such as disposal, depopulation, cleaning and disinfection, and biosecurity that are essential to effective preparedness and response to an FAD outbreak. These SOPs provide operational details that are not discussed in depth in strategy documents or disease-specific response plans.

Continuity of Business (commodity specific plans developed by public-private-academic partnerships)

- *Secure Egg Supply (SES) Plan:* The SES Plan uses proactive risk assessments, surveillance, biosecurity, and other requirements to facilitate the market continuity and movement of eggs and egg products during an HPAI outbreak.
- *Secure Milk Supply (SMS) Plan:* Currently under development, the SMS Plan will help facilitate market continuity for milk and milk products during an FMD outbreak. This Plan also will employ proactive risk assessments.
- *Secure Pork Supply (SPS) Plan:* Currently under development, the SPS Plan will help facilitate market continuity for pork and pork products during an FMD, classical swine fever, swine vesicular disease, or African swine fever outbreak.
- *Secure Turkey Supply (STS) Plan:* Currently under development, the STS Plan will help facilitate market continuity for the turkey sector during an HPAI outbreak.

Outbreak Response Tools

- Case definitions, appraisal and compensation guidelines and formulas, and specific surveillance guidance are examples of important outbreak response tools.

State/Tribal Planning

- State and Tribal planning is essential for an effective FAD response. These plans are tailored to the particular requirements and environments of the State or Tribal area, taking into account animal populations, industry, and population needs.

Industry, Academic, and Extension Planning

- Industry, academia, and extension stakeholder planning is critical and essential: emergency management is not just a Federal or State activity.

APHIS Emergency Management

- APHIS directives and Veterinary Services (VS) Memorandums provide critical emergency management policy. APHIS Emergency Management documents provide guidance on topics ranging from emergency mobilization, to the steps in investigating a potential FAD, to protecting personnel from HPAI.

Chapter 1: Broiler Industry

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Chapter 1: Broiler Industry

PART I: UNITED STATES BROILER PRODUCTION

1.1 SCOPE OF THE BROILER INDUSTRY

Broiler chickens are bred and raised for meat production. The broiler industry is the most advanced system of animal food production and the United States has the world's largest broiler industry. In 2012, data released by the National Chicken Council indicates that the broiler industry provides over 1 million jobs, $47 billion in wages, $197 billion in economic activity, and $17.2 billion in government revenue. Today's broiler industry consists of around 40 vertically integrated companies which contract with about 29,500 farmers who produce 95% of this nation's broiler chickens. About 5% of broilers are produced on company-owned farms. Since 2009, foreign ownership of US broiler companies has increased and now accounts for an estimated 25% of total production. The largest broiler companies, Tyson Foods and JBS-owned Pilgrim's Pride, are transnational, multi-animal protein companies with global marketing and distribution of their products. The top five broiler companies in this country are listed in Table 1 below.

Table 1. Leading Broiler Production Companies (2012)

National Ranking	*Company*	*Headquarters Location*	*Estimated Market Share (%)*
1	Tyson Foods, Inc.	Arkansas	27.1
2	Pilgrim's Pride	Colorado	24.1
3	Sanderson Farms	Mississippi	9.2
4	Perdue Farms	Maryland	8.9
5	Koch Foods, Inc.	Illinois	7.8

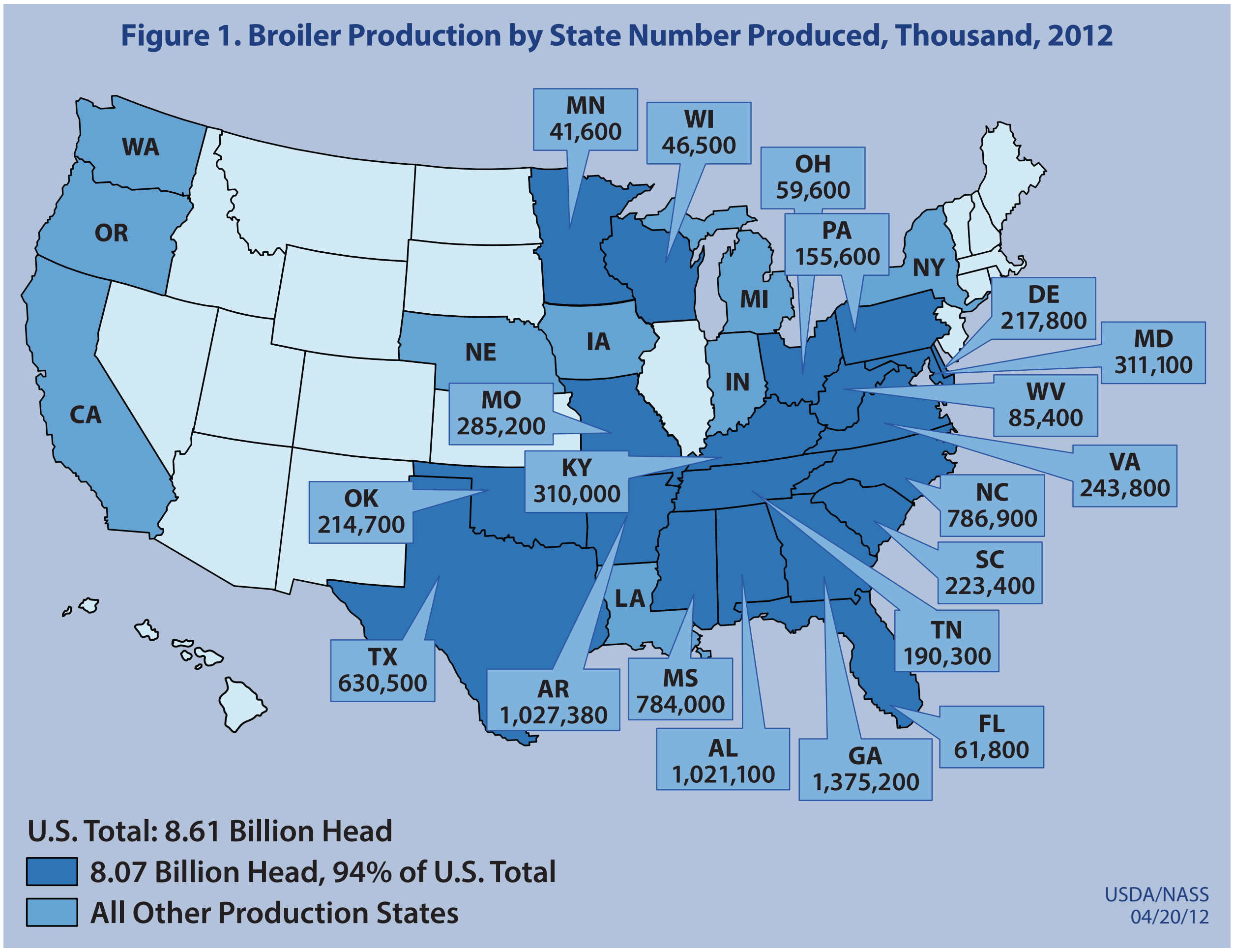
1.1.1 Broiler Numbers and Location

Approximately 9.0 billion broiler chickens are produced in this country each year with a combined live weight of 50 billion pounds resulting in the annual marketing of 36.5 billion pounds of chicken products on a ready-to-cook basis. Broiler chickens are marketed at an average age of 47 days with an average live weight of 5.80 pounds. The target weight of broilers at processing may be more or less than the average live weight, depending on the market and requirements of the processing plant. Average feed conversion of broiler chickens is 1.91 and average mortality from placement to marketing is 3.8%. The broiler industry in the United States is concentrated in the Southeast, due to a favorable climate and proximity to grains and final markets. The top five broiler-producing states are listed in Table 2 below.

Table 2. Leading Broiler Production States (2012)

National Ranking	*State*	*Billions of Broilers*
1	Georgia	1.362
2	Alabama	1.004
3	Arkansas	0.977
4	North Carolina	0.800
5	Mississippi	0.751

Broiler production by state is shown in Figure 1, below.



1.1.2 Broiler Industry Structure

1.1.2.1 Contract Production

During the 1950s, contract growing of broiler chickens began in response to farmers losing their farms due to risks associated with financing chicks and feed. Consequently, feed companies, hatcheries, and others began to provide financing and credit for growing broiler chickens. Contractors (financiers) assumed most of the financial risk and profits were shared between the financier and the contract grower. Today, vertically integrated broiler companies are the primary contractors; independent contract growers produce 95% of broiler chickens. Broiler companies furnish chicks, feed, medication, flock supervision, and labor and equipment for catching and transporting broiler chickens from the farm to the processing plant. Growers furnish houses, equipment (feeders, waterers, brooders, and fans), water, electricity, fuel, litter, and labor and follow management protocols specified by the processing company (integrator). Chickens belong to the integrator, not the contract grower. However, when a chicken dies, proper disposal of the carcass is the responsibility of the grower. Contract growers are dedicated to a specific company and specific processing plant and are usually paid based on the number of pounds of live broiler chickens delivered to the processing plant and production efficiency parameters including feed conversion ratio and overall cost of production. Growers should visit each flock twice daily to remove moribund or dead birds, adjust the height of feeders and waterers, check for proper ventilation, and monitor litter moisture content to avoid excess ammonia production.

1.1.2.2 Vertical Integration

Before 1950, the broiler industry consisted of tens of thousands of small businesses. With the advent of vertical integration in the 1950s, those thousands became an industry of hundreds. Vertical integration is a business arrangement wherein multiple stages of the production and marketing system are owned by one enterprise. By the mid-1960s, over 90% of broilers came from integrated farms. During the ensuing years, consolidation resulted in merging of companies to form the 40 odd companies that comprise today's industry. Vertically integrated broiler companies own breeder flocks, hatcheries, chickens in the broiler houses, feed mills, processing plants, and a fleet of trucks. Trucks are needed to transport chicks from hatcheries to farms, feed from the feed mill to farms, broiler chickens from farms to the processing plant, and often product to buyers. Vertical integration allows coordination of capacities at each stage of production and creates one profit center. This system allows a high degree of control over how broiler chickens are raised, fed, and processed and results in use of the best available technology and management to produce and process chickens. An integrated broiler operation, usually referred to as a complex or division, typically has a centrally located hatchery, feed mill, and processing plant that coordinate with pullet, breeder, and broiler farms. Processing plant capacity determines the number of farms required to provide a steady supply of chickens for the plant and the size of the feed mill needed to provide feed for chickens and breeders on those farms. Transportation costs associated with moving feed are significant and many companies require contract grower farms to be located within a 10-30 mile radius from the feed mill. Production and processing of 1 million broilers per week with an 8-week cycle requires 400 houses with an average capacity of 20,000 broilers. A typical broiler farm has four houses.

Integrators closely monitor factors affecting cost of production down to hundredths of a cent per pound. These factors include morbidity, mortality, rate of daily gain, feed conversion, and condemnations. Company veterinarians constantly monitor flocks for disease problems, which are quickly identified and corrected. Integrated companies are closed marketing systems and do not buy or sell birds in open livestock markets. There is little crossover of birds, people, or equipment between farms and between companies. Broilers are produced under single-age, all-in all-out production schemes which break the chain of disease transmission from one flock to the next. Extensive biosecurity programs limit access to poultry houses and encourage use of dedicated clothing and boots, discourage sharing of equipment, and prohibit contact with other birds including pets and other poultry.

1.1.3 Service Technicians

Service technicians are a critical part of broiler flock husbandry. Service technicians are employed by the integrator and act as a liaison between contract growers and company management. Company expectations and policy changes are presented to the growers by service technicians. Service technicians assist with scheduling chick arrivals, feed deliveries to farms, and final load-out for processing. Typically, service technicians visit each farm weekly and provide advice on best management practices for the strain of broiler chicken being grown to achieve the company's target market weight.

1.1.3.1 Responsibilities and Monitoring

Measurements are taken at specific times during grow-out and are monitored to evaluate flock health and progress. These measurements include water and feed consumption, mortality rates, and body weights. As flocks approach market weight, service technicians spot-weigh broilers and calculate the average rate of daily gain. This information, along with current health of the flock, is used to schedule flocks for processing. An unexplained decline in water consumption paired with a drop in feed consumption may indicate a disease challenge or equipment malfunction. Early investigation of flock problems by the grower and service technician is necessary to prevent large-scale problems from developing, and communication between the two is important.

1.1.3.2 Health Maintenance

Service technicians work with company veterinarians to diagnose and treat diseases. Service technicians typically perform on-site necropsies on several birds to help determine a disease diagnosis. Once a disease has been diagnosed and the company veterinarian has been consulted, field technicians determine the best way to handle the particular disease situation and may administer medication via water or feed and make recommendations to the grower.

1.2 BREEDING FLOCKS

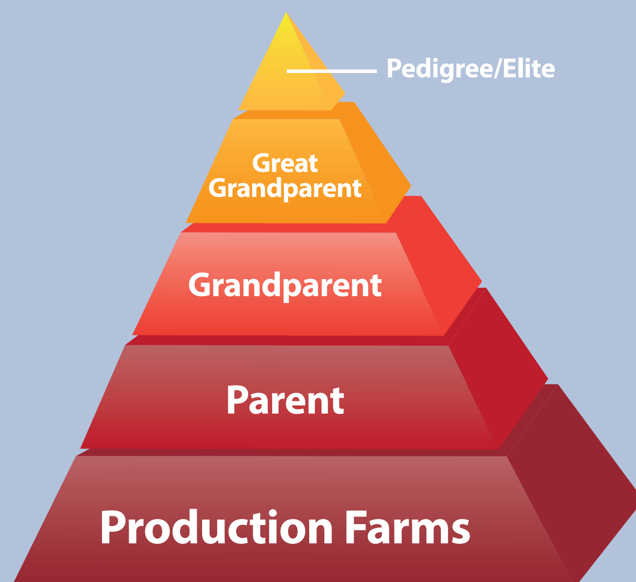
1.2.1 Primary Breeders

Primary breeding companies are large international enterprises with geneticists, nutritionists, veterinarians, and computer specialists on their staffs. Today, there are only three major primary broiler breeding companies in the world – Cobb-Vantress, Aviagen, and Hubbard. Cobb-Vantress incorporated the Hybro breed in 2007 and focuses on selection for feed conversion because feed is the single largest cost associated with producing broiler chickens. Aviagen's product portfolio includes Ross, Arbor Acres, and Lohmann Indian River (LIR) brands. Aviagen is the largest broiler breeding company in the world with 44% of global market share and operates in over 85 countries. Hubbard is owned by Groupe Grimaud, the second largest multi-species animal breeding company around the world. Hubbard has a presence in nearly 100 countries and offers a range of genetic products to meet specific needs for different market segments.

Primary breeding companies increase the genetic potential of broiler chickens by selecting for traits that improve production efficiency, such as rapid growth rate, feed efficiency, and breast meat yield and quality. Broiler breeding programs rely on quantitative genetics, computer science, and DNA chip technology to select breeding birds. DNA chip technology is a new genomic selection tool, which has been used to identify key genetic markers (single nucleotide polymorphisms) in pedigree selection programs. Genomic information is particularly helpful when selecting for sex-limited traits. Also, new measuring techniques, such as computer tomography to produce whole body reconstructions of broilers in three dimensions, have been included as one of the selection criteria. Primary breeding companies publish management guides for breeder and commercial broilers with standards of expected performance.

Genetic improvement of commercial broilers is achieved by using a production pyramid. A representative genetic pyramid illustrating production of broiler breeders is shown in the following figure. Primary breeders consist of pedigree, great grandparent, and grandparent generations that are owned by primary breeder companies. Eggs from pedigree flocks are hatched to produce great grandparent flocks, eggs from great grandparent flocks yield chicks for the grandparent generation. Grandparents consist of male and female lines, both of which are 2-way cross hybrids. Day-old chicks from male and female line grandparent stock are shipped to franchise hatcheries world-wide to create parent breeding flocks. Breeding the male and female parent lines together results in a 4-way cross broiler chicken. Primary breeder flocks are maintained under the highest level of biosecurity possible because of their value and critical importance in the production pyramid (Figure 2).

Figure 2. Structure of the U.S. Poultry Industry



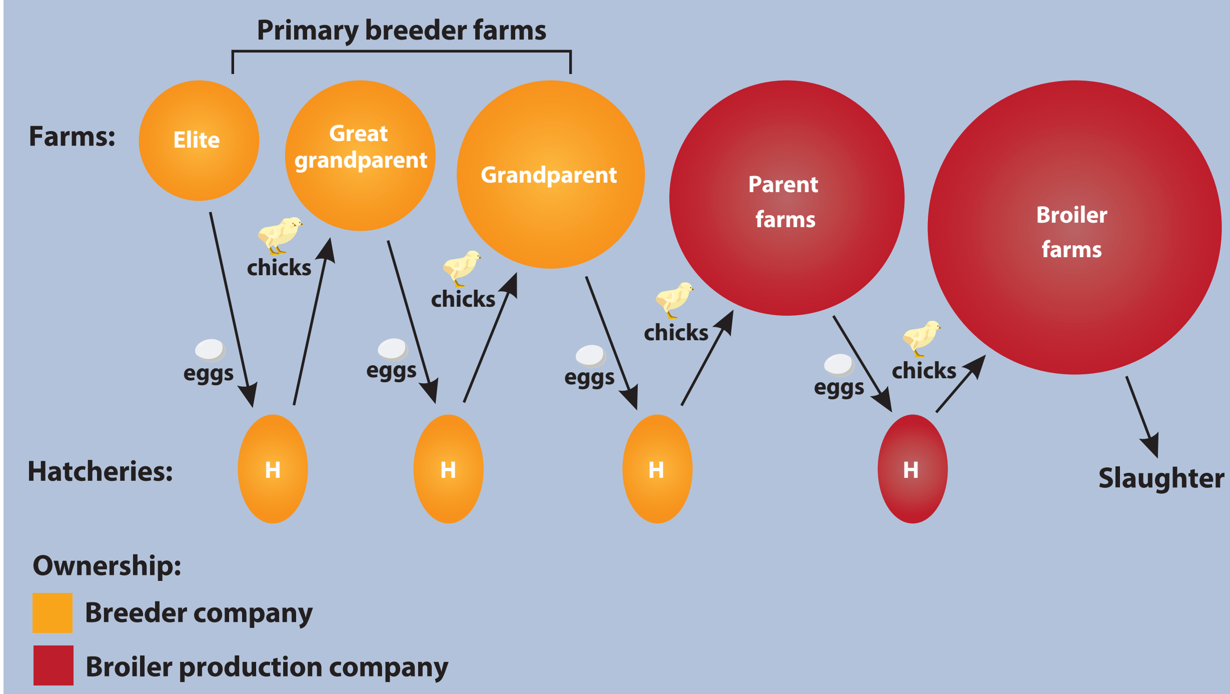
Live weights and feed utilization of commercial broilers have steadily improved over the last 50 years and over 90% of this improvement can be attributed to genetic changes. However, optimal nutrition, disease control, and environmental conditions must be provided for broiler chickens to reach their genetic potential.

Selection for rapid growth over many generations has reduced the ability of broiler breeders to produce high quality eggs in large numbers. A strong negative correlation between rapid growth and reproductive efficiency has resulted in broiler breeder hens with lower peak egg production and a shorter duration of lay than egg-type chickens. In addition, a positive correlation exists between high growth rates and multiple ovulations. Multiple ovulations result in eggs which are unsuitable for incubation because of double-yolks and thin or soft shells. Maintenance of fertility, hatchability, and egg production are important issues in the broiler breeder industry.

1.2.2 Parent Breeders

Parent breeding flocks are typically owned by commercial broiler companies. Eggs produced by parent flocks are transported to company-owned hatcheries. Chicks from these hatcheries are taken to commercial broiler farms that are owned or contracted to the company. The chicks are raised as commercial broilers, slaughtered in company-owned processing plants, and marketed for human consumption. The relationship between primary breeders, parent breeders, and commercial broilers is illustrated in the Figure 3 below.

Figure 3. Primary Breeders, Parent Breeders, and Commercial Broilers



1.2.3 Breeder Houses

In a typical breeder house, 2/3 of the floor is covered by wooden or plastic slats located on each side of the house and the center 1/3 of the floor consists of a litter-covered scratch and breeding area in the center of the house. Slat and litter houses allow for a higher stocking density, which reduces the housing cost per bird. Rows of automated mechanical nests are located on the slats near the edge of the scratch areas on each side of the house. Slats extend beyond the front of the automated nests and waterlines and female feeding lines are placed over the slats. Fewer eggs are laid on slat and litter floors than on all-litter floors, especially in houses with mechanical nest systems. Floor eggs should not be set because they are heavily contaminated with bacteria on the surface of the shells. Bacteria can invade the eggs, multiply, and potentially cause eggs to explode, which contaminates the incubator. In addition, a relatively high percentage of floor eggs may be broken, destroyed, or eaten). Most droppings are collected in an area beneath the slats which helps maintain the quality of litter in the centrally located scratch area. Temperature in the breeding house should be maintained between 59°F and 77°F.

Scratch and Breeding Area

Feeding and Waterlines

Biosecurity is higher on breeder farms than it generally is on commercial broiler farms, but it is not as stringently applied as on primary breeder farms. Breeder farms play a critical role in the operation of an integrated broiler company. Loss of a breeder flock to disease is not only costly, but loss of projected production from that flock makes losses much greater.

1.2.4 Photostimulation

Environmentally controlled rearing ("pullet") houses need to be light-proofed so light intensity is less than 0.5 lux (0.05 foot-candles) when lights are off. Fans and air inlets are covered with light traps to exclude natural daylight; all light is supplied by electric lighting. Black-out pullet houses allow farm managers to control the age of sexual maturity by conditioning the brain to respond to subsequent stimulatory long day lengths. Chickens do not initiate testicular and ovarian development until they are exposed to increased day length and light intensity. Light-proof pullet housing makes it possible for farm managers to improve flock uniformity by delaying light stimulation until a high percentage of pullets in a flock are physically and reproductively mature. If the flock is provided sufficient feed at the time of photostimulation to support both maintenance and egg production, small hens not producing eggs consume more feed than required for maintenance and become overweight prior to onset of egg production. Ultimately, they will produce fewer eggs with reduced fertility and hatchability. Flocks stimulated at older ages have a greater percentage of hens with mature reproductive systems than flocks stimulated at younger ages. Males and females are reared on the same lighting program to ensure both sexes reach sexual maturity at the same time. A lighting program for broiler breeder chickens reared and producing eggs in light-controlled houses is given below from the Cobb Broiler Breeder Management Guide (2008).

Table 3. Cobb Broiler Breeder Management Guide (2008)

Age(weeks)	*Light (hours)*	*Light Intensity (lux)*
1 - 3	Gradual decrease from 24 hours at Day 1 to 8 hours by 14-21 days	Gradual decrease from maximum light (>20 lux) to 20 lux by Day 7
3 - 20	8	5 - 10
20 - 21	11	40 - 60
21-22	13	40 - 60
22-23	14	40 - 60
23-60	15	40 - 60

1.2.5 Mating

Males and females are transferred from the pullet farm to the production farm between 18 and 23 weeks of age. Broiler breeders reproduce by natural mating. Unlike commercial turkeys, artificial insemination is not used. Flock or mass mating allows a number of males to mix with an entire flock of hens. Management practices to enhance mating efficiency include feeding programs to control body weights in female and male broiler breeders and maintenance of an optimum male:female ratio in the breeding flock. The recommended gender ratio is about 10 males per 100 females. Initially, eight males per 100 pullets may be better to reduce male aggression toward hens and other males, reduce female mortality, and encourage hen receptivity. Mating frequency of males is estimated to be 5-40 times per day. Mating frequency of hens is estimated to be about 0.5 to 1.0 per day. Broiler breeder male fertility is high (more than 95%) until approximately 40 weeks of age, but declines thereafter because of reduced rooster mating frequency, lower percentage of live sperm, and the need for hens to mate more often to maintain fertility. To compensate for a decline in mating activity, spiking or intra-spiking of the flock with new males is used to stimulate male interest in mating. Beyond 65-70 weeks of age, fertility drops to low levels and the flock is sold.

Spiking consists of adding new, younger roosters to a flock to compensate for a decline in fertility, which generally occurs after 40-45 weeks of age, but can occur anytime and may occur more than once. During the first 6 weeks after spiking, increased mating is primarily due to old males that are stimulated by the presence of the young males. After 6 weeks, increased mating is due to activity of the young males. For the first week after spiking there is an increase in male aggression with elevated male mortality and sexual interference (males preventing other males from mating). The result is approximately 12 weeks of increased or sustained fertility. During the first week after spiking, fertility declines slightly due to male aggression and mating interference but significantly increases by 2 weeks post-spiking.

Bringing new males into the flock creates a biosecurity risk. Intra-spiking overcomes this problem by exchanging males of the same age between houses on the same farm or between pens in the same house. Intra-spiking males are stimulated by encountering new hens and begin to mate immediately. Aggression and sexual interference increase for the first two weeks after intra-spiking but there is no significant increase in mortality from either the original males or spiked males. Double intra-spiking is possible and may help maintain higher levels of hatchability for up to 15 weeks.

1.2.6 Feeding

Controlling body weights of both males and females during rearing and egg production is a critical factor in determining their performance in the breeder house. Males and females are typically grown separately during the rearing period, as target body weights are different. Attaining target body weights as breeders age is achieved by regular adjustments of feed allowances based on weekly body weight measurements of chickens in the flock. Deviations from target body weight curves require adjustments to feed allocations that can be maintained or increased, but never decreased from day 1 of age until peak egg production at around 30 weeks of age. On days 7 and 14 after placement, 10 birds can be weighed together in a bucket. Thereafter, birds should be individually weighed at the same time on the same day of every week before feeding. Onset of sexual maturity is influenced by body composition, so males and females must have both correct body weights and correct body composition at the onset of lay. At the onset of lay, the females' body should have an adequate fat reserve as well as adequate muscle mass. Goals of a typical broiler breeder feeding program are shown in the table below.

Table 4. Goals of a Typical Breeder Feeding Program

Broiler Age Range	*Feeding Program Goals*
Day 1 - 4 weeks	Feed *ad libitum*
4 - 16 weeks	Control body weight by providing sufficient nutrition for growth and maintenance while preventing birds from becoming overweight by small, regular feed increases.
16 - 23 weeks	Accelerate bodyweight gain and promote rapid development of ovaries and testes in preparation for egg production by increasing the feed allocation
23 - 30 weeks	Meet demands of growth and egg production while avoiding excessive weight gain with small, frequent feed increases.
30 - 70 weeks	Avoid excessive weight gain after peak egg production has been reached and physical growth has ended by slowly reducing feed for females based on bodyweight and egg weights.

1.2.6.1 Females

Overfeeding broiler breeder hens leads to development of abnormal ovarian structure, reduced egg production, impaired fertility, increased hen mortality, and increased frequency of defective eggs. At the onset of lay, overweight pullets have a tendency to develop multiple large yellow ovarian follicles ("superovulation"), each of which produces progesterone. Superovulation results in excessive progesterone production, which triggers multiple concurrent ovulations. Multiple ovulations result in regular eggs or large eggs containing double yolks, which have no shell, soft shells, or thin shells. These defective eggs have poor embryo viability and poor hatchability and are not suitable for incubation. Multiple ovulations also may result in laying more than one egg per day, abdominal laying, and laying eggs at abnormal times in the day (erratic ovipositioning). In addition, overweight hens are too large to breed effectively and tend to have sperm storage and sperm transport problems because of fat infiltration into sperm storage glands at the shell gland-vaginal junction of the oviduct.

Optimum ovarian function is one ovulation per day, which can be achieved by feed restriction. Feed restriction during rearing, breeding, or both reduces the weight of the ovary and number of large yellow follicles at sexual maturity, erratic ovulation, and defective eggs. Additional benefits of restricted feeding include reduced mortality and lower feed costs. Reproductive performance of broiler breeder hens on restricted and *ad libitum* feeding programs is documented and compared in the table below (International Hatchery Practice, Volume 20, No. 1, page 7, 2009).

Table 5. Broiler Breeder Hens (0 to 60 Weeks of Age)

	Ad libitum	*Restricted*
Body Weight (lbs.)	11.7	8.2
Mortality (%)	46	4
Egg Numbers	58	157
Hatch of Eggs Set (%)	43	86
Feed Intake (g/day)		
0 - 24 weeks	163	63
24 - 37 weeks	192	157
37 - 60 weeks	142	151
No. Yellow Follicles	13.5	7.3

1.2.6.2 Males

Achieving male body weight targets that closely adhere to growth curve recommendations by primary breeder companies is the single most important factor in attaining high flock fertility. Male growth and breast muscle development must be controlled, especially during the first 16 weeks of life when skeletal size is largely determined. Overfeeding broiler breeder males causes excess body weight and excessive development of breast musculature, both of which impair mating efficiency. Fertilization requires semen transfer from males to females by copulation. Excessive pectoral muscle creates an imbalance so overweight roosters have difficulty making cloacal contact with hens and transferring semen. Furthermore, excessive body weight is associated with development of foot pad and leg problems, which negatively impact the mating process and occur in more than 30% of broiler breeder males.

Sertoli cells protect developing sperm cells and proliferate between 2 and 12 weeks of age, not thereafter. Numbers of mature sperm produced is limited by the number of Sertoli cells, so maximum potential for sperm production is established by 12 weeks of age. From 16 to 23 weeks of age, nutrition must be sufficient to support maintenance, growth of testes, and production of reproductive hormones. Appropriate levels of follicle stimulating hormone and luteinizing hormone are critical for testes development and establishing a "feedback loop" between the brain and the testes.

Feeding programs should allow males to increase their body weight gradually throughout the breeding period. Body weight gains should be limited to small, consistent amounts to prevent excessive breast muscle development. Male body weight loss will immediately result in diminished sperm production and decreased mating activity, so weight loss must be avoided.

1.2.6.3 Production Phase

Males need to be transferred to the production house 3-5 days earlier than the females, so they can learn to eat from the male feeder. After males and females are mixed, separate feeding systems are available so body weight and uniformity of males and females can be independently controlled. It is important that males do not have access to the females' feed and vice versa. As roosters have larger heads than hens, males can be kept out of female feeders by exclusion systems such as grills or roller bars. Grills placed over hen feed troughs create vertical and horizontal restrictions which exclude males with greater head width and full combs, but allow females unimpeded access to the feed. With some strains of broiler breeders, the difference between the size of the heads or combs between males and females is insufficient to control feed access with grills. In these cases, a plastic bar, commonly called a "nose bone" is placed through the nares and nasal septum. Male feed lines need to be sufficiently elevated above the floor to prevent hens from reaching feed intended for roosters. In some housing arrangements a separate male water line runs down the scratch area, but, more commonly, the males use the female water lines above the slates.

Ideally, breeders should be fed daily, but skip-a-day feeding programs have been used when feeding space is limited and are most common. Broiler breeders consume their feed in a short period of time (less than 30 minutes). Consequently, feed should be distributed to all chickens along the entire length of the feed line in less than 3 minutes so all birds can eat at the same time. If delivery takes too long, aggressive birds consume most of the feed as it leaves the hopper. If feed is not delivered along the length of the entire feed line in a short period of time, dominant birds have access to more feed and gain more weight each week than smaller, less dominant birds. Under these conditions, body weight uniformity declines even if initial body weight uniformity was good. Another problem that can occur with skip-a-day feeding is engorgement of food to the point that birds can compress the trachea and die of suffocation. When birds are seen in respiratory distress shortly after feeding, the crop needs to be checked to see if it is hard. If so, the bird can usually be saved by gently massaging the food laterally away from the trachea.

1.2.7 Hatchery

Hatcheries should be built in isolated locations away from feed mills, processing plants, or industrial buildings, which may produce contaminated dust or pollutants. Fences with a gate and a guard erected around the hatchery and decontamination equipment, showers, and change rooms for employees would provide maximum biosecurity, but currently are not common in the US. Separate rooms should be provided for the office, fumigation, egg grading, egg holding, setters (incubators), hatchers, chick grading and boxing, chick-holding, supplies, and waste disposal. Central fogging systems, which provide a timed release of disinfectant mist from high pressure nozzles, should be located throughout the hatchery, including the setters and hatchers. Strategically located high pressure hot water outlets enhance sanitation efforts, and walls and floor surfaces should constructed of durable, easy to clean materials. Floors slope toward drains, which are trapped to prevent blockages. Each room should have its own ventilation system and air pressure in each room should be adjusted so that the cleanest rooms have the highest positive pressure.

Hatchery work and egg flow patterns contribute to biosecurity, as do placement of ventilation inlets and exhausts. The hatchery should be divided into clean and dirty areas, which must be separated to avoid cross contamination. Hatching eggs should enter one end of the building and chicks should leave from the other end. Ventilation systems should move air from clean areas to the dirty areas, in the same direction as hatching eggs move from setters to hatchers. Air pressure differences among the areas in the hatchery help minimize backflow of contaminates into clean areas. Ventilation systems need frequent inspection a nd periodic cleaning.

1.2.7.1 Egg Collection, Selection, Storage, and Pre-Warming

Development of the embryo begins at the time of fertilization in the infundibulum of the oviduct and proceeds as the egg is formed until ovipositioning. As the egg cools, the rate of embryo development slows and it enters diapause. Careful handling of the egg is necessary to preserve the integrity and viability of the early embryo prior to incubation and further development.

Eggs should be collected at least 3 times per day in normal temperatures and 5 times per day when temperatures are above 85°F. Frequent gathering reduces the probability that eggs become contaminated with bacteria from feces or nest materials, and prevents overheating of eggs in summer and chilling of eggs during winter. Clean nest eggs should be collected first and submitted to the hatchery for incubation. Dirty nest eggs, cracked eggs, and floor eggs depress hatchability and should be collected and packaged separately. These eggs are not suitable for incubation. Most contamination in hatcheries originates on the breeder farm.

Egg selection is used to eliminate eggs that are less likely to hatch and produce quality chicks. Egg size is a selection criterion since unusually large or small eggs do not hatch as well as medium-sized eggs. Overweight and underweight eggs can be removed by automated equipment. Round or elongated eggs and eggs with thin or wrinkled shells do not hatch well and should not be sent to the hatchery. Dirty eggs may be contaminated with yolk, dried blood, or feces and these should be removed and discarded.

Eggs are moved into an air-conditioned egg room for storage until they are picked up and taken to the hatchery. They should be held in storage on the farm for as short a time as possible. After being picked up from the egg room on the breeder farm, they are placed in an egg holding room in the hatchery and stored there until they are incubated. Each day of storage adds one hour to the time required for incubation, so fresh and stored eggs should be set at different times. Diffusion of carbon dioxide and water vapor from the egg through pores in the shell contributes to loss in hatchability during storage. After 6 days of storage, hatchability declines by approximately 0.5 to 1.5% per day. Eggs should be cooled to below 75.2°F and held at 75-80% humidity in the storage room. Cooling eggs below physiological zero for broiler breeder eggs (75.2°F) minimizes embryo development during storage. The longer eggs are held in storage, the lower the recommended storage temperature.

Pre-warming eggs prior to setting is advisable to avoid temperature shock to the embryo and prevent condensation of moisture on the external surface of the egg's shell (egg sweating). Eggs may sweat when transported from a cold storage room on the farm to a warm hatchery or from a cold storage room in the hatchery to the setter room of the incubator. Eggs need 6 to 18 hours for pre-warming and good air circulation should be provided during the pre-warming period. A dedicated pre-warming room should provide a temperature of 73°F and 45% relative humidity.

1.2.7.2 Setter (Incubator)

Incubation involves bringing fertile eggs to hatching by natural or artificial means. Artificial incubation frees breeding hens from the necessity of incubating eggs so the hens can continue to produce eggs. Five well-known environmental factors impact embryonic development – temperature, humidity, ventilation, egg turning, and egg orientation. An incubator in a commercial broiler hatchery is shown in the photo on the right.

The recommended temperature for setters is 99.5 – 100°F in multi-staged machines. Later in incubation, embryos are relatively resistant to cooling. In contrast, overheating can cause malformations, malpositions, or may be lethal.Malformations may include exposed brains, missing eyes, beak or face abnormalities, or viscera outside the body cavity. All setters have hot spots and cold spots, and care should be taken that embryos in hot spots are not subjected to heat stress. In single-stage incubation, temperature can be reduced to compensate for the heat produced by growing embryos.

Relative humidity in setters should be 50-60% depending on manufacturer's recommendations. Water vapor is lost through the pores of the shell. Egg weight decreases because of water loss during incubation. While most animals try to conserve water, bird eggs must lose water during embryonic development to facilitate hatching. Metabolic water generated by the embryos must diffuse through the shell to maintain the relative water content of incubating eggs. A fresh egg should lose approximately 12% of its weight by 18 days of incubation due to loss of water from the egg. Loss of moisture during embryonic development allows the air cell to enlarge and occupy 1/3 of the egg by 19 days of incubation.

Ventilation in the setter must support embryonic respiration by providing an adequate supply of oxygen and removing excess carbon dioxide. The average chicken egg has around 10,000 pores, which allow oxygen and carbon dioxide to move through the shell by diffusion. Fresh air entering the setter contains 21.6% oxygen. If fresh air is dry and supplies little moisture, it may be necessary to humidify air in the room containing the setter; conversely, if ambient humidity is high, it may be necessary to dehumidify the air before it enters the incubator. Exhausted air leaving the setter removes water vapor, carbon dioxide, and excess heat. Carbon dioxide levels in the machine should not exceed 0.4%, as embryos can die if carbon dioxide levels become too high

Turning eggs in the setter on a regular schedule assists in the development of extra-embryonic membranes and aids in temperature control. In modern hatcheries, turning devices rotate eggs 90 degrees and are equipped with timing mechanisms so eggs are turned every hour. It is extremely important that eggs be placed in the setter with the large end up.

1.2.7.3 Hatcher

Hatchers are kept in a separate room to isolate the down, egg debris, and micro-organisms generated during hatching from the rest of the hatchery. Hatchers have chick-holding trays where eggs are laid on their sides to allow free movement of chicks out of the shell at hatching.

After 18 days of incubation, eggs are removed from the setter, vaccinated, and transferred to the hatcher. Eggs may be candled to identify and remove infertile eggs and dead embryos so live chicks are not exposed to these potential sources of pathogenic bacteria after hatching. *In ovo* injection systems are routinely used for administration of vaccines to protect broiler chickens against Marek's disease, infectious bursal disease, and fowl pox. Vaccination *in ovo* requires far less labor and time and is less stressful to the chicks than subcutaneous administration of Marek's disease vaccine. *In ovo* vaccination machines can vaccinate 60,000 eggs per hour while consistently delivering the correct dose to the correct location in the embryo. Chicks vaccinated *in ovo* can be moved out of the hatchery without delay, which reduces the time between hatching and access to feed and water in the brooder house.

Most broiler hatcheries hatch twice a week from each hatcher. The hatcher is cleaned and disinfected between hatches. Hatchers must be dry and up to proper temperature before receiving hatching eggs. Moisture must be adequate to ensure that shell membranes remain soft and pliable so chicks can escape from the eggs. Additional moisture may be supplied by a spray system. Temperature is slightly lower than the setter (98°F) to avoid overheating and the relative humidity of around 70% is higher than the setter.

The hatch window is the period of time when chicks emerge from the eggs. Chicks peck the inside of the eggshell until the shell is sufficiently broken to allow chicks to escape from the egg, a process called pipping. Internal pipping occurs a couple days before hatching when the beak of the embryo penetrates the air cell. Variability in hatching time is to be expected from chicks in a single setting because eggs in a hatch may differ in storage time and storage conditions, environmental conditions within the same setter or hatcher, age of breeder flocks supplying the eggs, shell characteristics, and original egg size. Eggs that hatch too early are susceptible to dehydration, which may result in increased early chick mortality and poor broiler performance. Eggs that hatch too late have poor hatchability, impaired chick quality, increased numbers of pipped but unhatched eggs, and increased numbers of unhatched eggs that contain live embryos.

Pulling the hatch refers to removing chicks from the hatcher. Chicks should be removed when most are dry and fluffed up but while around 5% are still damp on the back of their necks. Removing chicks from the hatcher too soon results in "green chicks" that are still wet, susceptible to chilling, or have open navels that provide entry points for bacteria. Excessive dehydration, elevated mortality after placement, and reduced growth and flock uniformity occur in chicks that remain in the hatcher too long.

1.2.7.4 Chick processing

After being separated from hatching tray debris, chicks are graded into first quality or culls. Chicks that possess anatomical deformities, partially closed navels, crooked toes, excessively wet down, or twisted legs are culled.

The gender of day old chicks can be determined by feather sexing or vent sexing. Feather sexing is based on the length of the primary and covert feathers on the wing. The top row of feathers is composed of the coverts and the bottom row of feathers are primary feathers. In females carrying fast feathering genes, coverts are always shorter than primaries. Males carry slow feathering genes, so covert feathers are always as long as primary feathers. Vent sexing involves examination of the cloacal wall to detect rudimentary male copulatory organs.

Spray vaccination of day-old chicks in the hatchery is a commonly used for mass administration of vaccines against Newcastle disease and infectious bronchitis. Aerosolized vaccine viruses contact mucous membranes of the nasal passages, trachea, and lungs and stimulate both local and systemic immunity. In addition, coccidiosis vaccines may be administered by a spray, which settles over the down on chicks and is subsequently ingested.

Chicks are sorted, counted, and placed into chick boxes before being moved to the chick holding area.

1.2.7.5 Chick Holding and Transport to Farms

After being placed into chick boxes, chicks are moved into the chick holding room where the flock to be delivered to the farm is assembled. It is common for flocks to have a hundred thousand or more chicks. The chick holding room at the hatchery should have a temperature of 75°F and relative humidity of 70%. These conditions are close to the chicks' thermo-neutral zone at which they are comfortable. Chicks are delivered to the farm in specialized vehicles equipped with heating, cooling, and ventilation systems to control the chick's environment. Chick delivery drivers are well trained and keep a log book, which records the time the truck leaves the hatcher, all stops, and time of arrival at the farm. The vehicle cab has a display showing the transport conditions.

1.2.7.6 Waste Disposal and Cleaning

With 85% hatchability, 15% of eggs will be infertile or contain dead embryos. Hatchery waste includes infertile eggs, dead embryos still in the egg, down, shell fragments, dead chicks, and cull chicks. Waste disposal may occur by incineration or hatchery waste may be processed into livestock food known as hatchery by-product. Cleanup after pulling the hatch, processing chicks, and holding chicks is critically important. A Material Safety Data Sheet should be on file for each disinfectant used in the hatchery and eyewash stations should be available for employees inadvertently exposed to chemicals. Microbiological monitoring using swabs or culture plates should routinely be used to monitor the level of contamination in a hatchery. Critical areas for sampling include egg room air, air inlets of each setter and hatcher, inside each setter, vaccination room air and surfaces, vaccine and diluent samples, chick room air, and chick processing equipment surfaces.

1.2.7.7 Automation

Automated hatcheries may hatch more than two million chicks per week and have shorter throughput times, which promote chick quality. Automation provides gentler handling of eggs, more precise vaccination, more accurate chick counting, and a better working environment for employees. Fully automated hatcheries require less labor, only one employee for every two million chicks hatched per year. Computer-controlled machines are available to grade eggs before setting and to monitor and control temperature, humidity, carbon dioxide, and egg turners in each setter. At 18 days of incubation, automated machines will candle eggs, perform *in ovo* vaccination, and transfer eggs to the hatcher. After hatching, machines can separate chicks from broken shells and hatching debris, count and weigh chicks, vaccinate with in-line sprayers, place chicks in boxes, and remove debris from the hatchery.

1.3 BROILER HOUSING FACILITIES

Enclosed housing is standard for the broiler industry and limits exposure to disease-carrying wild birds and animals. Houses should provide a source of heat for brooding and ventilation to supply oxygen and remove carbon dioxide, moisture, and ammonia. Houses should protect chickens from predators and exclude rodents and other harmful pests, such as litter beetles. The footing of a chicken house forms a solid barrier around the base of the house and prevents wood rot, sagging roofs and entry of pests and other intruders. Insulation is placed under the roof and occasionally on side and end walls to help retain heat during winter and exclude radiant heat in summer. Houses with solid side walls have air inlets located down the sides that allow fresh air to enter houses when an exhaust fan pulls air from the house.

Broiler houses typically measure 43’x 500’ and are constructed from metal, wood, or a combination of the two. However, house size ranges from 30’ to 66’ wide and 300’ to 600’ long. Steel truss houses are more efficient and have fewer rodent problems, allow for quicker construction and have better longevity. Wood truss houses tend to be less expensive to build and, when properly designed with a drop ceiling, provide efficient tunnel ventilation and heating. Floors consist of concrete or compacted soil.

1.3.1 Stocking Density

Correct stocking density is necessary to obtain optimal broiler performance, uniformity, product quality, and meet welfare requirements. Stocking density is influenced by climate (temperate vs. subtropical), season, (summer vs. winter), housing type (open-sided vs. solid-wall), target broiler weight at processing, and local welfare regulations. In winter, additional broilers may be placed in a house because heat produced by extra birds is more easily removed with colder outside temperatures. A guide to stocking densities according to bird numbers and live weight is given below from the Arbor Acres Broiler Management Guide (2010).

Table 6. Stocking Densities According to Bird Numbers and Live Weight

Bird Live Weight (lb)	*Square Feet/Bird*	*Birds/ft^2*	*Bird Weight (lb/ft^2)*
3.0	0.50	2.0	5.99
4.0	0.70	1.4	5.73
5.0	0.85	1.2	5.91
6.0	0.90	1.1	6.70
7.0	1.00	1.0	7.04
8.0	1.15	0.9	6.99

Maintaining normal stocking density is vital for a healthy flock. If overcrowding occurs, body weight suffers as well as feed consumption and efficiency. In addition, mortality can increase along with condemnations. In brief, the negative financial impact of overcrowding is tremendous. In 2012, average stocking density of broiler flocks was 0.84 ft2 /chicken placed or 7.4 lb/ft2.

1.3.2 Feeder Systems

Adequate feeding space is critical to obtaining optimum growth rates and uniformity. Most broiler house feed lines have automatic round pans that are 12 inches in diameter and designed to meet feeding requirements of 45-80 birds (lower ratio for bigger birds). Feed is distributed to pans through a metal tube containing an auger. At the far end of each feed line is a control pan, which controls the run-time of the auger. When feed levels in control pans are low, a relay switch signals augers to run and distribute feed throughout the system. Benefits of a feed pan system are faster fill times, unrestricted bird movement throughout the house, less feed wastage, easy height adjustment, and no accessible moving parts while allowing broilers continuous access to feed in a comfortable manner. Feeder pan height should be adjusted daily so the base of the pan is level with the birds' backs. The number of feed lines that are needed depends on house width. Guidelines given below are from the Arbor Acres Broiler Management Guide (2010).

Table 7. Feed Lines by House Width

House Width (feet)	*Number of Feed Lines*
42	2
50	3
65	4
85	5

Each broiler chicken house typically has two 10-12 ton feed storage bins from which feed is augered into feed hoppers inside the house. Outside feed bins may be found near the middle or at one end of the chicken house. Capacity of feed storage bins should be equal to 5 days of feed consumption and feed bins should be watertight to reduce mold and bacterial growth. Two feed bins for each house allows for rapid change of feed if medication is necessary and also can be used to prevent mixing of old and new feed in the same bin if one bin is filled at a time.

1.3.3 Drinker Systems

Adaptation of closed water systems in the early nineties was one of the great improvements in the broiler industry. Closed water systems are a marked improvement over open systems, such as bell drinkers, cups, troughs, or open water founts, all of which resulted in an unsanitary water supply. Closed water systems are less likely to be contaminated than open systems and, as there is better control of water usage by the birds, litter remains drier, which improves bird health. In addition, closed water systems do not require daily cleaning, which reduces labor. Closed water systems dispense water when the chickens peck at a metal trigger or nipple. Movement of the trigger up and down or side-to-side allows water to flow from the water line pipe to the nipple. A regulator located at the beginning of each line controls the rate of flow through the drinkers and can be adjusted depending on the age of birds and the drinker system. Critical to proper drinker management is checking for air locks, and ensuring an even depth of litter so broilers have uniform access to all drinkers. Drinkers should be just high enough that birds must slightly stretch to reach the trigger pin while their feet are flat on the floor. Birds should have their necks at a 45-degree angle when accessing water at the nipple.

Two types of closed water systems are used: low flow rate nipple drinkers and high flow rate nipple drinkers. Most broiler producers use low flow rate nipple drinkers, which operate at a flow rate of up to 2 fluid ounces per minute. Pressure is adjusted to meet water flow requirements and one nipple supplies water for approximately 10 chickens. A few broiler houses have high flow nipple drinkers with cups to catch water that may drip from the nipple. One nipple in high flow rate systems supplies water for approximately 12 broiler chickens. The actual number of birds per nipple depends on bird age, climate, flow rate, and design of the water system.

Water meters are an excellent tool for monitoring water usage and estimating feed consumption because the two are highly correlated. The water use:feed consumption ratio varies with ambient temperature as shown in the table on page 21 provided by the Cobb Broiler management Guide.

Table 8. Water Use to Feed Consumption Ratio	
Temperature (°F)	*Water to Feed Ratio*
39	1.7 : 1
68	2.0 : 1
79	2.5 : 1
99	5.0 : 1

Sudden changes in water consumption are a tell-tale sign of potential problems, such as stress, a feed issue, disease, or a water system leak. During hot weather, water lines should be flushed to ensure that water is as cool as possible. In the event that the main system fails, water storage tanks on the farm should have sufficient capacity to provide at least 24 hours of water at maximum consumption.

1.3.4 Lighting Systems

Lighting is a vital component of broiler production and represents 25-40% of electrical costs. Light intensity and photoperiod (day length) directly influence the time broiler chickens spend eating along with the general health and well-being of the birds. A period of darkness improves feed efficiency due to reduced metabolism during darkness and complements normal diurnal rhythms of bone mineralization and digestion. In addition, a period of darkness reduces the incidence of sudden death syndrome, ascites, and skeletal disorders. Most companies recommend 4 to 6 hours of darkness each day. Longer periods of darkness may exacerbate the negative effects of increased stocking density and limited feeder space.

Two types of bulbs are used for artificial lighting in solid side wall or dark curtained houses. The most common lights are 60 watt incandescent bulbs or 15-26 watt dimmable compact fluorescent light bulbs (CFL). Incandescent is the traditional light bulb used in broiler houses because of its affordability, ease of installation, and good spectral range. However, incandescent bulbs are losing popularity due to their short life span (5-6 months), high heat production, and relatively poor energy efficiency. CFL bulbs have a 60% energy savings over incandescent bulbs and produce 3 to 5 times the amount of light per watt but lack durability and lose intensity over time. Currently, light emitting diode (LED) bulbs are gaining popularity due to durability and energy savings.

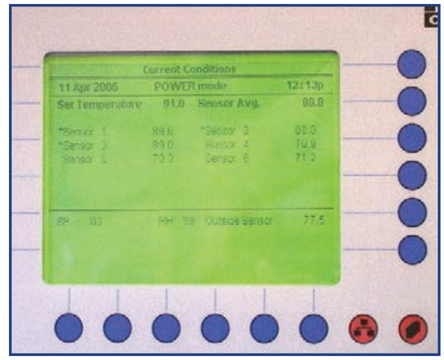
1.3.5 Heating Systems

Heating a house is critical to brooding success. Broiler houses can be heated through convection heat and/or radiant (infrared) heat. Forced air heaters (space heaters) are convection heaters, which heat air and create a uniform temperature throughout the entire house. Chicks do not have the option of seeking a more comfortable temperature by moving to a different location. Space heaters are usually placed in the middle of a house where air movement is slow. Broiler chickens and the litter will not be warm until most air in a house has been heated.

More commonly, small, round area heaters (“pancake brooders”, canopy, infrared or radiant heaters) are placed approximately 3-5 feet above the litter and create a large heated circular area underneath the heater. Radiant heat is transferred via infrared heat waves and these heaters (spot heaters) are very efficient because they heat objects toward which the heat waves are directed – not the air. Heat waves emitted from the glowing source of radiant brooders heat birds and the litter. These heaters create different temperature zones and chicks can move to the zone that best suits their temperature needs. A combination of radiant and space heaters can be used. Radiant heaters are often the primary heat source until chicks reach 14 days of age (end of brooding period) with forced air heaters used thereafter to provide supplemental heat.

Radiant tube heaters are a third option and consist of long tubes located along the apex of the roof or along the walls. Radiant tube heaters warm the entire floor surface of the house and create a uniform environment. However, they must be carefully managed to avoid making the floor too hot and driving chicks away from feed and water.

1.3.6 Environmental Control Systems



Computerized environmental controllers are available for broiler houses with natural ventilation and for broiler houses with tunnel ventilation. Environmental controllers provide real-time information on temperature, relative humidity, ammonia, carbon dioxide, and static pressure in a house and have a non-erasable memory that provides a record of environmental conditions in the house over time. Stored information includes a record of maximum and minimum house temperatures, including where and when they occurred in the chicken house. Similar data are recorded for heater and fan runtimes, relative humidity, and water consumption. Sophisticated computer control systems receive input from various thermal sensors located throughout the house at bird height and can turn fans or heaters on or off in order to maintain house temperatures within 3°F of the desired temperature, which decreases as broiler chickens age. Most controllers have a high and low temperature alarm system and a power failure alarm system. Environmental controllers from all houses on a broiler farm can be linked to software on personal computers so data can be accessed by flock managers in their home at any time of the day or night. Flock managers can use the software to change parameters in the controllers.

1.3.7 Ventilation Systems

Ventilation is the primary means for controlling the environment in a chicken house. There are two types of ventilation systems: natural ventilation used in open-sided housing and power ventilation used in controlled environment housing, commonly referred to as "tunnel ventilation". Natural ventilation requires continuous monitoring and adjustment of curtains in response to changes in temperature, humidity, wind velocity, and wind direction. Typical open-sided houses have curtains on the sidewalls that can be opened or closed. When house temperatures are warm, curtains are closed to allow a larger volume of air to move through the house. On hot days, circulation fans can be used to increase the rate of air exchange and foggers or misters can be used in combination with the fans to create an even greater cooling effect. When house temperatures are cool, curtains are closed to restrict the flow of air. The air exchange rate in natural ventilation houses depends on outside winds with mechanical assistance from fans.

Power ventilation systems provide more control over air exchange rates and air flow patterns, which allows flock managers to create more uniform conditions within a house. Electric exhaust fans pull air out of a house, which creates a negative static pressure inside the house and brings outside air into the house through computer-controlled openings in the sidewalls. The speed of air entering a house is determined by the amount of negative pressure (vacuum) in the house, which is controlled by matching the inlet area and fan capacity. "Migration fences", usually composed of lengths of 10" drainage pipe, are placed across the house to form three or more areas in the house. These keep the chickens distributed uniformly in the house and prevent them from migrating toward the air inlet end of the house where there is more light and piling up.

The objectives of ventilation are to provide adequate oxygen to support the metabolic needs of the chickens, control relative humidity to maintain litter conditions, and remove carbon dioxide (CO_2), carbon monoxide (CO), dust, and ammonia. Carbon monoxide may be produced if dust partially blocks air inlets on brooder stoves resulting in inefficient combustion of natural gas or liquid propane fuel. Because moisture is constantly introduced into a chicken house through bird excreta, bird respiration, spillage from drinkers, and fuel burned in brooder stoves; proper airflow is vital to prevent excess moisture accumulation in the litter. Ammonia is produced in the presence of moisture by bacterial breakdown of uric acid in bird excreta that accumulates in the litter. Prolonged exposure to high levels of ammonia causes structural damage to the respiratory system (>25 ppm), damage to the eyes (>60 ppm), and has a detrimental effect on body weight and feed efficiency. Limiting the amount of litter moisture through proper ventilation significantly reduces ammonia formation. The quantity of moisture and ammonia removed through ventilation is influenced by the temperature and humidity of incoming air, but is more dependent on its speed and direction. If inlets direct incoming air towards the chicken house ceiling, air temperature and moisture-holding capacity of incoming air will increase. Every 20°F rise in the temperature of incoming air cuts its relative humidity in half, improving its ability to remove house moisture.

Ventilation rates should be slowly increased each week as birds age to keep ammonia and moisture in check. When more than the minimum air exchange rate is needed, temperature sensors override the minimum ventilation timer to keep fans running. Ventilation should keep relative humidity at 70% or below to ensure that moisture will evaporate from litter. Relative humidity should remain above 50% to ensure that adequate moisture is left in litter to prevent dusty conditions.

1.3.8 Litter

Choosing the type of bedding material used in a broiler house is an important decision. Bedding dilutes excreta, absorbs fecal moisture, promotes drying of manure, provides a cushion for breast muscle and feet, and insulates the floor during cold weather. A good bedding material should be lightweight, highly absorbent, able to dry quickly, soft and compressible, inexpensive, useful as fertilizer, non-dusty, and free of pesticide residues, mold, and pathogens. The most common types of bedding are rice hulls and pine shavings, either separate or as a mix. While these are the preferred choices, rice hulls are now being burned for energy and pine shavings are used to manufacture particleboard, making these sources expensive. Alternative beddings sources with less desirable qualities include peanut hulls, chopped wheat or pine straw, pine bark, hardwood shavings, sawdust, chopped straw, shredded paper, peat moss, and sand. New bedding should be placed in a house at a depth of 3-4 inches.

1.4 BROODING

The two major stages of raising broiler chickens are brooding and grow-out. Brooding occurs during the initial 14 days of a broiler chicken's life or until the chicks are feathered and able to maintain body temperature. Frequent monitoring by producers enables quick identification and correction of problems, as well as documenting good, consistent growing conditions. Brooding is the most critical time in the life of a flock, and producers should monitor flocks a minimum of 3 times each day and walk the length of the brooding area several times during each inspection of the flock. The quality of care given to chicks during the first hours and days in the house can have a profound effect on final flock performance. While walking through the house, producers check feeders and drinkers, and monitor temperature, ventilation, and litter conditions. Dead birds need to be removed, recorded in the mortality record, and disposed of properly. Chicks that cannot reach food and water should be culled, documented in the flock records, and discarded. Producers should observe the behavior, activity level, and distribution of chicks in the house. Uniform distribution of chicks, with all areas of the house containing some chicks, is the goal. Signs of discomfort or stress should be investigated and addressed quickly. Distress signals include loud chirping, panting, or failure of lethargic, sluggish chicks to move away when approached by the grower. Loud chirping may indicate overheating, lack of feed, or lack of water. Panting by a large number of birds indicates the house is too warm and needs to be cooled down. Special attention should be given to flocks when weather conditions are unusually hot or unusually cold, or when large fluctuations in outdoor temperatures occur during the day. Flocks showing signs of disease warrant extra care and monitoring.

1.4.1 House Configuration

Two systems of temperature control are employed during brooding: a) whole house brooding with placement of chicks throughout the entire house and b) partial house brooding with chicks placed in a limited area of a house. Whole house brooding typically occurs in houses with solid sidewalls or in houses located in warm climates. Partial house brooding is used by most broiler producers to lower energy costs by heating only part of the house and reducing labor required to keep feed trays filled. Floor to ceiling plastic brooding curtains are placed across the width of the house to partition the house in half or thirds, and a solid barrier is placed on the floor in front of the curtain to prevent drafts. The area of the house used for brooding is called a brood, brooder, or brooding chamber. Typically, half of a chicken house is initially heated with radiant (canopy) heaters so chicks can select their preferred temperature. The remainder of the house is empty until the chicks are 11 to 16 days of age. In summer, broilers may be released into the remainder of the house at 11 days of age to reduce early bird density. In winter, partial house brooding may be extended to 16 days of age to reduce heating costs. Since the first few days of the brooding period require the greatest amount of heat, partial house brooding saves a significant amount of fuel.

At 11-16 days of age, broiler chicks require more floor space to reduce competition for feeder and drinker space. Preparations to provide a uniform, comfortable environment for the chicks will encourage them to move into the newly opened section of the house. Prior to removing the plastic curtain divider, the adjacent empty section of the house must be heated and ventilated to the same temperature as the area of the house being used for brooding. A uniform temperature will heat water in the water lines, encouraging water consumption and preventing broilers from becoming chilled by drinking cold water. Additionally, feeders in the unused section of the house must be filled with clean, fresh feed and supplemental feeders may be moved to the unused section of the house to help stimulate bird migration. Once these preparations are made, the brooding curtain and solid barrier on the floor can be removed, allowing chicks to occupy the remainder of the house.

1.4.2 Feed

The most important goal of management during the first week is to ensure that baby chicks consume enough feed and water because chick weight at 7 days of age is strongly correlated to final body weight at slaughter. Feed intake during the first 7 days is exceedingly important because chick weight is directly related to feed consumption and chicks should weigh 4.5 to 5.0 times their initial body weight by 7 days of age. Seven day weights are a measurement of the success of brooder management. Broiler chickens should be fed *ad libitum* so their crops are full of feed and water when lights are turned off in the evening and feed and water are immediately available as soon as lights are turned on in the morning.

Careful management and plenty of extra feed trays help chicks readily access feed and are necessary to ensure a good start. Feed should be clean, free of mold and have consistent particle size with minimal fines (powdery feed). Supplemental feeders are placed in houses during brooding and are essential for providing ample opportunity for young chicks to access feed. Supplemental feeders are plastic or paper feed trays that may be hand-filled and may include paper laid on the litter surface. Approximately 25% of the brooding area should be covered by the supplemental feed trays and paper with automatic feeding and drinking systems nearby. Most feed lines contain extra spouts that can be turned down so feed pours directly into the supplemental trays. Feed trays should be low to the ground and easy for chicks to access. After chicks learn the location of feed lines, growers can begin to remove supplemental feed trays, with one third typically removed over a period of several days. Sudden changes in feed location can disorient chicks, causing them to eat litter and predisposing them to disease.

Phase feeding of poultry started in the 1960s and is used to meet changing nutrient requirements of chickens as they grow. Four to 6 diets may be fed throughout the life of a broiler chicken. Separate feed formulations are used for pre-starter, starter, grower, finisher, and withdrawal rations. Transitioning from one feed ration to another is based primarily on the age and weight of broiler chickens in the house. During the brooder period, pre-starter and starter feeds are presented to the chicks in the form of crumbles (pelleted feed that has been crushed into smaller particles) or mini-pellets. Prestarter feeds need to provide nutrients that are easily digested because young chicks lack some of the digestive enzymes that digest carbohydrates and amino acids found in older birds. Prestarter and starter feeds stimulate a good appetite and maximize nutrient intake to support a high growth rate. They are fed while the chicks are relatively small and represent only a small part of total feed costs during the life of a flock.

1.4.3 Water

Water is the most immediate need when chicks arrive at a broiler house because they can easily dehydrate during hatching, processing, and transport to the farm. Supplemental mini-drinkers are placed near automated feeding and drinking systems and never allowed to run dry. Prior to arrival of chicks, water lines need to be filled with adequate time for water in the lines to warm. Water temperature during the first week should be around 77°F because cold water will chill chicks. At chick placement, drinkers are lowered to the chick's eye level for the first 2 to 3 hours with sufficient water pressure to produce a droplet of water suspended from the nipple. Suspended water droplets and a narrow layer of paper under water lines may be used to attract chicks to the water source. The sound of chick feet clicking on paper attracts other chicks, which discover the nipple drinkers when they investigate the noise. Within a few days, the thin paper breaks apart and disappears. Supplemental mini-drinkers can be removed approximately 2 days after placement.

1.4.4 Light

During brooding, as well as during the entire flock life, lighting is provided during the majority of the day. Adequate hours of light each day and adequate light intensity are needed during the first 7 days to stimulate feed consumption and development of the digestive system. Providing chicks with 24 hours of light during the first day after placement is common. From days 2 through 7 after placement, 23 hours of light followed by 1 hour of darkness is typically recommended. During the first week, a light intensity of approximately 2 to 4 foot-candles (30-40 lux) at chick height over the feed and water lines is used to help stimulate feed consumption. Too little light exposure during brooding results in chicks failing to thrive. During the second week, foot candles can be gradually decreased to around 0.5 to 1.0 (5–10 lux), while the daily photoperiod changes to approximately 18 hours of light and 6 hours of darkness. A period of darkness is provided each day to allow the chicks to become familiar with darkness so they do not panic and suffocate from piling in the event of an electrical system failure. Melatonin is produced in the pineal gland during hours of darkness, which promotes development of the immune system. Lower light intensity has been associated with a reduction in aggressive behaviors such as fighting, cannibalism, and feather picking, and a reduction in skeletal disorders including tibial dyschondroplasia and enlarged hocks.

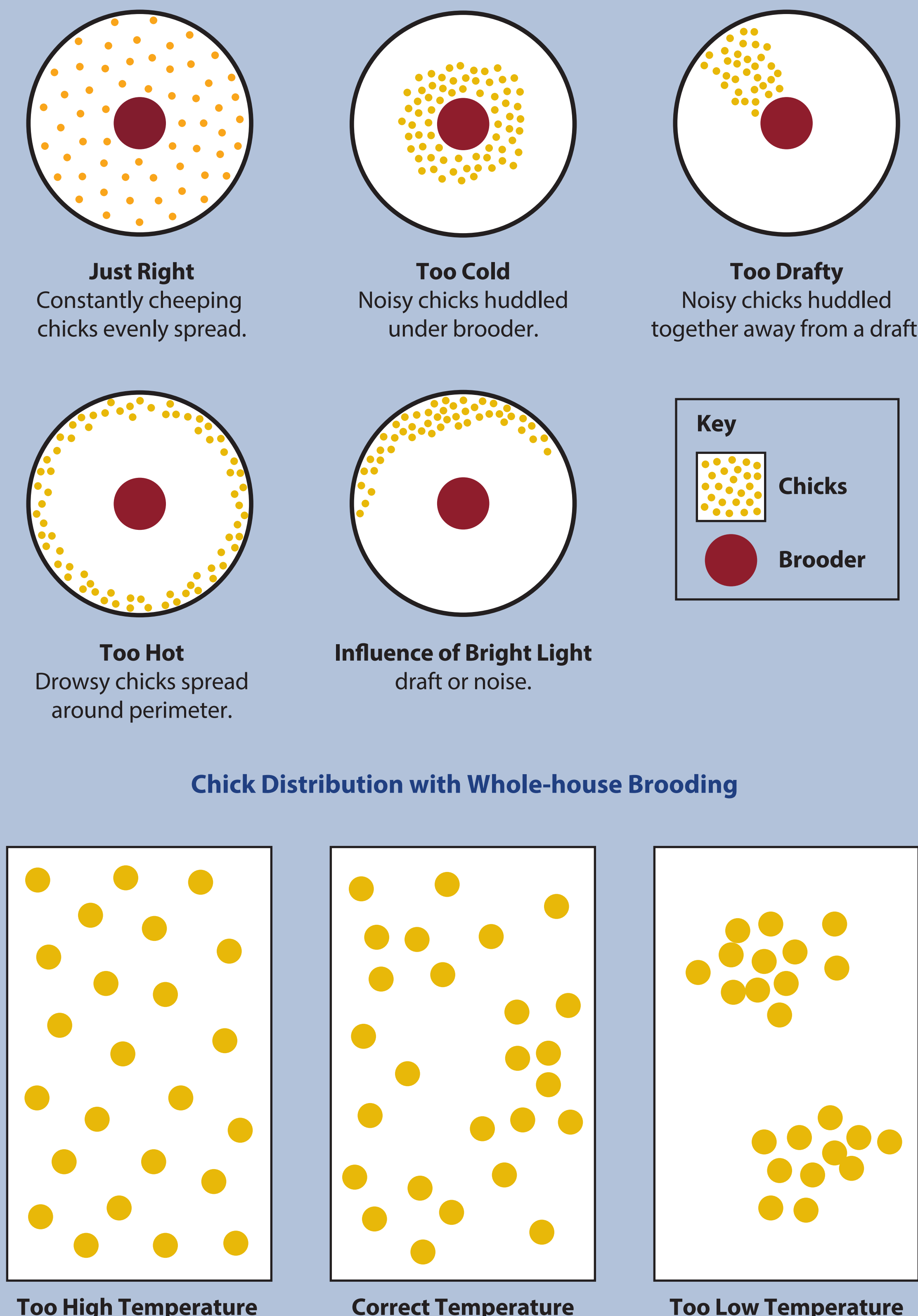
Preventing excessive growth between 7 and 21 days of age helps reduce mortality from metabolic conditions, such as pulmonary hypertension syndrome ("ascites") and sudden death syndrome. Growth control may be achieved by physical feed restriction, diet dilution, and lighting schedules, which limit feeding time by providing a period of darkness. Slower initial growth followed by compensatory growth promotes improved feed efficiency and allows the skeleton of broiler chickens to develop and become more mature before significant amounts of muscle mass are added.

1.4.5 Temperature

Maintaining correct environmental temperature for chicks during the first two weeks of life is critically important. At hatch, and for about the first 5 days of life, chicks are poikilothermic, which means their body temperature is determined by the temperature of their environment. Thermoregulation is not fully developed until sometime between 7 and 14 days of age. Chicks that are too hot or too cold will have less than optimal feed consumption, growth rate, and feed conversion. When ambient temperatures are in the thermal neutral zone, chicks can maintain their body temperatures at normal levels (104-106°F rectal temperature measured with a child's ear thermometer) with minimal energy expended to regulate their body temperature. Temperatures outside the thermal neutral zone result in less energy expenditure for growth and more energy spent cooling by panting or warming by increasing body heat production. Chicks that are too hot have depressed appetites, pant, and stretch out on the litter. Panting leads to excessive water loss and dehydration. Chicks that are too cold tend to sit on the floor, huddle together for warmth instead of searching for food or water, and utilize energy in the feed to generate body heat instead of for growth. Chicks that have been chilled are more susceptible to disease because their immune and digestive systems have been compromised. Chilled chicks have cold feet, which can be detected by placing a chick's feet on the caretaker's neck.

Visual observation of chick distribution in a house at 1 - 2 hours after placement allows growers to gauge the comfort of chicks and make appropriate temperature and ventilation adjustments. In houses with pancake heaters, either alone or in combination with large space heaters, chicks should be distributed uniformly under and around the outer area of the pancake brooders. If chicks are far away from the heat source, the stove area is too hot. If chicks are huddled and clustered directly under the stove, the temperature is too cool. Non-uniform clustering of chicks with avoidance of certain areas indicates a draft. In houses heated with large space heaters, the ideal distribution of chicks is uniform spacing throughout the house, with no large areas being avoided and no large groups of chicks clustered together. Chicks normally group together, but warm chicks will break from these groups and randomly form new groups that continue to form and disperse. If chicks avoid certain areas in a house, they may be too cool or drafty; large open areas with no birds usually indicate drafts. Chick distribution and activity associated with different temperature and draft conditions under pancake brooders are shown in the Cobb Broiler Management Guide (2010) and chick distribution with different temperatures during whole-house brooding is shown in the Ross Broiler Management Guide (2010) (Figure 4).

Figure 4. Chick Distribution with Pancake Brooders



Floor temperature may be more important than air temperature because chicks are in contact with litter via bare feet. If the floor is cold, chicks lose body heat to the floor through their feet and through their body when they sit down. Chicks placed on cold litter will migrate to feeder lids within 2 hours of placement. Floor temperatures can be measured with an infrared thermometer. During brooding with force air heating, the target floor temperature on day one is 90°F. With radiant heaters (brooder stoves), the target floor temperature is 105°F. Brooder houses should be preheated so the floor temperature, air temperature, and relative humidity are stabilized by 24 hours prior to chick placement.

Air temperature recommendations vary with relative humidity and strain of chick, but typically ambient air temperature at chick level should be around 90°F (or a little less) when chicks enter a house with a relative humidity of 60-70% to prevent dehydration of chicks. Dry bulb temperatures should be higher when relative humidity is lower and vice versa. Air temperatures should gradual decrease thereafter. Insulated broiler houses have ventilation systems designed to keep house temperatures within 3 degrees of the desired temperature. Adjustments to temperature should be made gradually and flocks need to be observed after adjustments are made to be certain that birds are not excessively cooled or heated. While automated temperature control systems have alleviated the grower of making manual adjustments to control the environment, growers must still be conscious of potential problems that can arise in controllers and check house temperatures frequently. Recommended dry bulb house temperatures at different broiler ages when relative humidity is 60% or 70% are shown in the table below taken from the 2009 Ross Broiler management Guide.

Table 9. Recommended Dry Bulb House Temperatures

		Dry Bulb Temperature	
Broiler Age (Days)	*Target Temperature*	*60% Relative Humidity*	*70% Relative Humidity*
1	86.0	87.4	84.6
3	82.4	84.0	81.1
6	80.6	81.9	78.8
9	78.8	80.1	77.0
12	77.0	78.3	75.2
15	75.2	76.6	73.4
18	73.4	74.5	71.4
21	71.6	72.9	70.3
24	69.8	71.1	68.4
27	68.0	69.3	66.7

1.4.6 Ventilation

Minimum ventilation rates are needed to remove ammonia, moisture, carbon dioxide, and carbon monoxide from broiler houses. During brooding, the goal for air exchange is replacement of approximately half of the air in an entire house each minute on a 5 minute cycle. Therefore, if a house is 500 feet long, air should move at the rate of 250 feet per minute. Minimum air exchange rates are maintained by fans controlled by a timer. Minimum ventilation recommendations in cubic feet per minute for a house designed to hold 20,000 broiler chickens have been provided by Lacy and Czarick from the University of Georgia.

Table 10. Minimum Ventilation Rates (Cubic Feet Per Minute)			
	Nighttime Temperature		
Bird Age (Weeks)	*Below 30°F*	*30 - 60°F*	*Above 60°F*
1	2,000	2,000	2,000
2	3,000	4,000	5,000
3	5,000	7,000	8,000
4	8,000	10,000	11,000
5	11,000	13,000	14,000
6	14,000	16,000	17,000
7	17,000	19,000	20,000

Relative humidity should be monitored, with a target of 60-70% during the first 3 days in the brooder chamber. Humidity exceeding 70% limits the amount of evaporation that occurs in a house, causing wet litter and excessive litter caking. Wet litter combined with high litter pH promotes microbial growth, including bacterial pathogens, and ammonia production. If relative humidity falls below 50% during the first week of life, chicks will begin to dehydrate, the house will become dusty, and respiratory problems may occur in the flock. High pressure foggers or misters used for cooling on hot days, or backpack portable sprayers, can be used to increase relative humidity during brooding. As chicks grow older, relative humidity can decline with no ill effect.

Ammonia can be a problem when brooding on built-up litter during cold times of the year. Atmospheric ammonia should never exceed 20 ppm. In addition to causing corneal ulcers and blindness, high levels of aerial ammonia can damage cilia in the respiratory tract. Loss of cilia prevents removal of bacteria associated with inhaled dust particles, which may lead to bacterial respiratory tract disease and septicemia. High ammonia levels in the litter may contribute to foot pad "burns" and breast blisters causing broilers to be downgraded at processing. It is important for broiler producers to minimize foot pad damage so chicken feet ("paws") can be sold in Asian markets.

1.4.7 Litter

At the beginning of brooding, litter can be new, or as is more often the case, reused litter from a previous flock. Litter used for brooding successive flocks is referred to as "built up" litter. Chicks on built up litter generally do better than chicks on new litter. The latter can result in a phenomenon called "New house" syndrome. If new litter material can be acquired at a reasonable price and land is available for disposal of old litter, then most broiler houses are totally cleaned once per year. Old litter is spread on farm land as a fertilizer and new litter is placed in the house. However, availability and cost constraints associated with replacing litter for each flock often necessitate reusing litter. After a flock has been removed from a broiler house at the end of a production cycle, litter intended for reuse is "de-caked". "De-caking" is accomplished by removing the wettest and most compressed parts of litter (top few inches) from the chicken house followed by tilling and evenly spreading the remaining litter across the floor in preparation for the next flock. "De-caking" releases trapped ammonia and allows the litter to dry. Another procedure that is gaining favor is to windrow the litter down the center of the house and let it compost. Composting is an excellent way of reducing pathogens in litter. After it is spread out in the house, old litter is usually "top-dressed" by placing 1- 2 inches of new litter over the old litter.

It is important to maintain proper levels of litter moisture (20-30%). Litter moisture can be evaluated by squeezing it in the hand. When litter is released, it should slightly adhere to the hand and break down when dropped. Litter that is too wet (> 35%) forms a complete ball when squeezed. Wet litter can result in excessive ammonia production by bacteria in the litter and contributes to development of breast blisters, foot pad ulceration, and excess condemnations at processing. Wet litter can be caused by water line leaks, excess humidity, inadequate moisture removal due to poor ventilation, watery droppings associated with enteritis, high salt or high protein rations, poor quality fats, and improper drinker management. Lack of clumping when squeezed indicates the litter is too dry, which can lead to dusty conditions and contribute to respiratory infections.

When proper litter conditions are maintained, growth will be closer to optimum targets, there are few to no flies and parasites, feed efficiency is improved, and feathering is better.

1.4.8 Chick Delivery and Placement

Chicks are transported from hatcheries to farms on the day they are hatched. Chicks delivered to a single house should be from breeders of a similar age and genetic background. Under an "all-in, all-out" system, all chicks enter a house on the same day and leave the house for transport to a processing plant on the same day. Most commercial broiler hatcheries are completely automated with little labor needed for separation of chicks from shells, vaccinations, or placement into delivery boxes. The majority of the broiler industry uses straight run chicks, which include males and females in the same flock. No beak conditioning is done on broilers at the hatchery. Vaccinations post-hatching are done primarily through spray cabinets where each box of 100 chicks is dosed with an aerosol vaccine. Spray vaccines for coccidiosis are usually colored so chicks will ingest the vaccine off the down of other birds. Prepared chicks are placed in ventilated boxes and loaded into an environmentally controlled vehicle, usually a chick bus or enclosed trailer that may transport over 100,000 chicks at a time. After chicks are taken to a farm, they need to be immediately unloaded from the transport vehicle and moved into the chicken house to avoid dehydration and overheating. On delivery of chicks, growers assume responsibility for care of the birds.

Growers and company personnel are responsible for placing chicks inside the house. Pallets of chick boxes are driven into the house on a forklift. Starting at the back of the house, chick boxes are emptied by hand so chicks are placed near to and have immediate access to clean, fresh feed and water. If supplemental feed is on paper, chicks should be placed on the paper. Placement of 20,000 chicks can take less than ten minutes with a skilled crew. Chicks are monitored to make sure they are locating feed and water, and to ensure house temperature and ventilation are correct. The goal is active, curious chicks that eat and drink in less than 24 hours. By 8 hours after placement, at least 80% of chicks should have crops that are full, soft, and rounded if chicks have been eating and drinking properly. By 24 hours after placement, 95-100% of chicks should have a full crop. A crop-fill evaluation should be done on at least 100 chicks selected from three different locations within the house. If feed consumption is delayed, chicks will use both fat and protein from their yolk sac for energy resulting in inadequate protein available for growth.

1.4.9 Imprinting

During the first two weeks of life, chickens imprint on their environment. Imprinting involves formation of habits and associations that remain throughout their lives. Producers have a brief opportunity to introduce flocks to positive habits and conditions. Chicks are stimulated to locate feed and water as soon as possible and are introduced to periods of darkness. The imprinting period is a good opportunity for producers to control and encourage desirable behaviors in a flock.

1.5 GROW OUT

Grow-out, the second stage of broiler growth, begins when the house dividers are removed and chickens move into the entire house. This period typically begins at 11-16 days of age and continues until the broilers are removed for processing. During grow-out, broilers are no longer as fragile and not quite as susceptible to disease or changes in temperature. However, care must continue in the grow-out stage to enable the broilers to reach their maximum potential.

1.5.1 Feed

Feed is the largest single cost in broiler production. Broiler chicken feed consists largely (about 85 percent) of corn and soybean meal. There are no major differences in nutritional requirements between broiler strains but goals of a nutrition program may differ between production companies. Rations formulated by poultry nutritionists may be designed to attain maximum profitability of live birds or they may be designed to optimize yields of certain carcass components, such as breast muscle. High energy rations optimize live weight gain and feed conversion but may result in higher carcass fat content and a higher incidence of metabolic disorders. Diets with optimal crude protein and amino acids may produce slower weight gains and poorer feed conversion but yield more lean muscle in carcasses. Formulation of broiler rations is influenced by availability of raw materials and their cost, age and sex of chickens in the house, and desired live weights at slaughter. Furthermore, rations may be modified during periods of high ambient temperature to minimize heat stress or reduce environmental contamination associated with nitrogen and/or phosphorus excretion. In 2012, average cost per ton of feed was $347. Average feed cost per pound of broiler meat was $0.31.

Soybean meal is the major source of protein and amino acids in poultry feed throughout the world. The amino acid profile of soybean meal is excellent for chickens. Protein and amino acids are absorbed from the gut and are primary constituents of skeletal muscle, feathers, bone matrix, ligaments, skin, nerves, and organs. Feeds are often supplemented with synthetic amino acids, such as methionine, lysine, and threonine, to satisfy requirements for growth-limiting amino acids. Sulfur-containing amino acids, such as methionine, are the first limiting amino acids in broiler feed because they are used for feather growth, which has priority over muscle growth. Lowering feed costs by lowering protein levels may result in deficiencies of one or more amino acids and reduction in breast meat yield. Corn and wheat are primary sources of energy-producing carbohydrates in broiler diets with lesser amounts of energy coming from fats or oils. Energy is needed to support rapid growth, maintenance of body tissues, and activities of the birds. A vitamin-mineral premix is used at varying levels throughout the life of broiler chickens. Vitamins include fat-soluble (A, D, E, and K) and water soluble vitamins (B-complex and C). Limestone and oyster shell are sources of calcium, which is needed for formation of bones, blood clotting, and intracellular communication. Phosphorus is required for bone formation, energy transfer, and phospholipids. Potassium, sodium, chloride, and magnesium work with phosphates and bicarbonates to maintain correct levels of osmotic pressure and pH. Trace minerals are part of larger organic molecules involved in many metabolic reactions and include iron, iodine, copper, manganese, zinc, and selenium.

Enzymes are used in broiler chicken feed to improve digestibility of feed ingredients. Phytate phosphorus accounts for 60-70% of phosphorus in plants and is poorly digestible. Phytase is widely used in broiler chicken feed to release phosphorus bound to phytic acid in plant materials. Inorganic phosphorus is expensive to purchase and using phytase lowers feed costs by lowering the amount of inorganic phosphorus needed in the ration. In addition, phytase has a positive effect on the environment by reducing the amount of phosphorus excreted in droppings. Other enzymes can be employed to improve the digestibility of carbohydrates in cereals grains. Wheat, barley, sorghum, oats, and rye contain non-starch polysaccharides (previously called fiber), which become more digestible after the addition of appropriate exogenous enzymes to the feed. New enzymes that are not destroyed by heating and can be added to the feed before pelleting are being developed.

During the grow-out period, feeding programs attempt to optimize body weight uniformity, feed efficiency, average daily gain, and livability. As the broilers grow, each successive diet has a lower level of protein and a higher level of energy. Changing nutrient requirements as broiler chickens age are satisfied by providing separate grower, finisher, and withdrawal feeds in the form of pellets, larger particles that deliver more volume per bite. The change from crumbles to a pellet diet is initiated by the integrator who supplies the feed. Each pellet provides a complete nutritional package when eaten. Pelleted feeds are easier to handle and produce better feed efficiency and growth rates than mash feeds. High temperatures during pelleting reduces bacterial levels in feed by 5 to 10 times, however, spore-forming bacteria are not completely inactivated. Grower feed is given to broilers for 14 to 16 days after the starter feed. It has the highest nutrient density, which supports maximum growth rates. Finisher feeds are given from approximately 25 days of age until processing and account for the major volume and cost of feeds ingested by broiler chickens. Using least cost feed formulation is important when designing finisher feeds to maximize financial returns. Withdrawal feeds are fed for a sufficient period of time prior to slaughter (usually around 5 days) to meet federal drug withdrawal requirements for antibiotics, growth promoters, or coccidiostats so drug residues do not occur in broiler chicken tissues following processing.

1.5.2 Water

Water is an essential nutrient for digestion that should be continuously available. Approximately 70% of a broiler's body weight is water, of which 70% is intracellular and 30% extracellular. Providing sufficient, clean water is critical to a flock's success. Water should not contain excessive amounts of minerals, bacteria, nitrates, or nitrites. Water consumption increases with bird age and ambient temperatures and is influenced by relative humidity and diet composition. Excessively warm water reduces intake so flushing water lines during hot weather helps to provide cool water and encourage water consumption. Broiler chickens in temperate climates drink approximately twice as much water as feed consumed on a weight basis. Water consumption rates shown in the table below were derived from those published by Leeson and Summers in the book entitled *Commercial Poultry Nutrition* (3rd edition).

Table 11. Daily Water Consumption of Broiler Chickens (gallons/1,000 birds)

Age (Weeks)	*Ambient Temperature*	
	68°F	*90°F*
1	6.3	10.5
3	26.2	50.0
6	62.9	131.0
9	78.6	157.0

1.5.3 Light

Lighting programs for broiler chickens during grow-out are either restricted or intermittent. Restricted lighting programs use a daily photoperiod of about 18-20 hours of light with 4-6 hours of darkness during a 24 hour day, depending on the desired live weight at slaughter. Numbers of hours of light available each day and the light intensity affect bird behavior and activity. A light schedule should provide adequate dark time for broilers to rest, but be short enough to prevent lengthy periods when the flock is without feed. Feed takes approximately 4 hours to pass through the intestinal tract of broiler chickens. Aggressive feeding behavior resulting in skin scratches, which predispose to infectious process and increased condemnations at processing, occurs when the birds do not have feed for more than 6 hours. Periods of darkness longer than 6 hours exacerbate problems associated with high stocking densities and limited feeder space. In addition, too much light exposure may cause increased activity of broiler chickens and lead to carcass bruising, infectious process, and poor feed conversion. After chicks are released from the brood chamber and have spread uniformly throughout the house, light intensity may be dropped to about 0.5 to 1.0 foot candle (5-10 lux). A dimmer switch can be used to gradually increase light intensity over a one hour period after lights come on in the morning and slowly decrease light intensity over a one hour period before lights go off in the evening.

Intermittent lighting programs often use 6 cycles of one hour of light followed by 3 hours of darkness in a 24 hour day.

1.5.4 Temperature

Heating and cooling the house is an essential part of raising broiler chickens. Average house temperatures must be reduced as broiler chickens age because rapidly growing chickens generate substantial amounts of heat throughout the house. In the case of a ventilation failure, death results from overheating rather than inadequate oxygen. Instead of supplying heat, as occurs during brooding, heat removal becomes more critical. Older birds are more difficult to keep cool because they are better feathered and insulated and generate significant amounts of body heat. Broiler chickens remove excess body heat through sensible and latent heat loss mechanisms. Sensible heat loss occurs via convection, radiation, and conduction. Latent heat loss takes place by evaporation of water from the respiratory tract. In summer, approximately one third of body heat lost by broilers occurs from sensible heat loss and two thirds from evaporative cooling via panting. Once birds begin panting, efficiency of body weight gain and feed conversion are sacrificed. Therefore, the closer poultry producers maintain ideal temperatures during summer heat, the better bird performance.

The majority of broiler houses have computerized environmental controllers that control temperature based on feedback from thermal sensors. Environmental controllers activate fans, side-wall inlets, tunnel ventilation, evaporative cooling pads, and curtains as needed to achieve the desired temperature. Foggers, evaporative cooling pads, and sprinklers are frequently used to cool houses and birds in summer. During hot weather, tunnel ventilation allows for maximum airflow in a house. To prevent temperature build up, air speeds for older birds in a house should be around 500 to 600 ft/min. Air movement at this speed creates a wind-chill effect and pulls trapped heat from between the chickens. Air is drawn into the house through evaporative cooling pads, which further aids in maintaining house and bird temperatures. Insulation is of great importance to prevent transfer of radiant heat from the roof to the broilers. While the cost of insulation is quite high in parts of the world, it is still more effective than over-sizing ventilation and cooling systems.

High relative humidity on hot days impairs the efficacy of evaporative cooling by the ventilation system and reduces heat loss through evaporation of water off the birds' respiratory system, which can result in high mortality. Conversely, if relative humidity is low and house conditions are dusty, respiratory problems, airsacculitis, poor feed conversion, and poor weight gains are likely to occur.

1.5.5 Ventilation

Modern broiler houses use power tunnel ventilation and have solid side walls, roof insulation, evaporative cooling pads, and fogging systems. Automated systems control house temperature and monitor static pressure, air velocity, and negative pressure. Computer controllers can be programmed to adjust the minimum ventilation rate as birds age so that adequate moisture and gas removal occur even during cold conditions. Tunnel ventilation systems have air intakes at one end of a house and exhaust fans at the other end. Negative pressure is created within air-tight houses by turning on electric exhaust fans that draw air out of the house. The speed at which air enters the house is determined by the vacuum created within the house and the size and shape of air inlets. Typically, air is drawn through the length of a house at the rate of about 500 feet per minute, which creates a wind-chill effect and lowers the effective temperature by about 10o F. Tunnel ventilation, when combined with evaporative cooling pads and fogging systems, effectively cools broiler chickens during periods of intense summer heat unless the humidity is also high. With evaporative cooling, air is drawn through wetted cellulose pads and energy released during evaporation reduces the temperature of air entering the chicken house. Fogging systems cool incoming air by evaporation of water that has passed through fogger nozzles.

Older chicken houses use natural ventilation, usually lack insulation, and have curtains on the sidewalls that can be raised or lowered. Natural ventilation consists of air currents that enter one side of a house, pass over broilers in the house, and leave through the opposite side wall. The rate of air exchange depends primarily on outside winds and sidewall fans that are used to improve air circulation and help create a wind-chill effect. In older houses without automated control systems, growers must adjust curtains several times a day to optimize ammonia and moisture removal and still maintain good growing conditions. On hot summer days, curtains are lowered to allow more outside air to enter the house and foggers or misters are used when further cooling is needed. In addition, circulation fans can be used to increase air speed at bird level. During cold weather, curtains are raised to limit the flow of air into a house and circulation fans are used to mix incoming cold air with warm air in the house.

Ventilation is used to remove heat from broiler houses during summer and to remove moisture from broiler houses during winter. A flock of 20,000 seven-week-old broilers produces approximately 500,000 British Thermal Units (BTUs) of heat each hour in a chicken house. In addition, on hot days, heat entering a house through the ceiling and side walls may add another 150,000 BTUs. If excessive heat is not removed, broiler chickens may die. The air exchange rate during grow-out should be double the air exchange rate during brooding. Exhaust fans controlled by a timer, not by a thermostat, pull hot air out of broiler houses and may completely exchange the air in one minute. In cold weather, minimum ventilation is maintained to bring fresh air into houses and prevent moisture build up. Air exchange may occur once per minute in 3-6 minute cycles, which will optimize air quality without over chilling the air.

1.5.6 Litter

Over time, litter builds up and gradually decreases in quality. As chickens age, they excrete larger amounts of waste that accumulates resulting in litter becoming “caked”, or clumped. As much as 100 tons of litter and excreta can be produced during the course of a year from 6 flocks in a 40’ by 400’ house. Due to the shortage of bedding material available to the industry, it is a common practice for producers to reuse litter (bedding plus excreta) for a year or longer, a process referred to as using “built-up litter”. Composting built up litter between flocks helps reduce pathogens, parasites, and insect pests that can carry over in the litter from the previous flock.

1.5.7 Mortality

In the first week, mortality may be around 1% but should decrease to 0.5% or less during the second week. Through weeks 3 and 4, mortality should remain very low. It may slowly increase from week 5 through the end of production. Typically, 6-week-old flocks of broiler chickens go to market with only 2-4% mortality during the life of the flock. Average mortality of broiler flocks between placement and processing was about 3.6% in 2011 in the United States.

It is vital to be conscious of bird health throughout grow-out, especially towards load-out. As birds approach market age, high mortality greatly increases financial loss because a substantial amount of labor and feed have been put into growing these older chickens. The greatest economic loss comes from birds condemned at processing. Mortality must be monitored daily and dead birds promptly removed from the house.

1.5.7.1 Culling

Culling to remove sick chickens is important in preventing or limiting disease outbreaks. Growers should walk houses daily to check for sick and dead birds, record their number, and dispose of carcasses properly. Broiler chicks that have crossed beaks, show signs of illness, cannot stand to eat or drink, are blind, or are excessively small should be culled. These chicks consume feed and water but are likely to die and spread disease. Culling birds on the farm prior to load-out helps reduce losses from condemnation at processing. Chickens to be culled are usually killed by cervical dislocation or carbon dioxide gas.

1.5.7.2 Carcass Disposal

Disposal of dead birds is regulated by local, state, and federal governments to control the impact of carcass disposal on air quality, water quality, and the spread of disease. Disposal of mortality is a daily necessity since dead birds can harbor pathogenic microorganisms with potential transmission to other poultry. Cost of supplies, labor reliability, maximum anticipated daily mortality, and degree of biosecurity associated with each method must be assessed.

Carcass disposal methods include composting, rendering, burial, and incineration. Burial has been banned in most states due to the risk of contaminating ground water. Most states allow on-site or landfill burial through permit only and only under catastrophic conditions. Incineration is the most biologically safe way to dispose of dead birds. It does not negatively impact water quality when ash is properly handled and does not contribute to problems with disease, insects, or vermin. However, incinerators must be properly designed to avoid odor problems and should be located down-wind from residences and other poultry houses. Because of fuel costs, incineration tends to be expensive.

Composting is popular because it is inexpensive to manage and, when done properly, creates an environmentally friendly, pathogen-free fertilizer. Composting requires construction of a solid floor and covered roof system that has adequate primary and secondary bin capacity to meet the predicted mortality level for the farm. Composting is achieved by providing a mixture of carbon, nitrogen, air, and water to encourage microbial growth. A carbon to nitrogen ratio of 25-40:1 is created by layering litter and other organic material, such as straw, with moisture-rich carcasses. The level of moisture in the composting material should be 40-60%. Addition of air by turning the material at set intervals creates the perfect recipe for natural aerobic breakdown of organic materials. In properly constructed piles, temperatures are expected to reach between 120 to 160°F within the first 10 days. It is generally thought that 1 to 2 days at 149°F is sufficient to inactivate pathogens. Once the compost temperature begins to drop below 55°F, it should be aerated by turning the pile or moving composting material to a secondary bin. Composting requires 16 to 20 days for the first heat cycle and roughly the same amount of time for the second heat cycle. Major drawbacks to composting are construction and labor costs, since the system requires careful and frequent management.

Rendering is the process of mechanically processing carcasses to reduce tissue size with subsequent cooking and further refinement resulting in the formation of a carcass meal. Rendering was once a popular method of carcass disposal because dead birds were processed into a value-added, protein-rich feedstuff that could be added into poultry feed or pet food. Rendering has now fallen out of favor, primarily because of biosecurity issues and high fuel costs. Movement of rendering trucks handling dead birds and moving from farm to farm has been identified as a risk factor for spreading diseases, such as avian influenza. Significant costs are associated with transporting carcasses to rendering facilities.

1.6 LOAD-OUT

Load out is usually done at night or under very dim lighting conditions, which helps keep birds calm during the catching process. Catching broilers at night reduces the probability of scratches, fractured leg or wing bones, and suffocation from piling. Feeder lines, water lines, and other equipment that might interfere with catching crews, or injure birds, need to be raised or removed. Research has shown that 50% of bruising occurs in the last 3 days that broiler chickens are in houses, so it is vital to avoid injuring birds while catching and loading to minimize condemnations at the plant due to bruising. In 2011, average broiler whole bird condemnations at processing caused by bruising were about 0.001%.

1.6.1 Feed Withdrawal

Withholding feed from broiler chickens immediately prior to catching, loading, and transportation to a processing plant is a standard management practice. Objectives of feed withdrawal are to reduce fecal excretion and external cross-contamination during transportation and to reduce fecal contamination of poultry carcasses that may occur during automated evisceration in a processing plant. During this time, broilers' crops are emptied of feed and the volume of ingesta in the intestines is markedly reduced, but cecal contents may or may not be evacuated. Integrators provide producers with a load-out time and a detailed feed withdrawal schedule. After 6-10 hours without feed, intestines are flattened and lie low in the body cavity, which allows automated machines to eviscerate the birds without breaking the intestine.

When feed withdrawal time is too short, contamination ensues, causing processing plants to use more water and more labor to process the flock. When feed withdrawal time is too long (greater than 12-14 hours), water can be transferred from muscles to the digestive tract, creating watery intestinal contents and increasing the likelihood of fecal contamination.

Typically, feed is withdrawn approximately 6 hours prior to loading by raising feed lines but broiler chickens should still have access to water right up to catch time to prevent dehydration. Until feed lines are raised, feed should be available in all feed pans to assure that feed withdrawal is done uniformly throughout the flock. However, producers should avoid adding large amounts of finisher feed into the feed system at the start of the withdrawal period and allow birds to clean up feed in pans. When feed in a pan is down to dust, chickens in a house are out of feed. If only feed dust remains in feeders when feed lines are raised, the broilers have been without feed for longer than the recommended time and correct procedures were not followed. Numbers of *Salmonella* and *Campylobacter* in crops and ceca at processing are increased after prolonged feed withdrawal because broilers begin to consume litter and fecal material.

1.6.2 Catching

Broiler chickens can be caught using manual labor or a mechanical harvester. All equipment, including feeders, waterers, brooders, and fans, must be raised to the ceiling or removed from the house before catching begins. Manual catching crews containing 7 or 10 people typically catch between 7,000 and 8,000 chickens per hour. A person catching chickens by hand may lift 5 to 10 tons of broilers during an average shift. Manual catching may result in rough handling and excessive excitement in the flock and be a major cause of injury to the birds. With manual catching, broilers should be caught by two legs, supported by a hand under the breast, and placed (not thrown) into crates.

Mechanical harvester crews usually consist of a team of 4 people who operate 2 catching units, a packing unit, and a forklift. Four people operate as two catching teams, which use independent catching and packing units but share transport trucks. Mechanical catching machines have long rubber fingers that transfer broiler chickens from the surface of the litter to conveyor belts for delivery to a caging system at the rear of the machine. Mechanical harvesters can catch, batch count, and load up to 8,000 chickens per hour. Chickens are transferred by a short conveyor to packing units which consist of a 5-tier by 3-drawer packing module. Forklifts transfer loaded packing modules to a transport truck that usually holds 20 modules stacked 2 high. Approximately 6,000 broiler chickens are loaded on each truck. When operated correctly, mechanical harvesters require no human contact with the chickens and reduce bruising and other causes of downgrading.

Producers are encouraged to be present during load-out to verify that the chickens are loaded carefully. During load-out, producers are encouraged to walk the house with the loading crew foreman to do a final check for dead birds. If broilers die right before or during load-out, they should be loaded onto the truck to be counted in the final weight. Each load of chickens is weighed immediately on arrival at the processing plant and this weight will be used to determine the producer's pay.

PART II: RESPONSE TO A HIGHLY CONTAGIOUS FOREIGN ANIMAL DISEASE

1.7 BIOSECURITY

Poultry medicine focuses on prevention through biosecurity, vaccination, medication, and harmonizing the environment. Each disease control strategy requires a financial investment with an expectation of a financial return on investment. The function of a health program is not necessarily to eradicate or completely eliminate a disease, but to find a level that will optimize return on investment.

Biosecurity encompasses procedures that reduce the probability of disease outbreaks and includes two components: a) bioexclusion prior to an outbreak (keeping pathogens out) and b) biocontainment after an outbreak (keeping pathogens from leaving an infected flock to prevent disease transmission).

Biosecurity is critical from start to finish of a flock and should be in place on every farm. Farms with poor biosecurity are vulnerable to diseases, which have the potential to ruin an entire flock. Loss of income from an entire flock is an enormous financial burden on growers. The importance of biosecurity cannot be overstated.

1.7.1 Conceptual Biosecurity

Conceptual biosecurity requires selecting a location for a broiler farm that will isolate the premises from other domestic poultry, wild waterfowl, and livestock, which are potential reservoirs of infectious diseases. Broiler farms should be geographically separated from other poultry units because pathogenic bacteria and viruses may be carried by the wind or by various vectors and fomites to adjacent premises. Ducks and geese are reservoirs of avian influenza and Newcastle disease viruses so broiler farms should not be located near lakes, ponds, or rivers. In addition, broiler farms should not be located near highly traveled public roads, hatcheries, feed mills, or processing plants. Single-age sites help reduce cycling of field and live vaccine viruses. Broiler houses on a farm should be separated into units that can be isolated and quarantined should the need arise.

1.7.2 Structural Biosecurity

Investments in biosecurity are necessary to protect broiler chickens from exposure to pathogenic micro-organisms. Buildings and other structures on the farm should be constructed to minimize the risk of infectious disease microbes entering a chicken house. Fences with gates should be built to prevent access by unauthorized visitors, wildlife, and domestic animals. Roads should be located to allow clean vehicles to approach chicken houses and to divert potentially contaminated vehicles away from the houses. Equipment and supplies to decontaminate vehicles and farm equipment should be purchased and readily available for use when needed. Showers and changing rooms should be provided for employees and visitors. Signs should be posted to serve as visual reminders of the important role of biosecurity in keeping broiler chickens healthy.

Chicken houses should be bird-proof and rodent-proof. Grain on broiler farms will always attract birds, rodents, and wild animals, such as skunks and raccoons. Houses, feed storage areas, and water sources should be constructed to exclude free-flying wild birds and rodents. Wild birds can be vectors for numerous diseases including *Mycoplasma*, *Salmonella*, and avian influenza. Rodents can be a reservoir of *Salmonella* or *Pasteurella*.

1.7.3 Operational Biosecurity

Operational biosecurity consists of routine procedures intended to prevent introduction of infectious disease agents. Components of a good biosecurity plan include (but are not limited to) the following measures.

1.7.3.1 Visitors, Service Technicians, and Employees

- No visitors should be allowed on the farm or enter broiler chicken houses unless absolutely necessary. Footwear, hands, and clothing can carry infectious micro-organisms onto a farm. Everyone must be respectful of growers and their investments so visitor restrictions must include neighbors and contract work crews.
- Visitor logbooks should be routinely used. Visitors who have had contact with birds during the preceding 72 hours should be prohibited from entering broiler houses.
- Visitors and laborers should wear clean coveralls, hair nets, and clean footwear and must use disinfection stations provided at the door before entering a chicken house.
- Service technicians and other company personnel should wear protective coveralls, hairnets, and shoe covers. They also should use antibacterial hand sanitizer and spray tires and undersides of vehicles with an antimicrobial solution between farm visits.
- Service technicians should wash their vehicles after visiting sick chickens. When service technicians know they are going to visit a farm with sick birds, they should visit that farm last during the day.
- Employees should not have contact with other birds not owned by the business– including birds at live markets, pet birds, domestic chickens, fighting chickens, ducks, geese, waterfowl, exotic birds, quail, partridge, or pheasants. In the event that contact is made with any of the above, employees should agree to comply with a 24-hour waiting period before returning to work.
- Employees should wear clean, laundered, or new disposable coveralls and a hat in addition to disinfected rubber footwear (*i.e.*, protective clothing).
- Disposable items used during the flock visit should be bagged and left on the farm.

1.7.3.2 Vehicles and Drivers

- All vehicles should be cleaned before entering a farm. Feed delivery trucks should be washed and sanitized between farm visits. Transport trucks and load-out equipment should be cleaned and disinfected prior to entry onto the farm.
- Drivers should wear clean boots (rubber or disposable) before getting out of the vehicle and should use a hand sanitizer before leaving and after re-entering the cab.

1.7.3.3 Equipment

- All equipment should be cleaned and disinfected before it is brought onto a farm. Equipment that has been in a chicken house should be thoroughly cleaned and disinfected before being placed back into a vehicle.
- Sharing equipment between broiler farms is not recommended. In the event that equipment must be shared, effective cleaning and disinfecting should take place between uses. Equipment should be inspected prior to entry onto the farm.

1.7.3.4 Broiler Houses

- Doors should be secure even when houses are empty and all possible entries for wild birds should be sealed and checked frequently.
- Cats and dogs should not be allowed in broiler houses because they can harbor enteric pathogens, Pasteurella in their mouths, and influenza viruses, or be mechanical carriers of pathogens on their feet, hair coat, or in their upper respiratory system.
- Footbaths should be available outside all entry points to the chicken house and everyone entering a house should dip both feet. Foot baths typically contain phenolic or quaternary ammonium antimicrobial liquids, dry chlorine, or hydrated lime powder.

1.7.3.5 Feed and Water

- Feed bins should be secured to prevent contamination by wild birds or rodents.
- Spilled feed should be cleaned up promptly to prevent attracting wild birds and rodents.
- Water sources should be secure and deny access to free-flying birds or rodents and their excreta. Water sources should be chlorinate or otherwise disinfected.
- Lids of feed bins need to fit properly and remain closed to keep rain from soaking the feed. Wet feed fosters mold growth and multiplication of micro-organisms.

1.7.3.6 Rodent and Insect Control

- Rodent control is critical for disease prevention. Rats, mice and other rodents contaminate feed and litter with Salmonella via their feces. Farms should have bait stations around the perimeter of chicken houses that prevent pets and livestock from gaining access to the bait, but provide easy access to the bait by the rodents. Rotation of bait is essential.

- Insect control also is important because insects can harbor infectious agents and permit them to survive from one flock to the next. Darkling beetles are vectors of virtually every disease known to poultry, while their larvae are destructive to insulation. The life cycle of a darkling beetle is 6-8 weeks and warm, nutrient-rich poultry house environments are ideal locations. Beetles can become resistant to pesticides, so rotation of products between flocks is necessary for optimal control.

1.7.3.7 Manure Removal and Dead Bird Disposal

- Composting should be managed to ensure that carcasses are covered to prevent access by wild animals and to maintain adequate temperatures for composting.
- When on-farm incineration is used, carcasses should be protected from exposure to wild animals.
- Trucks moving manure or dead birds should be covered to prevent dissemination of potentially contaminated feathers and follow a designated, approved route.
- Trucks moving manure or dead birds should be cleaned and disinfected after deliveries and before entering another farm. Movement of avian influenza virus between farms has been associated with contaminated rendering trucks.

1.8 PROVIDING ANIMAL CARE

1.8.1 Feed

In the event of a foreign animal disease (FAD), provisions for feeding unaffected flocks in the quarantine zone must be provided. If all of a broiler company's farms and the company feed mill are within the same quarantine zone, then the only consideration for feed delivery trucks is to avoid routes that take them by affected farms. Feed will not be delivered to an Infected Premises because flocks on those farms will be depopulated. Feed already present on an Infected Premises will be destroyed on the farm.

When only some broiler company farms receiving feed from the company feed mill are within the same quarantine zone, some company feed delivery trucks will be dedicated to deliver feed to farms within the quarantine zone and other company feed delivery trucks will be dedicated to deliver feed to farms outside the quarantine zone. Within the Control Area, trucks should deliver feed to a single premises instead of delivering feed to several farms. Routes and farm deliveries need to be recorded in the event that additional flocks develop the FAD. Before feed delivery trucks leave a farm, they must be carefully cleaned and disinfected, especially if they are leaving the quarantine zone and returning to the feed mill.

1.8.2 Water

Water is provided from municipal or on-farm sources. No special provisions for delivering water are needed.

1.8.3 Light

No special provisions for lighting are needed. Dimming lights prior to mass euthanasia may help calm the chickens.

1.8.4 Temperature

No special provisions are needed beyond those for normal production as described above.

1.8.5 Ventilation

No changes from normal ventilation are indicated. Ventilation can be shut down just prior to mass euthanasia of an affected flock, but should not cause extreme discomfort or result in death of the birds. There is no data to indicate that exotic Newcastle disease (END) or highly pathogenic avian influenza viruses (HPAI) survive very long in the environment, and airborne transmission is unlikely.

1.9 ON-FARM WASTE HANDLING

1.9.1 Litter and Manure

After depopulation of an infected flock, chicken houses should be closed and litter should remain in the house for at least 2 weeks. If possible, the house should be heated to accelerate destruction of the virus. Moving litter shortly after a diseased flock has been removed from a house puts other flocks at risk because viable virus is almost certainly still present in the litter. Avian influenza viruses are destroyed in litter by heating to 135°F (56°C) for 90 minutes or heating to 140°F (60°C) for 10 minutes. In-house composting of litter to temperatures higher than those required to destroy avian influenza virus is recommended, especially when litter composting is combined with in-house composting of dead birds. A negative test(s) of the litter for viable avian influenza virus should be obtained prior to removal of litter from the house. When litter is removed, it must be transported in covered trucks and trucks must be thoroughly cleaned and disinfected afterwards.

1.9.2 Residual Feed

Residual feed from an infected flock must be removed from feed lines, hoppers, and bins and added to the litter prior to litter composting. Feed from a premises with an infected flock cannot be removed from the farm or used to feed other birds. Feed may be transferred from a premises that has tested negative to another negative premises within the same Control Area, but not outside the Control Area.

1.9.3 Mortalities

Mass euthanasia is usually accomplished by using carbon dioxide, although fire foam is showing promise as a better method. Catastrophic losses, regardless if they are from heat, accidents, weather events, END, or HPAI, require extraordinary measures. Permission to bury carcasses on the premises or to incinerate large numbers of birds because of an emergency may be granted, but more often, these measures remain unavailable. Movement to a landfill where carcasses will be buried is an option, but not all landfills accept animal disposal and costs associated with transporting and using the landfill may be high. Information on possible use of landfills needs to be obtained prior to a crisis.

In-house composting of carcasses is cost effective and can be used when birds die or are euthanized in the house. Birds are piled into one or more rows down the middle of the house, covered with at least 2 feet of litter, and left for 2 weeks. Daily temperatures should be taken using a probe to ensure that composting temperatures are sufficient to kill END or HPAI viruses. When internal temperatures of the composting material drops, the composting rows should be aerated by turning in the house or the compost should be removed to a secondary composting facility on the farm where the process can be continued until complete. Compost should be sampled and found to be negative for viable HPAI or END viruses before it is removed from the house. Following removal of compost material, the house must be thoroughly cleaned and disinfected.

1.10 SURVEILLANCE

1.10.1 Zone and Area Designations

The Incident Commander will work with the Operations Section and Situation Unit within the Planning Section to determine appropriate zones, areas, and premises designations in the event of an HPAI outbreak. These zones, areas, and premises designations are used in quarantine and movement control efforts. The Infected Zone immediately surrounds an Infected Premises. The Buffer Zone immediately surrounds an Infected Zone or Contact Premises. The Control Area consists of the Infected Zone and Buffer Zone. A Surveillance Zone is outside and along the border of the Control Area. A Free Area (FA) is not included in any Control Area.

The Infected Zone is frequently illustrated by a concentric circle with a radius of approximately 2 miles (3.0 km) around the Infected Premises. Similarly, the Buffer Zone is shown as a concentric circle with a radius of approximately 6.2 miles (10 km) around the infected premises. Because the Control Area includes both the Infected and Buffer Zones, the Control Area extends for a radius of 6.2 miles (10 km) around the Infected Premises. In reality, Control Areas are influenced by geography, political boundaries, and movements within the company having an infected farm(s). Criteria for issuing permits that allow movement of products within, between, or out of zones, should be in place and agreed on prior to an outbreak. As a rule, nothing moves on or off a farm with a known or suspected infected flock except what is essential for disposing of the flock and subsequent cleaning and disinfection.

1.10.2 People

Avian influenza viruses are highly transmissible. Movement of people among farms is the most common means by which the virus is transferred from one flock to another. Access to the Control Area is restricted to essential personnel and only necessary movement within the Control Area is allowed. Regular visits to flocks by service technicians are stopped and replaced by telephone consultations. All personnel are required to follow strict biosecurity procedures for entering and leaving premises. Disposable personal protective equipment (PPE) should be used and left on the farm. Any non-disposable items must be disinfected, double-bagged, and the outer bag disinfected prior to removal from the farm and disinfection again later in a secure area. Personnel need to shower and change clothes after leaving a farm. A record of personnel movement is kept.

Avian influenza can infect people and may even cause death. Appropriate protective gear including a respirator (N-95 or better) and goggles should be worn for one's personal safety. People entering a positive flock need to be healthy without symptoms of possible human influenza, and they should be up-to-date on their vaccination for seasonal flu. Clinical signs of influenza in people include conjunctivitis, fever, and respiratory disease. While seasonal flu vaccination does not protect against avian influenza, it does minimize the possibility of reassortment of gene segments between human and avian strains of influenza viruses. If any workers in contact with infected flocks develop symptoms consistent with influenza, they must be seen immediately by a physician and tested for influenza. Workers may be put on prophylactic antivirals, but the value of this procedure is controversial. Taking antivirals can provide a sense of false security and relaxation of personal protection.

Cancelling local and regional poultry sales and shows during a FAD outbreak is a prudent measure to prevent potential spread of the disease to other areas.

1.10.3 Vehicle Traffic

Vehicle access to a Control Area is restricted and includes vehicles moving all types of poultry and some types of livestock. Movement is by permit only. Control points along roads into and out of the Control Area may be needed. Vehicles are cleaned and disinfected when leaving an affected farm. Portable disinfection stations may be set up to facilitate vehicle decontamination. Particular attention should be given to the inside of vehicles (they should be either uncarpeted or have rubber flooring that can be easily disinfected), wheels, tires, and undercarriage. Routes by which vehicles travel are recorded and, if available, a GPS monitoring device is placed in each vehicle.

In the event of an H5 or H7 Low-Path AI outbreak, controlled slaughter of flocks may be permitted. Flocks should be processed as soon as possible even if they are not at the normal age. Flocks in the Control Area that are too young for processing may need to be euthanized to depopulate the area in preparation for repopulation and release of the quarantine.

1.10.4 Disease Monitoring

Swabs shall be collected for 5-bird pooled samples (see below) from the daily dead birds or euthanatized sick birds from each flock on each premises every other day for 14 days. Contact Premises (CP), Suspect Premises (SP), and Monitored Premises that test negative should be re-sampled as described for At-Risk Premises (ARPs). Monitored Premises may be sampled more frequently depending on the need to ship product but at the minimum must be sampled as listed above. For ARPs, swabs should be collected for 5-bird pools on each premises every 5 days for the duration of the quarantine.

1.10.5 Surveillance and Sampling Prior to Movement of Chickens

- **Number of Broilers Sampled**. One 5-bird pooled sample must be tested by RRT-PCR for each 50 dead broilers and found to be negative from every house on the premises for two consecutive days prior to movement of live broilers or broiler hatching eggs. The time interval between sample collections on consecutive days must be at least 18 hours. If there are less than 5 dead broilers in the house, the remainder of the samples should be taken from sick broilers. Two 5-bird pooled samples that test negative provide a 95% level of confidence that HPAI will be detected if at least 40% of sampled broilers are shedding HPAI virus. For products that move daily, one 5-bird pool from each house on the premises must test negative by the RRT-PCR test on each day prior to movement of eggs and broilers.
- A **5-bird pooled sample** consists of combined samples taken from five broilers from each flock on a premises that died of natural causes during the preceding 24 hours or sick broilers that were euthanized during the preceding 24 hours. If there are less than 5 dead broilers available to create a pool, remaining samples should be taken from euthanized sick broilers.
- A **flock** consists of broiler chickens of the same age in one building that are marketed on the same day.
- **Time to Sample Dead or Euthanized Sick Broilers Chickens**. Samples must be taken within 24 hours prior to movement of live chickens (or broiler chicken products) from the premises. If an unusual HPAI virus proves to be slow-moving, adjustments to the sampling protocol will be made. For example, if broiler chickens from one farm will be marketed on four consecutive days, then samples will be collected each day for four days from all houses with birds. Targeting dead and euthanized sick birds reduces the sample size required for the 99% confidence level because the prevalence of HPAI infected birds should be higher in this group than in the house as a whole.
- **Chickens Selected for Sampling**. Oropharyngeal swabs must be taken only from dead or euthanized sick broilers and dead chickens should be sampled before sick chickens. Sick birds selected for euthanasia and sampling should exhibit clinical signs compatible with HPAI (depression or respiratory signs).

- **Location of Sampling**. Dead chickens from each house (flock) must be placed in a leak-proof container (such as a heavy-duty plastic garbage bag) each morning. Each container shall be labeled with the farm of origin, house of origin, number of birds found dead in the house that day, and the premises identification. Containers must be brought to a location near the premises designated by the Incident Command (IC).
- **Sampling Procedure**. An individual authorized by the IC will sample each chicken by swabbing the oropharynx of each dead chicken in the leak-proof container. One Dacron swab is used to swab the palatine (choanal) cleft on the roof of the mouth and the trachea of one chicken, picking up as much mucus as possible. Thereafter, the swab is vigorously swirled in 1.0 to 2.0 ml of Brain-Heart Infusion (BHI) broth and as much fluid as possible is squeezed out of the swab by pressing the swab on the inside of the tube before withdrawing the swab from the BHI tube. Swabs from 5 broilers should be swirled in one BHI tube.
- **Disposal of Chickens after Sampling**. After samples have been taken, farm personnel shall dispose of carcasses in accordance with an approved biosecurity protocol.

1.10.6 Sample Submission

- **Laboratory Submission**. BHI tubes containing oropharyngeal samples (5 oropharyngeal swabs/BHI tube) will be submitted as directed by the IC to an authorized State Veterinary Diagnostic Laboratory (VDL). These samples must be submitted on the day of sample collection by a State or Federal regulatory official or an IC-authorized person. The State VDL and IC will establish the time of day by which samples must be submitted to an authorized VDL (for example, by 12:30 p.m.).
- **Laboratory Testing and Reporting**. VDL personnel performing RRT-PCR will test samples immediately on receipt and electronically send test results to the IC by the end of each day. The IC will report test results to farm managers as soon as results are available. If the RRT-PCR test on the dead bird pool is not negative, additional diagnostic testing will be conducted.
- **Negative RRT-PCR Results Required**. Prior to movement, all the premises' tests of 5-bird pools taken 24 hour before movement must be negative.

Acknowledgements

Information for the Broiler Industry chapter of the Poultry Industry Manual was obtained from the following sources:

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This FAD PReP Industry Manual was produced in collaboration with USDA-APHIS-VS National Center for Animal Health and Emergency Management by the Center for Food Security and Public Health, Iowa State University of Science and Technology, College of Veterinary Medicine through a cooperative agreement.

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Acknowledgements

- Dr. Susan Watkins
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This chapter was reviewed by:
- Dr. Michael Martin
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Photo and Illustration Credits

Page 1 Photo strip: Left to right: Chicks; Holstein heifers; Landrace pigs; Red Angus/Simmental cross beef cow with calf; and feedlot cattle. *Photo sources: USDA; Mark Kirkpatrick, Idaho; Iowa State University; Beth Carlson, North Dakota; and Danelle Bickett-Weddle, Iowa State University.*

Page 2 FAD PReP Suite of Documents and Materials *Graphic illustration by: USDA*

Page 7 ***(Top)*** Table 1. Leading Broiler Production Companies (2011). *Graphic illustration by: Dani Ausen, Iowa State University*

(Bottom) Table 2. Leading Broiler Production States (2011). *Graphic illustration by: Dani Ausen, Iowa State University*

Page 8 Figure 1. Broiler Production by State Number Produced, Thousand, 2011. *Content provided by: USDA National Agriculture Statistics Service; Graphic illustration by: Dani Ausen, Iowa State University*

Page 10 Figure 2. Structure of the U. S. Poultry Industry, 2010. *Content provided by: USDA APHIS VS NAHMS; Graphic illustration by: Kate Harvey, Iowa State University*

Page 11 ***(Top)*** Figure 3. Health and Management Practices on Breeder Chicken Farms in the United States, 2010. *Content provided by: USDA APHIS VS NAHMS*; *Graphic illustration by: Kate Harvey, Iowa State University*

(Bottom) Broiler breeder house. Approximately 2/3rds of the house is occupied by raised slats while the remaining central part is litter-covered floor called the scratch area. Breeding occurs in the scratch area. Nest boxes are near the outer edge of the slats and extend down both sides of the house. The male feed line is raised and can be seen elevated above the scratch area. A row of lights provides the duration and intensity of lighting needed to stimulate reproduction (left). Breeder hens at feeders. Females spend most of their time on the slats, only going to the scratch area when receptive to breeding. Feed and water lines are placed above slats for use by the hens. The grill on the feed line prevents males from eating feed provided for females. The larger head and comb of a male compared to females can be seen. Note how the water line is positioned so hens have to stretch their necks at about a 45o angle to drink. Evaporative cooling pads that help maintain air temperature and quality are located in the background (right). *Photo sources: Michael Wineland, North Carolina State University (left); Michael Wineland and Michael Martin, North Carolina State University (right)*

Page 12 ***(Top)*** Biosecurity. It is important for everyone to understand the need for biosecurity. *Photo source: Michael Martin, North Carolina State University*

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Page 16 ***(Top)*** Egg room. After eggs are collected and put into trays, they are placed in an air-conditioned egg room where they are held until picked up and taken to the hatchery. Eggs are usually picked up 2-3 times each week. *Photo source: Poultry Health Management Team, North Carolina State University*

(Bottom) Incubator. Each trolley within the incubator contains eggs in different stages of incubation. After 18 days, eggs are removed, usually vaccinated *in ovo*, and transferred to setters that have been scheduled to hatch that batch of eggs. *Photo source: Poultry Health Management Team, North Carolina State University*

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Page 17	Eggs in hatcher tray. Eggs in the hatcher are not turned as they are in the incubator. These eggs are scheduled to hatch the following day, but a few chicks are already beginning to hatch. *Photo source: Michael Martin, North Carolina State University*
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Page 19	***(Top)*** Broiler Farm. *Photo source: Susan Watkins, University of Arkansas* ***(Center)*** Table 6. Stocking Densities According to Bird Numbers and Live Weight. *Content provided by: Arbor Acres Broiler Management Guide (2010); Graphic illustration by: Dani Ausen, Iowa State University* ***(Bottom)*** Control pan on feed line. *Photo source: Susan Watkins, University of Arkansas*
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Chapter 2: Turkey Industry

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INTRODUCTION

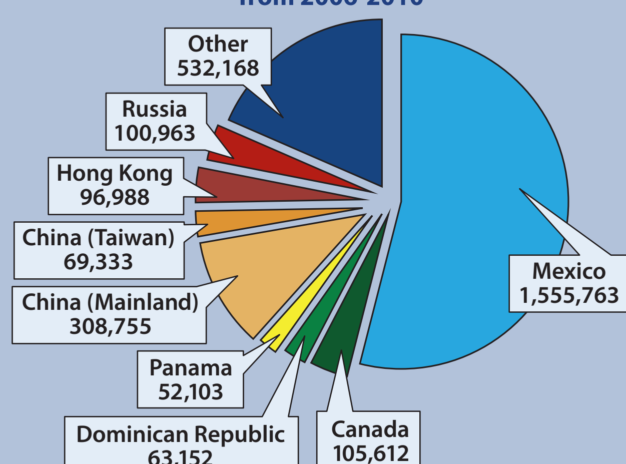
Turkeys are primarily ground dwelling birds in the order *Galliformes*, family *Phasianidae* that are more closely related to pheasants than chickens. Domestication of wild turkeys took place in Mesoamerica prior to the arrival of Europeans in the New World. The origin of modern commercial turkeys can be traced to the Mexican subspecies of the wild turkey, *Meleagris gallopavo gallopavo*. Descendants of these early domesticated turkeys (*Pavo creollo*) can still be found in rural areas of southern Mexico, although breeding with reintroduced European strains has occurred. Domesticated turkeys from North America were exported to Europe shortly after colonization of the New World began, where they were bred for various characteristics and re-exported to other parts of the world including back to North America. Turkeys were highly prized for their meat qualities and were served on special occasions. It is believed that confusion with guinea fowl provided by merchants from Turkey, known as "turkey coq" in Europe, led to the name turkey, but other theories also exist. Crossing domestic European turkeys with the wild turkey resulted in a larger, more robust, colorful bird that became known as the Bronze turkey. The Broad-breasted Bronze turkey, developed through selection of Bronze turkeys for growth, became the worldwide standard for commercial turkey production until the 1950's, when it was replaced by the Broad-breasted White turkey. Primary turkey breeding companies have continued to select breeding stock resulting in annual improvements in growth and feed efficiency (Smith, 2006).

PART I: TURKEY PRODUCTION

2.1 SCOPE OF THE TURKEY INDUSTRY

Profitable production of turkey meat is the goal of the commercial turkey industry in the United States. The U.S. is the largest producer of turkey in the world accounting for just over half of the annual world production of 2.6 million metric tons followed by the European Union-27 member states. The U.S. also continues to be the largest consumer of turkey meat, but *per capita* consumption of turkey is highest in Israel at approximately 22 pounds/per person, followed by *per capita* consumption in the U.S. at approximately 17 pounds. Turkey is consumed throughout the year, but consumption in the U.S. still peaks during the Thanksgiving and Christmas holiday season. Primary trading partners purchasing U.S. turkey were Mexico, China, Canada, Russia, Hong Kong, Taiwan, Dominican Republic, and Panama; Mexico accounted for over half of all turkey exports.

Figure 1. U.S. Turkey Exports (1,000 pounds) by Country from 2006-2010



In many ways, the turkey industry is similar to the broiler industry as both use intensive management systems to achieve the goal of producing meat. However, there are differences including the way in which breeding stock is obtained and managed, length of time flocks are grown, production characteristics, physiologic differences, prevalence of backyard/niche flocks, and presence of a free-living population of wild turkeys. The turkey is not merely an over-sized chicken; they are actually quite different from each other (Table 1).

Table 1. Differences Between Commercial Turkeys and Broilers	
Turkeys and chickens are much different from each other. Turkeys should not be thought of as just big chickens.	
TURKEYS	**BROILERS**
Breeding stock usually supplied as fertile eggs	Breeding stock usually supplied as chicks
Male and female breeders managed separately	Male and female breeders commingled
Reproduction by artificial insemination	Reproduction by natural mating
Larger adult (♀~26 lbs,♂~50 lbs)	Smaller adult (♀~7 lbs,♂~12 lbs)
Hens become broody if not controlled	Broody control not important
90 - 120 fertile eggs/hen	150 - 175 fertile eggs/hen
Larger, brown speckled eggs	Smaller, light brown eggs
28 day incubation period	21 day incubation period
Poults sexed at hatch	Chicks not sexed at hatch
Poults sexed by vent examination	Chicks sexed by sex-linked feathering
Servicing at hatch*	Usually no servicing at hatch
Separate hen and tom farms	Sexes usually grown together on same farm
Poults usually brooded in rings in brooder house	Chicks brooded in section of production house
Moved to separate housing for finishing	Brooded and finised in same house
Faster growth rate	Slower growth rate
Require higher protein starter (28%)	Lower protein starter (18%)
Feeds more expensive	Feeds less expensive
Free-living native turkeys	No free-living chickens
Processed at older ages (16-22 weeks)	Processed at younger ages (6-9 weeks)
More susceptible to disease	Less susceptible to disease
More resistant to avian paramyxovirus 1	More susceptible to avian paramyxovirus 1
More susceptible to avian influenza virus	Less susceptible to avian influenza virus
*See glossary under '**Servicing**'.	

2.1.1 Turkey Numbers and Location

Approximately 260 million turkeys are grown in the U.S. annually. Most commercial production occurs in the North-central, Central, Mid-east, and Mid-Atlantic regions of the U.S., and California (Figure 2). Top turkey producing states in 2010 are listed in Table 2. In 2010, combined production of the top three states, Minnesota, North Carolina, and Arkansas, accounted for 43% of total U.S. production. Top turkey producing companies are listed in Table 3 and information about turkey companies in the U.S. can be found at *http://www.poultryegg.org/economic_data/docs/USTurkeyCompanies.pdf*. Two genetic strains of turkeys are used for commercial production in the U.S.: Aviagen Turkeys (formerly Nicholas Turkeys), located in Lewisburg, West Virginia, and Hybrid Turkeys located in Kitchener, Ontario. A third strain, BUTA (British United Turkeys of America), is no longer marketed in the U.S. but is grown internationally as BUT. BUT breeding stock also is owned by Aviagen, Inc.

Figure 2. Number of Turkeys Raised, 2010 (Per Thousand Head)

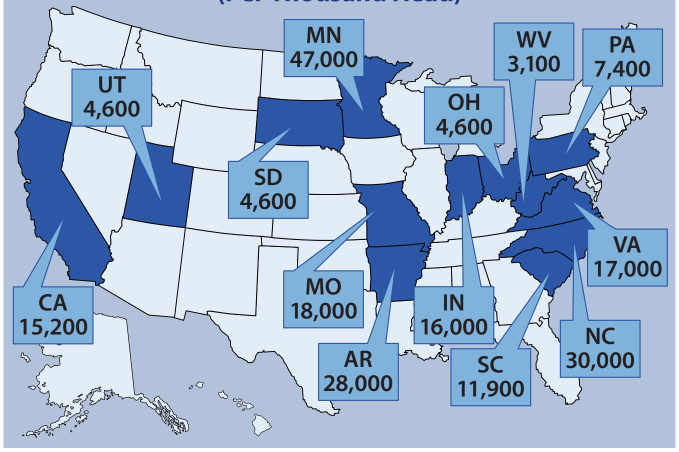


Table 2. Top Turkey Producing States in the US in 2011.				
Rank	**State**	**Number of Birds (head, millions)**	**Pounds Produced (millions)**	**Value (millions)**
1	Minnesota	46.5	1,171.8	799.2
2	North Carolina	32.0	1,132.8	772.6
3	Arkansas	30.5	603.9	411.9
4	Missouri	17.5	568.8	387.9
5	Virginia	17.5	460.3	313.9
6	Indiana	16.0	579.2	395.0
7	California	15.0	421.5	287.5
8	South Carolina	11.5	448.5	305.9
9	Pennsylvania	7.5	174.8	119.2
10	Ohio	5.0	210.0	143.2
11	South Dakota	4.4	180.4	123.0
12	Utah	4.3	97.6	66.6
13	West Virginia	3.3	92.4	63.9
	Other	37.5	1,177.4	803.0
Source: USDA, National Agricultural Statistics Service, 2012 Summary				

Table 3. Top Turkey Producing Companies in the U.S. in 2011 (Live Weight Processed).		
Rank	**Company**	**Pounds (millions)**
1	Butterball	1,300
2	Jennie-O Turkey Store	1,290
3	Cargill Value Added Meats	1,095
4	Farbest Foods	360
5	HIllshire Brands	340
6	Kraft Foods, Inc./Oscar Meyer	280
7	Foster Farms	274
8	Perdue Farms	271
9	House of Raeford Farms	259
10	Virginia Poultry Growers	245
Source: 2012 *Watt Poultry USA*		

2.1.2 Turkey Production Systems

While the vast majority of turkeys in the U.S. are Broad-breasted White turkeys raised intensively for commercial meat production, other types of turkeys are kept for similar or different purposes.

Some turkey flocks are raised to preserve specific breeds. These are known as "Heritage Turkeys". Some breeds are extremely rare with fewer than a hundred individuals known to exist. Recognized heritage breeds are those described in the American Poultry Association *Standard of Perfection* judging guide: Black, Bronze, Narragansett, White Holland, Slate, Bourbon Red, Beltsville Small White, and Royal Palm. Other color varieties also are often accepted as heritage breeds or are referred to as "Heritage-type" turkeys. Characteristics of heritage turkeys are an ability to mate naturally, long reproductive period, ability to thrive in free-range systems, and slow growth. Images of heritage turkeys can be found at *http://www.porterturkeys.com4/* and *http://albc-usa.org/cpl/wtchlist.html*.

Small flocks of turkeys, usually heritage-type turkeys, are produced for specialty niche markets or direct sale. Management systems vary, but typically, heritage-type turkeys are raised seasonally for the holiday market with access to free-range and minimum confinement.

Occasionally turkeys are kept along with a menagerie of other birds in backyard flocks (see Chapter 4), but they are not common because turkeys are more expensive to maintain, require a higher level of management, can contract histomoniasis (a serious, often fatal disease) and *Mycoplasma gallisepticum* from chickens, have a lower reproductive potential, and do not produce marketable eggs. In addition to captive rearing of turkeys, production in many areas coincides with the range of free-living wild turkeys, making disease transmission between captive and free-living flocks possible.

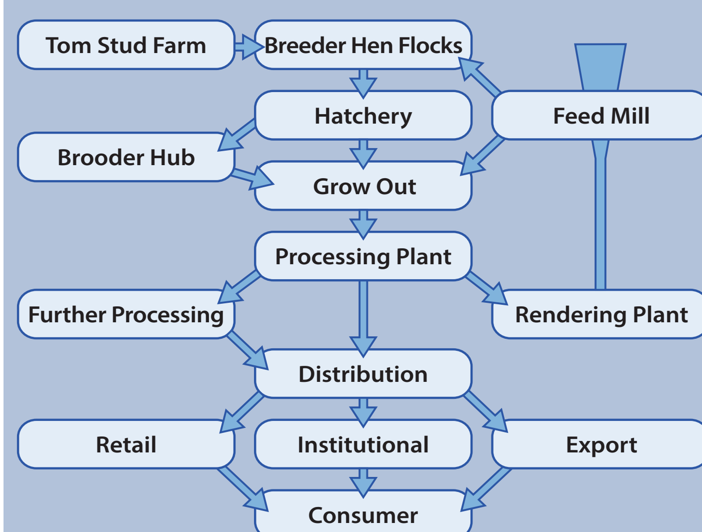
2.1.3 Turkey Industry Structure

Most commercially raised turkeys are produced by vertically integrated companies that have one or more complexes. Less commonly, turkeys are produced by cooperatives formed by owners of the production facilities. However, cooperatives also own or control various steps in the production cycle and are vertically integrated.

2.1.3.1 Vertical Integration

Vertically integrated companies control multiple stages of the production cycle, which facilitates synchronization of scheduling to meet product demand and plan for future markets, removes middlemen, and integrates profit centers to maximize financial returns. Costs are spread over the entire production process. Not every stage has to generate a profit so long as overall production is profitable. For example, day-old poult costs may be higher for a superior strain of turkey, but these costs may be offset by increased productivity of the superior birds when they are grown. Maximizing profit by balancing inputs and outputs for each stage of production requires excellent supervisory skills and decision making.

Figure 3. Structure of a Typical Vertically Integrated Turkey Company



The degree of vertical integration varies among companies. Structure of a typical vertically integrated turkey company is shown in Figure 3. Each stage is managed as either a cost or a profit center. A complex consists of a vertically integrated unit that usually includes breeders, hatchery, brooding, finishing, feed mill, and processing. Larger companies often have multiple complexes located in different geographic areas, either within a state or in other states. Production of around 12 million turkeys in a complex is considered optimum for resource utilization; however, the number of birds produced in a complex varies greatly among companies. Some integrated turkey companies also raise other commodity livestock such as broiler chickens or pigs because production of these animals is similar to that for turkeys, e.g., feed manufacturing and delivery, processing, and marketing.

How much a company actually owns in the integration and how much it controls through contractual arrangements differs among companies. When aspects of production are owned and operated by the company, critical stages such as breeding, which require close control and a high level of management, are more likely to be owned and operated by the company. Losses on the breeding farm have an impact throughout the whole company. Sometimes a company will own part of a production step, while the balance will be contracted.

Most finishing is done by contract producers who provide the facilities and labor in return for a contract price when the flock is marketed. Bonuses are provided for superior results in performance parameters including livability, growth, and feed conversion. The company owns the birds and provides feed, health care, and technical expertise for the birds. Service technicians, employed by the company, oversee the turkeys through regular visits to the flocks during which they monitor the flock's progress and advise on management and health. Service technicians usually have formal post-secondary education or long-term experience raising turkeys. Sometimes they also have their own farm and flocks, which they grow under contract for the company. They are not permitted to have other types of poultry in any numbers or contract flocks with another company.

When depopulation is necessary, such as limiting spread of a foreign animal disease, it can become problematic as to how payments for compensation should be made. Payment for the birds is made to the company, but the producer also loses much of their income because of the depopulation. Usually an equitable solution is determined between the company and contract growers and may have been predetermined in the contract. Similarly, dead bird disposal can be an issue between the company and contract producer. The grower is responsible for the collection and disposal of mortality in the flock, which can be a considerable expense if mortality is high, especially when birds are older.

2.1.4 Economics

Both fixed costs for buildings, equipment, utilities, taxes, and mortgage payments, and variable costs including poults, labor, transportation, processing, health care, and feed go into the cost of producing turkeys. Feed accounts for approximately two-thirds of the cost of production. Prices for corn and soybean meal, the main feed ingredients, largely determine the cost of feed. Turkey feeds tend to be more expensive than feeds for broilers because of the higher protein and energy requirements for optimal turkey growth. Similarly, feeds for young birds, which have higher protein and lower energy, are more expensive than feeds for older turkeys, which have lower protein and higher energy. Overall feed costs in 2011 are over $300/ton and expected to rise further due to the high price of corn, soybean meal, and supplemental fat.

Turkey accounts for approximately 13% of income generated from the sale of poultry products in the U.S.. Between 2006 and 2010, around 260 million turkeys were raised annually in the U.S.. An average of 7.4 billion pounds live weight was produced that was worth an average of nearly 4 billion dollars. Price per pound averaged 53.6 cents. *Per capita* consumption averaged just over 17 pounds/person. Exports accounted for slightly more than 10% of processed turkey (Table 4).

Table 4. Annual Production of Turkey in the U.S.

Year	Head (millions)	Pounds (billions)	Value (millions)	Price/lb (dollars)	Export (%)	Per capita Consumption
2006	262.0	7,418	3,551	.479	547 (10.2)	16.9
2007	266.8	7,566	3,954	.523	547 (10.9)	17.5
2008	273.1	7.922	4,477	.565	676 (9.2)	17.6
2009	247.4	7,149	3,573	.500	534 (10.6)	16.9
2010	244.2	7,107	4,371	.615	583 (9.7)	16.4
5 Year Average	258.7	7,432	3,985	.536	577 (10.1)	17.1

Source: USDA, Economic Research Service, National Agricultural Statistics Service

2.1.5 Capital Investment

Construction of a new turkey finishing farm with four houses in the Southeastern U.S. will cost around $1.5 million dollars exclusive of land (a minimum of 20 acres [8.1 ha]), land preparation, a well to provide adequate water, and utilities. However, costs may vary considerably according to geographic location, type of housing, current market prices, and size of the farm. Houses are usually 40 to 50 feet (12.2-15.2 m) wide and 500 to 700 feet (152-213 m) long. Previously, houses were curtain-sided and relied heavily on natural ventilation, but current housing is closed (solid side-wall housing), heavily insulated, and tunnel ventilated with automated fans and controllers. Backup generators provide electricity in the event of a power failure. Contract prices per pound of turkey are generally range from 4.5-5.0 cents/lb live weight. Number of pounds of turkey produced annually depends on the type of management system (on-site or off-site brooding), size of the farm, and efficiency of production. Brooding of poults on-site or off-site affects contract prices. Many companies have moved to off-site brooding at farms called "brooder hubs", especially for tom production, to maximize the biosecurity value of "All in/All out" production (see Section 2.4). Brooding off-site permits a greater number of flocks to be grown on a farm because 5 to 6 weeks of the growing cycle occur on the brooder hub. Hen flocks are usually marketed at 14-18 weeks weighing 14-18 pounds (6.4-8.2 kg) while tom flocks are marketed at 20-22 weeks weighing 40-44 pounds (18-20 kg).

Return on investment is also highly variable. Assuming a house has 25,000 ft^2 (50 x 500 ft) [2323 m^2 (15 x 152m)], hens are stocked at a final density of 2.5 ft^2 (0.23 m^2) per bird (10,000 hens), livability is 95% (9500 hens), average weight is 15 lbs (6.8 kg), grower pay is 4.5 cents per lb (9.9 cents per kg), and 4 flocks are produced with off-site brooding (~10 weeks for finishing and a minimum of 2 weeks downtime between flocks), the projected gross income would be (9500 hens x 4 flocks x 15 lbs x $.045) $25650. For toms, the same calculations (5625 toms [stocking at 4 ft^2/bird x 90% livability] x 3 flocks x 41 lbs [18.6 kg] x $.045) would result in a projected annual gross income of $31,130. If the brooder hub also is managed as a contract operation, a contract price for the turkeys is provided for this phase of the production cycle based on livability or other production parameters. Contract growers of breeders are paid for number of eggs. Often this is specified to be settable eggs (normal clean eggs suitable for incubation) that can be used for hatching, rather than total eggs.

2.1.6 Allied Industries

Not only is the turkey industry a producing industry, it also is a consuming industry. The greatest input is feed; corn and soybeans account for 83-91 percent of total feed ingredients. The turkey industry consumes over 7.67 million tons of corn and 2.5 million tons of soybean meal annually. In Minnesota, the number one turkey producing state, corn and soybean consumption by the turkey industry is equivalent to the production of nearly 2000 grain farmers. Other inputs required by the turkey industry are housing and equipment, vehicles, additional feed ingredients, products for cleaning and disinfection, and health products including vaccines and pharmaceuticals. Many of these products are provided by industries allied to the turkey industry, which may also provide technical expertise to support use of their products. In areas where there are multiple integrated poultry or swine companies, formation of a cooperative to provide supplies to the companies at cost have been created.

2.1.7 Diverse Workforce

Most workers on commercial and breeder turkey farms are of foreign descent, especially Hispanic. Knowledge of conversational Spanish, or having a person of Hispanic descent on an investigative team, is helpful when trying to learn how flocks are actually being managed on a farm. Interviewing the producer and farm workers about biosecurity or other management practices often results in divergent answers. Gaining the trust of the farm workers is particularly helpful in the event that a foreign animal disease control program is needed. Workers in processing plants also often come from diverse backgrounds, more so than those that work on turkey farms.

2.1.8 Premises Registration and Traceback

Knowledge of the location, type, and size of turkey flocks is important for disease control, especially in the event of a foreign animal disease outbreak. Prompt diagnosis and rapid, effective containment is critical to minimize the economic impact of an outbreak. Each turkey company has excellent record systems and can track a flock from its breeder source to the lot in which it was processed. Subsequently, trace back of processed product to the company and flock of origin is possible by examining processing and production records. For security purposes there has been reluctance to integrate farm and flock information among companies, but this has been done in several states where turkey production is important (e.g., North Carolina). Access to these databases is strictly controlled and cannot be released. Cooperation between Federal and State agencies is in concert with the current United States Department of Agriculture (USDA) position on animal traceability (Animal Disease Traceability Framework: Comprehensive Report and Implementation Plan, USDA, 2011, *http://www.aphis.usda.gov/traceability/downloads/report_implementation_plan.pdf*).

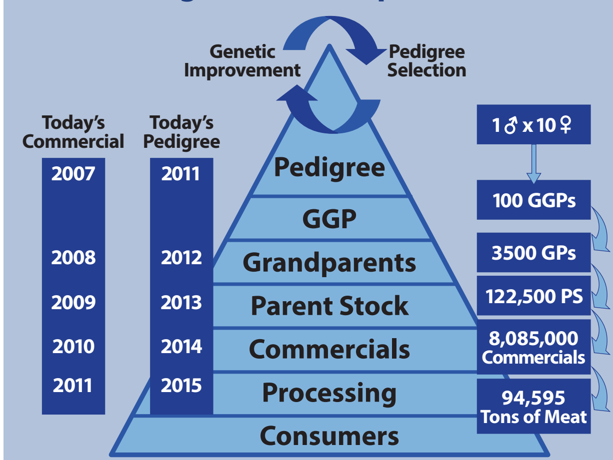
Interstate movement of poultry, including turkeys, also will be covered under the new traceability regulation. Unless exempted, each lot or group of birds will be identified by an Interstate Certificate of Veterinary Inspection (ICVI) issued by a Federal, State, or accredited veterinarian. Exemptions to the regulation can be found in the 2011 Animal Disease Traceability Plan. In this plan, poultry will be identified by sealed and numbered leg bands according to National Poultry Improvement Plan (NPIP) regulations, a group identification number, or other means agreed to by State or Tribal officials. A timeline for implementing the traceability plan for poultry has not been established.

2.2 LIFE STAGES AND POULTRY HUSBANDRY NEEDS

2.2.1 Production Cycle of Turkeys

Fertile eggs are produced on breeder farms by hens that are periodically inseminated artificially with fresh semen from tom turkeys maintained separately from the hens. Eggs are usually cleaned, surface disinfected, and stored in an egg cooler on the breeder farm for 1-4 days before being transported to a hatchery where they are held for another 3-7 days before being placed into the incubator (setter). After approximately 25 days of incubation, eggs are transferred to the hatcher where they remain until the poults hatch at around 28 days. Poults are sexed and serviced (see 2.3.1) at the hatchery, taken to either hen or tom farms where they are grown to market weight, loaded onto transport trucks, and taken to the plant where they are processed (see 4.4). Product from the processing plant is shipped to distributors for additional processing or sale.

Figure 4. "The Pipeline"



Source: Aviagen Turkeys, Nicholas

2.2.2 Breeding Flocks

2.2.2.1 Primary Breeders

Genetic improvement of commercial turkeys is done using a pyramid system similar to that for broilers and swine. A representative genetic pyramid illustrating production of Aviagen turkey breeders is shown in Figure 4. As many as 5 generations go into producing commercial turkeys. Individual lines are purebred so that the final generation is a three- or four-way cross. It takes about 4 years for pedigree genetics to be realized in the commercial meat birds. To obtain turkeys with the highest production potential, substantial selection pressure is applied to primary breeders. Primary breeders are maintained under the highest level of biosecurity possible because of their value and critical importance in the production pyramid. Each pedigree tom is ultimately responsible for producing over 8 million commercial turkeys and just over 94.5 tons of turkey meat, while each pedigree hen is ultimately responsible for around 800,000 commercial turkeys and nearly 9.5 tons of turkey meat. Primary breeder companies are independent of commercial turkey producers.

Primary breeders select for turkeys that improve production efficiency (growth rate, feed utilization, meat yield and quality), reproductive performance (number of eggs, number of poults, poult cost), and ability to do well in production environments (high livability, low morbidity). During the past few decades, live weights and feed utilization of commercial turkeys have increased approximately 2.3% and 1% per year respectively. Realization of these annual improvements in genetic potential requires meeting the turkey's nutritional, environmental, and health requirements for optimal production. Attention to growth (body weight control) and skeletal (frame) development, proper light stimulation, and good nutrition are essential for optimal rearing of both breeder hens and toms.

2.2.2.2 Parent Stock (Commercial or Multiplier Breeders)

Female parent breeding stock is usually supplied by primary breeders to commercial companies as fertile eggs from the hen line while tom parent breeders are provided as day-old poults. One or both grandparent lines are hybrids. When they are crossed to create the parent breeders (also called multiplier breeders), the commercial turkeys will be either 3-way or 4-way hybrids. Eggs supplied by the primary breeders for parent stock are hatched in the most biosecure method available to the company. Sometimes a hatchery separate from where commercial poults are hatched is used, but more commonly, breeder eggs are hatched in the same hatchery by themselves without commercial poults being hatched at the same time. In the hatchery, breeder poults are serviced the same as commercial poults (see 2.3.1). Off-sex poults (males from the female line) are raised as commercial poults, but their productivity is lower. Breeder ("replacement") hens and toms go to breeder farms where they are raised separately.

2.2.2.2.1 Breeder Toms

Replacement tom poults are placed on a tom only ("stud") farm, in a separate facility on a breeder replacement farm, or in a separate pen in a house that also has replacement hen poults. Ideally, breeders are placed on single-age farms that are isolated from commercial farms and other poultry. Regardless of the exact arrangement, sexes are reared separately. Facilities for breeders are thoroughly cleaned and disinfected prior to arrival of the poults. Except for providing approximately twice the floor space and optimizing biosecurity and management, brooding breeder toms is not significantly different from brooding commercial toms (see 2.4).

Controlling weight and development is essential for producing good breeders. To aid in development of male breeders, starter feed with higher protein (28%) and energy levels is provided for at least 4 weeks. Feed is generally not restricted until candidate breeders are selected at 16-18 weeks of age. This permits identification of the best males based on how well they have grown and developed. Following selection, weights of specific toms are determined weekly and growth is controlled through either qualitative (*ad libitum* feeding) or quantitative feeding programs (limited feeding). Both programs use low density rations that typically have around 10% protein. However, it is important for toms to continue to gain a recommended amount of weight throughout the production period, and to weigh approximately 50 lbs (22.5 kg) at 30 weeks when semen is first collected. Just over 200 lbs (91 kg) of feed per tom are needed to meet this target. Uniformity also is important; 90% of toms need to be at target weight (average weight ±10%) when semen is first collected. Standard body weights and recommended feeding programs are available online for both Aviagen (Nicholas) and Hybrid commercial turkeys (see Acknowledgements).

From one to 15 weeks of age, breeder toms are given more floor space than commercial toms to promote activity and develop strong legs (4-6 ft^2 [0.3-0.6 m^2]. They receive 8-10 ft^2 [0.7-0.9 m^2] from 16 weeks to the end of semen production). After selection, groups of 20-25 toms are placed into pens of at least 250 ft^2 [23 m^2] in the tom barn. Groups often are divided into the heaviest toms, which are the prime breeders and used most often for insemination, intermediate toms used when additional inseminations are needed, and lighter toms kept in reserve.

Light stimulation initiates sexual development of breeder toms. Several factors need to be considered when determining how the birds should be light stimulated including type of housing, feeding program, exposure to ambient light, geographic location, and time of the year. Compared to hens, toms are more responsive to light intensity than day length and will respond to lower light levels. Prior to 24 weeks of age, exposure of males to less than 12 hours of light within light-proof "dark out" houses that are designed to control light intensity and exclude light during the remainder of the day, is recommended to prevent premature testicular development. At 24 weeks, or approximately 6 weeks prior to semen collection, day length is increased to at least 14 hours of light at 20-30 lux. Development of secondary sex characteristics and male behavior signify appropriate responses to light stimulation. Longer day lengths or gradual weekly increases in day length may be needed under certain conditions. However, day length should never exceed 18 hours of light. It is important to provide even lighting and not decrease either light intensity or duration during sexual development and semen production.

Only a small number of males placed as poults are actually retained as breeders. Selection pressure results in only the best males being used for breeding. Identification of candidate breeders begins at placement and continues throughout the life of the flock. Birds with physical defects or are undersized are removed. It is important to provide good growing conditions and keep the birds healthy to allow desirable traits of the breeders to be fully expressed. Particular attention is given to conformation, leg strength, and walking ability. At around 17 weeks, candidate breeders are individually evaluated for fitness, growth, and development. Each tom is weighed and judged against an average for the flock. Typically, a maximum of 30% of the best males are selected. Unselected males are removed and processed.

2.2.2.2.2 Breeder Hens

Breeder replacement hens are brooded and raised in breeder replacement (rearing) houses as single age flocks similar to brooding and growing commercial hens. Biosecurity is high because of their value and critical role in providing fertile eggs for the company. Breeder replacement hens are typically given about twice as much floor space (4-5 ft^2) as their commercial counterparts, and are provided an optimal environment, especially as it relates to air quality. Around 17 weeks of age, hens to be used as breeders are selected. In contrast to toms, selection pressure for candidate breeder hens is minimal, generally around 5%. Following selection, they are placed into a light-proof "dark-out" house and exposed to short day lengths (6-8 hrs light [L]:16-18 hrs dark [D]) for at least 12 weeks. At 29 weeks, hens are moved into the laying house where they are photostimulated (minimum 14L:10D @ 100 lux), rapidly mature sexually in response to the increased light, and begin egg production between 31 and 32 weeks of age. Egg production peaks a few weeks later when around 75% of the hens will lay eggs each day. Peak production is followed by a gradual decline throughout the remainder of the production period. Egg production typically lasts for 28 weeks but may be a few weeks shorter or longer depending on how the flock is producing, need for fertile eggs, and economics. Each hen produces between 100 to 120 eggs from which 90 to 100 poults are hatched. Typical overall hatchability is 82 to 84 percent. Hens may be brought into a second egg production cycle ("recycled") by moving them back to a dark-out house and inducing molting. Recycled hens produce fewer eggs, but eggs are larger resulting in high quality poults. Breeder hens are processed for meat at the end of their egg laying cycle(s).

Management considerations for turkey breeder hens include nutrition, weight management and hen development, vaccination, light control, insemination, broodiness control, and egg production and handling. Desirable outcomes for a turkey breeder flock are uniform egg production that meets or exceeds breed standards, high peak egg production, persistence of egg production (total eggs/hen housed), and high fertility and hatchability, which all contribute to reduced poult cost.

Weight control and development to achieve optimal reproductive performance are more important for breeder replacement hens than toms. Overweight hens are poor breeders, prone to reproductive disorders, produce fewer eggs, more likely to become broody, and more likely to be culled. Determining weekly weights of a representative number of hens beginning at 3 weeks of age is ideal, but critical weight determinations are at 6, 16, and 22 weeks. At least 50 birds should be weighed to get an accurate average weight. The amount and type of feed allocated to the birds is based on the average weight of the flock. Higher protein feed is given to flocks that are lighter than the target, while heavier flocks are moved more quickly onto lower protein rations. Adjustments in growth need to be made gradually; hens must continually gain weight prior to egg production even if they are above the target. Hens are usually switched to a laying ration when they are moved to the laying house, but in some cases, a pre-lay ration that is intermediate between the conditioning ration and laying ration is used for the last few weeks in the dark-out house. The average weight of breeder hens at photostimulation needs to be around 26 lbs (11.8 kg).

Sexual development and initiation of egg production are highly dependent on light exposure including duration, intensity, and wavelength. Replacement hens are naturally photorefractory when they are young, but afterwards become photosensitive to even very low levels of light. If exposed to additional light during dark-out, sexual maturity begins prematurely and hens will be poor breeders. Hen flocks that become sexually mature during the time when it would occur naturally (increasing day length) tend to produce more eggs, even when maintained in a light-controlled environment. Hens receptive to breeding display a characteristic "squatting" behavior that has occasionally been confused with lameness. This should be seen in the majority of the hens after light stimulation. Initial insemination is done at this time. Inseminating the hens too soon can result in vaginitis, peritonitis, impaired reproduction, and death (Gazdzinski and Barnes, 2004). If squatting is seen during dark-out, it indicates a problem with light control. It is critical that neither the duration nor intensity of light is reduced while the hens are in production. Day length can be increased, but should not exceed 18 hours.

Vaccination of breeder hens is done to prevent mortality and maintain egg production and quality. Although not as important in turkeys as it is in broiler chickens, a few vaccines are given to provide maternal immunity to poults (e.g., hemorrhagic enteritis). Another purpose of breeder hen vaccination is to reduce or eliminate vertical disease transmission (e.g., avian encephalomyelitis virus, *Salmonella*). Vaccination programs vary among companies and geographic region. Inactivated oil-emulsion vaccines are given several weeks prior to photostimulation to avoid drops in egg production that occur when they are used while hens are laying. Inactivated vaccines made with aluminum hydroxide can safely be used when the hens are in production. Commercially available vaccines used in turkey breeders are listed in Table 5. Under special circumstances, inactivated autogenous vaccines are prepared and used following strict guidelines. An example of an autogenous vaccine in current use is one that contains *Pasteurella multocida*, *Ornithobacterium rhinotracheale* ("*ORT*"), and *Erysipelothrix rhusiopathiae* to aid in the prevention of fowl cholera, ORT, and erysipelas respectively. Vaccines for chickens are sometimes used off-label in turkeys and usually have good efficacy. An example of such use is immunizing breeder replacements with herpes virus of turkeys (HVT)-vectored avian paramyxovirus 1 (Newcastle) vaccine. Live mycoplasmal vaccines are not recommended for turkeys, as they are more virulent in turkeys than they are in layer chickens.

Table 5. Vaccines Used in Turkey Breeder Hens.

Vaccine	Type	Administration	Comments
Avian paramyxovirus 1 (Newcastle)	Live. Strains C2, B_1, La Sota, N-79, N-63, Clone 30, etc.	Water, spray, intranasal, eye-drop.	Vaccines made for chickens typically include infectious bronchitis virus (IBV). There is no evidence that IBV will infect turkeys.
Avian paramyxovirus 1 (Newcastle)	Inactivated.	Injection.	Often combined with other vaccines (e.g., PMV3, Influenza). Used in breeders to provide high immunity of long duration.
Paramyxovirus 3	Inactivated.	Injection.	Often combined with other inactivated virus vaccines.
Influenza	Inactivated. H1N1, H3N2 swine strains.	Injection.	Often combined with other inactivated virus vaccines.
Hemorrhagic enteritis	Live. Avirulent, pheasant origin.	Water.	Splenic homegenate vaccines should not be used in breeders.
Avian encephalomyelitis	Live. Strain 1143.	Wing-web, water, spray.	Often combined with pox and given via wing web inoculation.
Pox	Live. Fowl, turkey, pigeon types.	Wing-web, feather follicle.	Often combined with AE and given via wing web inoculation.
Turkey rhinotracheitis	Live, inactivated. Avian metapneumovirus.	Water, eye-drop, intranasal, coarse spray, injection.	Used where TRT is endemic.
Erysipelas	Inactivated.	Injection.	Often combined with other bacterial antigens.
Fowl cholera	Live, inactivated. Strains M-9, PM-1, CU.	Water, wing-web, SQ or IM injection (inactivated).	One to 2 "priming" vaccinations given in water with low virulent strains followed by injection with higher virulent strain.
Salmonella	Inactivated.	SQ injection.	Used to reduce *Salmonella* contamination of eggs and vertical transmission.
Colibacillosis	Live, inactivated.	Spray, SQ injection (inactivated).	Intramuscular vaccination with inactivated vaccine can produce severe granulomatous myositis.

Egg production commences 2 to 3 weeks after hens are placed into the laying house and exposed to increased light. Eggs from young breeders are smaller and produce smaller poults that are more difficult to start when placed on a brooder farm. It is important during the early laying period to train the hens to use the nest for laying. Eggs laid outside the nest ("floor eggs") are more likely to be contaminated and either not hatch or explode when incubated due to growth of gas-forming bacteria that penetrate the egg shell. A nest box needs to be provided for every 4 to 6 hens. Semi-trap nest boxes prevent more than one hen from entering the nest box. Both manual and automatic nest boxes are used. To obtain the most sanitary eggs, bedding in nest boxes needs to be kept clean, eggs collected frequently, and hens not permitted to remain on the nest. Abnormally small, large (double-yolk), misshapen, cracked, or excessively dirty eggs are removed and discarded. In contrast to broiler hatching eggs, turkey hatching eggs are often washed in a warm (110-120°F, 43-49°C) detergent-sanitizer solution. However, egg washing is not a substitute for management practices that result in production of clean eggs, or a salvage procedure for excessively dirty eggs. After drying, eggs are identified, dated, packed, and placed into an egg cooler where they are kept at 55-65°F (13-18°C) until they are picked up, usually twice a week, and moved to the hatchery. Eggs may be kept at slightly warmer or cooler temperatures if they are going to be stored for shorter or longer periods respectively. Optimal relative humidity is 60-80%. Sweating of eggs as they are transported to the hatchery can be a problem if ambient temperature and humidity are high. Moisture that develops on the eggs from sweating favors bacterial multiplication and wicking of bacteria into the egg through pores in the shell.

Turkey breeder hens retain some of their natural instinct to brood a clutch of a dozen or so eggs after they have been laid. Prevention of broodiness is necessary to obtain maximum egg production. Broody hens may be difficult to recognize but usually they want to stay in the nest box, go out of production, or are more aggressive at protecting the nest. Some hens do not show any signs. Once a hen becomes broody, her reproductive cycle has ended until after she molts. Several management practices are used to prevent broodiness including providing a house environment that is not conducive to nest building, making sure the hen does not stay in the nest box longer than necessary, keeping hens out of nest boxes overnight, providing uniform lighting without dark areas, frequently collecting eggs including picking up floor eggs, checking for hens that return to a nest box shortly after having laid an egg, and marking hens showing signs of becoming broody. Suspect broody hens are transferred to broody pens where their normal environment and routine are altered, or they are moved among pens in the same house. When a hen resumes squatting, she is not broody and can be returned to the flock. While controlling broodiness is important, it is equally important not to be overly aggressive and interrupt production of normal hens.

2.2.2.2.3 Artificial Insemination

A common belief is that commercial turkeys are incapable of natural breeding due to their large breast size. This is not entirely correct. They can mate naturally, but the process is not efficient enough to meet the needs of commercial production. Artificial insemination is used to improve and maintain a high level of fertility in commercial turkey flocks. Toms are large birds and expensive to maintain, which makes maximum use of semen from each tom essential to minimize poult costs. Typically, a single reproductively sound male is sufficient for inseminating between 16 and 22 hens. Artificial insemination has also been useful for controlling venereal diseases, especially mycoplasmosis, by preventing mating with infected hens,

Semen is collected from tom turkeys by manual ejaculation (“milking”), pooled, chilled to 1-3°C (33-37°F), and used as quickly as possible, ideally within 30 minutes. Good quality semen is thick, creamy, and white whereas semen that is thin, watery, and yellow is poor quality and should not be used. Usually between 0.3 and 0.6 ml of semen is produced per ejaculation that contains 2 to 6 billion spermatozoa. Semen can be collected twice a week without affecting its quality. Even if semen is not needed and will be discarded, toms should be ejaculated at least weekly to maintain production.

Fertility depends on number of spermatozoa inseminated. Semen is typically diluted 1:1 with semen extender to contain between 300 and 400 million spermatozoa per insemination depending on the age of the breeder hens to be inseminated. Semen extenders are added to pooled semen to increase semen volume so that more hens can be inseminated, but they do not affect the lifespan of the spermatozoa. Semen is deposited by gently blowing it through a pipette inserted deeply into the female’s everted vagina. By placing semen directly into the vagina, spermatozoa are deposited close to sperm host (“sperm storage”) glands where they can survive for up to 3 weeks or longer. However, to insure continual high fertility, insemination of hens is done multiple times during the first few weeks, followed by weekly inseminations thereafter. Additional inseminations and inseminating hens outside of the daily peak of egg production are also done.

Insemination requires precision and coordination to be done effectively and efficiently. Details are beyond the scope of this chapter but can be found in technical information available from Aviagen Turkeys (*http://en.aviagen.com/turkeys/*), Hybrid Turkeys (*http://www.hybridturkeys.com/*), and The Midwest Poultry Federation (Bakst and Long, 2010).

2.2.3 Turkey Hatching

When fertile eggs from the breeder farm arrive at the hatchery, they are placed into an egg holding room where they are maintained at the same temperature and humidity as the egg room on the farm. Eggs are held for 2-14 days after having been laid depending on several factors including breeder production, egg availability, supply and demand, and transportation issues. Optimal hatchability occurs when eggs are stored for approximately 7 days. Setting freshly laid eggs less than 2 days or older eggs over 14 days of age results in significantly reduced hatchability.

Hatching typically occurs 4 times a week on Monday, Tuesday, Thursday, and Friday. Wednesday is used for thorough cleaning of the hatchery. Some companies may use non-hatch days for hatching hen parent stock. Racks containing the eggs are often placed into an area for up to 12 hrs to warm up prior to being placed into the incubator. Incubators may be filled with a single setting of eggs (single-stage incubator) or have sets of eggs added sequentially (multi-stage incubator). Both types have advantages and disadvantages. Incubator temperature and humidity are precisely controlled based on the type of incubator and characteristics of the eggs, especially how long they have been stored, age of breeders when eggs were laid, and timing and duration of the hatch window. The more uniform the eggs, the easier it is to set incubator conditions for optimal hatching.

At approximately 25 days of incubation, eggs are transferred to the hatcher. *In ovo* injection of turkey eggs is not as common as it is for broiler eggs, but can be done at this time. Poults hatch between 27 and 28 days. A narrow hatch window is desirable to minimize variability among poults. Hatchability is usually 82-86% with few culls or small poults. In the hatcher, poults are allowed to dry and have their navels seal over before they are pulled, separated from unhatched eggs and shells, and prepared for movement to the farm. A sample of unhatched eggs from each group of eggs in the incubator may be examined to determine why they did not hatch, especially if there are hatchability problems with particular flocks or incubators. Categories of unhatched eggs include infertile, and early, middle, or late embryo death. Correct position of the embryo in the egg is determined (head needs to be up and under the right wing), whether internal pipping occurred, how much residual albumin and urates are present, vascular development of the chorioallantoic membrane, and if the embryo is malformed. Cull poults, unhatched poults, egg residue, and shells are usually macerated on site. Maceration equipment must be well maintained to make sure euthanasia of cull and unhatched poults is instantaneous.

Hatchery design and sanitation, particularly cleaning and disinfection, are extremely important in the production of healthy poults. Contact of open navels with bacteria in the environment can lead to infection and death. Fungal spores inhaled by poults from mold growth in the ventilation system results in losses due to brooder pneumonia. Programs based on culturing environmental swabs and air plates are used in most hatcheries to monitor sanitation. A one-way path through the hatchery with egg arrival on one side, poult shipment on the other side, and incubators, hatchers, and processing area in between is the best design. Some turkey hatcheries require showering of all personnel and wearing clean clothing provided by the company before entering the egg/poult areas. Adequate facilities to clean and disinfect all equipment are needed.

2.2.3.1 Poult Servicing

Newly hatched poults undergo several procedures in the hatchery to prevent diseases and trauma, and prepare them for the farm. Collectively, these procedures are called servicing and include sex determination, trimming of the beak and toes, and administration of injections of vitamins, fluids, or antibiotics. Historically, the snood of male poults also was amputated during servicing to protect turkeys from erysipelas, which often began in the snood traumatized by males fighting to determine dominance, but that practice is rarely done today. Aerosol application of vaccines, such as Newcastle disease, may also be done if the disease occurs in the area where the turkeys will be grown.

Males and females are separated using vent sexing by specialists trained in this procedure. Sufficient pressure is applied to the abdomen to evert the vent, permitting visualization of the primordial phallus in the male, or its absence in the female. Accuracy by well-trained individuals can exceed 98%. The usual sex ratio of poults is 52% males and 48% females.

Trimming of the beak and toes is done to reduce trauma among birds in the flock from pecking, feather pulling, and scratches, which can lead to infection and death or necessitate culling. The procedures are done with either a hot blade that immediately trims and cauterizes the tissue or specially designed equipment that utilizes laser light or microwaves, which causes necrosis and sloughing of beak and toe tissue within a few weeks leaving a healed surface. After using these methods of beak and toe trimming for several years, no significant adverse effects have been identified and they have become the standard in the turkey industry (National Turkey Federation, 2009). Poults are counted and placed into boxes divided into 4 quarters, each with 20-25 poults.

Following servicing, boxes containing the poults are stacked and organized into flocks in a warm, dimly-lit, holding room to rest overnight. Early the following morning the poults are delivered to the farm in specially designed vehicles ("poult buses") that provide controlled temperature and ventilation for the poults. Placing all poults on a farm from a single breeder flock is ideal; however, most flocks consist of poults from multiple breeder flocks. The more breeder flock sources a commercial flock has, the more likely the flock is to have health problems. Every attempt should be made to match poults as closely as possible. For example, if a flock is put together with poults from young breeders (which produce small poults that are difficult to start) and poults from recycled breeders (which are larger and easier to start), mortality among poults from young breeders will be higher and their growth rate will be less than if they were brooded by themselves.


Poult Hatchery


Poult Buses

2.2.4 Turkey Brooding

Brooding is the period after hatching during which a turkey poult requires supplemental heat. The term also is used when the poult is in the brooder house. Brooding is done in a house specifically designed for this purpose. Poults are usually allocated at least one ft^2 (0.1 m^2) per bird. They are usually restricted in brooding rings during the first few days of life. The brooding period encompasses the first 5-6 weeks of the turkey production cycle.

2.2.4.1 Brooder Houses

Preparations for brooding begin as soon as the previous flock in the house has been removed. Litter and all organic material are removed and insecticides or other control measures for darkling (litter) beetles (*Alphitobius diaperinus*) are applied while they are still active. Over the next several days, the house, entry way and surrounding areas, equipment, water lines, feed lines, and feed bins are thoroughly cleaned and disinfected. Fans, timers, lighting, alarms, curtains or air inlets, and other equipment are similarly inspected to insure they are in good working order. After cleaning, the house is closed and left vacant. The sooner the house is prepared, the longer the down time before the new flock arrives. A minimum down time of 10 days is recommended, but longer times are preferred to permit microbes in the house to die.

Fresh, clean, dry litter (usually kiln-dried pine shavings) is delivered to the farm and spread evenly over the floor to a depth of 3-4 in (7.6-10.2 cm). A spray may be applied to the surface of the litter to help reduce fungal spores and other contaminants. Brooder equipment is checked several days before placement and any repairs made. Brooder stoves should have a blue flame and cycle appropriately in response to changes in temperature settings. A yellow flame indicates incomplete combustion, which generates carbon monoxide. Carbon monoxide above 20 ppm is detrimental to poults and people working in the house. Pancake or pan brooders are usually set at 24 in (61 cm) but may be raised or lowered slightly to obtain optimal litter temperatures. Brooders must always have a safety chain to prevent them from accidentally falling into the litter, and propane lines need to be checked with soapy water for leaks. Radiant tube heating systems mounted on the ceiling are used in some newer brooder housing. They rely less on heating circulating air than traditional pan brooders. Regardless of the type of brooding equipment, it needs to provide even, appropriate house temperatures at the level of the poults.

Brooder Hub Setup

Radiant Heat Brooder Stove

At least one day before placing the poults, fresh feed is delivered to the farm and the house is set up. It is important to use fresh feed, as it will stimulate the poults to eat. Circular or oval brooder rings, 12-14 ft (3.7-4.3 m) in diameter and 12-18 in (30.5-45.7 cm) high made of new corrugated cardboard are placed in the litter around each pan brooder. Single brooder rings are sufficient for around 300 poults. Some growers use an oval double ring that is suitable for more poults and surrounds two or more conventional pan brooders. Larger rings also are used for radiant heat brooder stoves. In houses with radiant tube heating, birds may be placed directly in the house with cardboard only used to round the corners of the house to prevent piling of poults for the first few days. Conventional and supplemental feeders and drinkers are radially arranged about midway between the brooder equipment and wall of the ring and completely filled with fresh feed and water. Poults are provided with at least 1 in (2.5 cm) of drinker space and 1.25 in (3.2 cm) of feeder space. Nipple drinkers are becoming more common and are replacing traditional bell drinkers. For starting poults, cups on nipple drinkers should be filled.

Brooders are lit the day before poults arrive to warm the food, water, litter, and house to the desired environmental temperature. Temperatures of the litter under the brooders and at the edge of the ring should be checked with an infrared gun to be sure they are between 100-115°F (38-46°C) and 75-85°F (24-29°C) respectively. It is important to have a 20-30°F (9-15°C) gradient between the center and edge of the ring to allow each poult to locate its own comfort zone. House temperatures are more uniform when radiant tube heating is used. Ventilation fans are adjusted to run a minimum of one minute out of five minutes. Thermostat fans are set to run when target temperatures exceed 2°F (1°C). Poor ventilation results in weak, inactive poults that do not start well. Ammonia and carbon dioxide levels above 25 ppm and 2500 ppm respectively are detrimental to the poults. Measurements of gases need to be at bird level to be meaningful. A carbon monoxide detector can be taken into the house when poults are being checked first thing in the morning to determine if toxic levels exist, but dust may interfere with its operation if it is left in the house continuously. Lighting needs to be uniform with an intensity of 50-70 lux.

On the day of placement, poults are delivered early in the morning so they have the full day to adjust to their new surroundings and begin eating and drinking, which are critical to the poults getting a good start. Poults must drink or they will not eat. Equal numbers of poults are allocated per ring. They are gently transferred from poult boxes to the rings and given a short interval to spread out and acquaint themselves with their new environment. Dead or cull poults are removed and may be saved by refrigeration or freezing for possible future diagnostic use. If there are no significant disease problems in the first few days after placement, cull and dead poults that have been saved can be discarded. As a general rule, the earlier poults die after placement, the more likely the problem came from the hatchery or breeder flock; conversely, the later they die, the more likely the farm environment was the source of the disease.

While the birds need to be checked frequently the first day and night, conditions in the house need to remain as quiet and calm as possible. Poults are curious and gather along the side of the ring in response to sounds or activity in the house. This is detrimental, as they need to be learning to eat, drink, and find their comfort zone. Poults often sleep off and on during much of the first day, but by the second day, they should be active and evenly distributed. Clustering of poults under a brooder or along the edge of the ring indicates that conditions are too cool or hot respectively and need to be checked and adjusted. Poults in one spot away from the heat source indicate a possible draft. Poults receive constant light on the first day.

During the next few days, poults continue to be checked frequently; drinkers are adjusted to compensate for litter compaction and average poult size, cleaned, and kept filled. After poults are drinking well, the depth of water in the drinkers can gradually be reduced to decrease spillage and soiled litter. Spilled or soiled feed is removed and feeders adjusted and refilled. Feeders are generally kept completely filled for the first couple of weeks. Height of drinkers and feeders is adjusted to be at the level of the poults' shoulder. Soiled litter that accumulates around drinkers and feeders is either tilled into adjacent good litter or removed and replaced. Light duration is reduced to provide a period of at least one hour of darkness so the poults will not panic if there is an electrical failure.

Poults are more challenging to start than chicks. They have little available energy reserves when they hatch and must rapidly switch from a lipid-based to a carbohydrate-based metabolism by synthesizing glycogen from protein via gluconeogenesis. Attempts to assist in this process through nutrition have not been successful. Weak poults, undersized poults, and "flip-overs" (poults that get over on their backs and cannot right themselves) are removed and either culled or placed into a "hospital" pen where they have access to fresh feed and water, but a lower temperature. A few poults never learn to eat or drink. Sometimes they can be recognized because they still have the egg tooth, which normally is knocked off when a poult begins to eat. Occasionally it is possible to teach them by dipping their beaks into water and feed, but most often, they die of starvation. Such birds are called starve-outs and are found mainly between 4-6 days of age. Starve-outs occur more frequently in poults that come from young breeder flocks. Poults in the hospital pen that recover can be returned to the rest of the flock.

A common practice is to combine two pens together after 3-5 days and remove them altogether by 7 days. Cardboard that formed the rings is discarded. In some instances, it may be helpful to put cardboard in the corners of the house to round them out for a few more days to prevent piling. Similarly, any open containers (e.g., buckets) or equipment should be taken out of the house to prevent poults from getting into them and smothering each other. Supplemental drinkers and feeders are gradually removed as the poults learn to use the equipment that will remain in the house. For turkeys, it is important that this change be made gradually over 3 or 4 days. Temperatures under the brooder and in the house are reduced by approximately 5°F (2.8°C) weekly until they match ambient temperatures, and ventilation is increased to control litter moisture, ammonia, and dust levels in the house.

Poults grow rapidly during the remainder of the brooding period. It is important to check them at least twice a day, and to adjust feeders and drinkers to the correct height and depth every few days. Feeders and open drinkers are adjusted to shoulder height so that poults need to slightly bend their head and neck over the edge of the feeder or drinker to eat or drink. Birds should be able to walk under feeders and drinkers. If feeders and drinkers are raised too high, the birds can irritate their necks when they eat or drink, which can lead to a form of persecution ("cannibalism") called neck picking. Litter needs to be raked daily or removed to prevent buildup of cake along feed lines and around drinkers. Mortality is picked up at least twice daily, recorded, and disposed of by burning, composting, or rendering depending on state regulations and availability. If mortality exceeds a certain threshold (commonly one bird per 1000), and there is no obvious cause, a diagnostic investigation may be indicated during which fresh dead and clinically affected turkeys are examined to establish a diagnosis. Vaccination for hemorrhagic enteritis is done between 4-5 weeks of age in most turkey flocks; other vaccinations may be given via water or spray if indicated. Vaccinations should be completed at least one week prior to the turkeys being moved to finishing.

Feeder

Drinker

2.2.4.1.1 On-farm Brooding

Until the past 15 years, almost all turkeys were brooded in a separate brooder house, constructed and equipped for brooding, on the same farm where they were grown and finished. These are called ‘brood and grow’ farms. Both two- and three-stage production systems evolved to maximize utilization of housing and equipment on the farm, and amortize fixed costs over maximum production. In multi-stage production systems, two or three flocks of different ages are always on the farm. This makes disease control difficult as older flocks on the farm serve as reservoirs of infectious agents for the younger birds. Spread of disease from older flocks on the farm to the next flock as it was placed led to infection in younger birds, increasing severity of disease because of early exposure, increased exposure, and passage through successive groups of birds. On-farm brooding is still done, especially for hen flocks, but it is becoming less common as the industry moves to off-site brooding.

Two-stage systems have a brooder house matched with either two or three finishing houses. Typically there are two finishing houses for hen production and three finishing houses for tom production, but there is farm-to-farm variability. The brooder house is divided into two sections for hens or three sections for toms. Turkeys in one section of the brooding house usually populate one finishing house. At around 5 weeks of age, turkeys in each section are slowly walked through temporary corridors constructed of wooden panels and stakes, or, less commonly, a permanent breezeway, from the brooder house to a finishing house. Turkeys are easily moved using “flags” - poles with one or more strips of plastic or cloth attached to the end. In the finishing houses, hens and toms receive at least 2 or 3 ft^2 (0.2 - 0.3 m^2) of floor space respectively, which accounts for the brooder:finishing house ratios of 1:2 for hens and 1:3 for toms. After the brooder house is vacated, it is cleaned, disinfected, and prepared for the next flock, which arrives before the older flock on the farm has been processed. Larger farms have multiples of this same 3 or 4 house design.

Double brooding is a variation of two-stage production used for growing tom flocks. The longer cycle for toms allows two flocks of turkeys to be brooded for two finishing house units. These farms typically have one brooder house and 6 finishing houses or their equivalent (e.g., 4 larger houses with floor space equivalent to 6 conventional sized houses). Each finishing unit needs to have at least 3 times the floor space of the brooder house. While technically a two-stage system of production, this system has many of the same disadvantages of three-stage production including three age groups on the farm, continuous production on the farm, and minimum downtime between flocks in the brooder house. Health problems tend to be greater on these farms, similar to those of farms using three stages of production.

Efficiency of the two-stage system declined as hens grew faster and were marketed as whole birds at younger ages and toms were held longer and marketed for further processing (“cut-up”) at older ages. Either there was inadequate turn-around time in the case of hens, or the brooder house sat idle for an extended period for tom flocks. This ushered in the 3-stage production system for tom turkeys, again designed to maximize use of housing and equipment. In this system, production is divided into 3 stages – brooding (0-5 weeks), intermediate (6-11 weeks), and finishing (12-18 weeks). Brooding and intermediate stages are done in a single house. One-third of the house is used for brooding, while the remainder is used for the intermediate stage. The two parts are separated by a solid partition with doors that can be opened. Ventilation flows from brooding to intermediate sections to conserve heat from the brooding end of the house, and it is simple to move birds from brooding to intermediate by opening the partition, turning lights on in the intermediate section, and turning them off in the brooding section. Birds naturally migrate to the lighted section of the house. Finishing takes place in separate houses on the same farm similar to that in 2-stage production.

While both two- and three-stage production systems make economic sense, they violate the basic “All in/All out” principle of biosecurity. In these production systems, either two or three flocks are on the farm at the same time, and there is never a time when the farm is completely depopulated. Especially problematic is the 3-stage system where two different flocks are in the same barn. As enteric diseases such as turkey coronaviral enteritis, poult enteritis complex, and poult enteritis mortality syndrome (PEMS) emerged as serious problems in the turkey industry, controlling them on multi-stage farms became difficult to impossible. Losses from disease soon outweighed the economic advantages of staged growing. While some staged growing still exists, especially for hens, three-stage production is probably no longer practiced, and two-stage production is becoming less common.

A couple of single-stage variants of on-farm brooding are occasionally done on older ‘brood and grow’ farms. One single stage management system is similar to production of broiler chickens. The house is divided by a removable partition (often a drop curtain) into two parts. Typically about one-half or one-third of the house is used for brooding hens and toms respectively. When brooder stoves are no longer needed at around 3-4 weeks, the partition is removed and the flock has the entire house where they stay until they are processed. Separate feed lines for younger and older birds are needed, but a single water line is usually adequate. This production system is best suited to growing light hens. It is possible to produce three hen flocks, but only two flocks of toms annually in this production system. With either type of turkey, this system still lacks economic efficiency compared to multi-stage growing.

The other single stage production system has similarities to multi-stage production systems. Poults are brooded in one or more brooding houses on the farm. When they reach 5-6 weeks of age, most of the birds are moved to other houses on the farm, but some of the birds remain in the brooder houses. In this way, all of the birds on the farm are a single age, but there are empty houses on the farm with longer down time while the poults are brooding and therefore there are greater overhead expenses. Also, this is usually not done with tom turkeys, as the equipment used in the brooding houses is not adequate for growing toms to processing.

2.2.4.1.2 Off-site Brooding (Brooder Hubs)

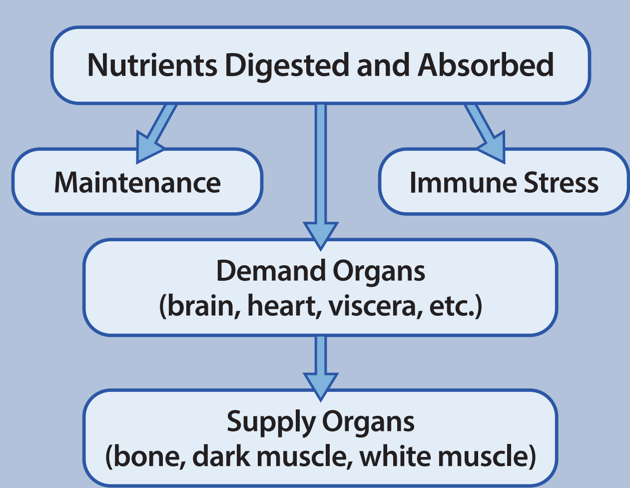
To capture the health advantages of "All in/All out" production and economic benefits of multi-staged growing, many companies have moved to off-site brooding. These farms only brood turkeys and are commonly called "brooder hubs". Brooder hubs are most efficient for producing toms because of their longer production cycle and higher value at processing, which can be divided between brooding and finishing farms. One brooder hub can provide poults for two groups of tom finishing farms. Having a facility dedicated solely to brooding permits a high level of biosecurity, intense management focused on the needs of the young turkey, quantity purchases of supplies, especially propane, and total clean out between flocks. Poults are delivered to the brooder hub, grown to 4-5 weeks of age, loaded into transport coops, and taken to several finishing farms where they are grown to processing. Determining the average weight when poults are transferred from the brooder farm to the finishing farm and dividing it by their age in days provides the overall average daily gain for the brooding period. In addition to livability, average daily gain is an excellent way to monitor how well poults grew during brooding and the measure correlates well with how they will process. After turkeys have been removed from the brooder hub, it is thoroughly cleaned, disinfected, and prepared for the next flock.

Disadvantages of this production system are the stress of moving the turkeys from the brooder hub to finishing farms, possibility of trauma during loading and unloading, and that several finishing farms could be adversely affected if the poults experience a disease on the brooder hub that depresses their growth and development. The abrupt change in environment during transfer often sets the turkeys back for a few days as they re-learn how to get food and water and re-establish their social interactions. It is common for them to lose up to 10% of their body weight during moving and the first few days after being placed into the finishing farm. They generally regain this lost weight before they are processed.

2.2.4.2 Physiological Development of Poults

Turkey poults are precocial and may seem developed at hatch, but actually, they are still immature and require several weeks to develop completely functional body systems. An example is the immune system, which will not be capable of fully responding to an antigen until the turkey is around 6 weeks of age. Vision is poorly developed at hatching, which may help explain why poults have difficulty finding food and water after hatching. Consumption of feed as soon as possible after hatching is important as this initiates development of the digestive and immune systems and stimulates the absorption of yolk, which contains maternal antibodies and nutrients essential for early growth (Halevy et al., 2003).

Figure 5. Nutrient Budget



It is important to understand the "nutrient budget" as it pertains to poult growth and development (Figure 5). Prior to hatching, everything required by the turkey embryo to develop into a poult comes from the hen via the egg. After hatching, everything required by the turkey to maintain itself and grow comes from nutrition via the digestive system. This includes feed intake, digestion, absorption, and assimilation at the cellular level. Early growth and development of the digestive system is several times greater than the body as a whole.

Organs of the digestive tract, along with those critical for survival (immune, cardiovascular, respiratory, nervous, and special senses) comprise the “Demand” organs. Nutrients are preferentially supplied for maintenance, response to immune stresses, and demand organs. When the digestive system is functioning normally, supply organs also are provided with nutrients, based on the needs of the developing poult, to the skeletal system, dark muscles, and lastly white muscles. If nutrients are not adequately provided by the digestive system because of inadequate feed intake or enteric disease, a greater proportion of the nutrient budget shifts from the supply organs to deal with immune stress and provide for the demand organs. This results in stunting, poor skeletal development, and reduced muscle and ultimately meat, especially white meat, at processing. If nutrients are not available, as in severe disease and anorexia, muscle is catabolized to provide for maintenance, immune stresses, and minimum nutrients essential for survival. These birds become runted, rarely ever recover, and need to be culled.

Growth of turkeys is rapid. At hatching, poults weigh around 60 g, while toms have an average weight of 20.5 kg when they are processed at 20 weeks of age. Thus, male turkeys increase their original body weight over 340 times in a period of 140 days; an average of nearly 2.5 times their initial weight every day. Growth rates of hens are similar, but not as rapid, and they are marketed earlier at lower body weights. Failure to grow, even for a few days, becomes obvious because of the high growth rate, which leads to poor flock uniformity.

2.2.5 Turkey Finishing

Key to managing turkeys during finishing is to provide adequate ventilation, clean cool water, good quality feed, and a healthy sanitary environment with sufficient space. The importance of animal husbandry and management cannot be over emphasized. Disease is usually an indication of a failure in management – something was done that should not have been done, or, conversely, something that should have been done was not done.

2.2.5.1 Range (Pasture) Finishing

Initially, turkeys were produced during the summer on open range, primarily for the Thanksgiving and Christmas holidays. Small turkey flocks for niche markets are still raised this way, but finishing on range is rarely used anymore for commercial flocks. Poults are obtained in late winter or early spring and brooded in a brooder house. After brooding, at about 8 weeks of age, they are moved onto pasture where they remain until they are processed. Number of turkeys per acre varies widely from 100-250 depending on soil type and vegetation. Part of the nutrition for the birds is provided by the environment, but the turkeys still require commercial feeds. Shelters, feeders, and drinkers are provided. Roosts and 2-3 ft^2 (0.2-0.3 m^2) of floor space are provided under the shelters. Health problems include predation, weather-related losses, theft, and diseases contracted from free-living animals. Fowl cholera, caused by *Pasteurella multocida*, is often present in the mouths of rodents and small carnivores, including dogs and cats. It is a common cause of high mortality in range flocks. Free-living birds, especially migratory waterfowl, can shed avian paramyxoviruses and influenza viruses in their feces and introduce them into the flock. Dividing the pasture and periodically rotating the flock through the different sections reduces disease risks.

2.2.5.2 Confinement Finishing

Finishing houses are prepared for the arrival of the turkeys from the brooding house, but, unless there was a disease outbreak in the previous flock, they are only completely cleaned and disinfected annually. Equipment is checked, repaired, and structural repairs are done as needed. Water lines are flushed and disinfected. Feed lines are emptied and cleaned; feed bins are inspected for residual caked feed and cleaned if indicated. Entryways and areas around the house are inspected and cleaned. Vegetation along the sides of the house is sprayed with herbicide and rodent bait stations are replenished. Caked litter is removed and the remaining litter worked so that it is friable. Litter is occasionally composted by moving it into one or more raised “wind-rows” the length of the house. Heat from composting significantly reduces infectious agents in the litter. If the floor is exposed, rock salt, at the rate of 75-100 lbs (34-45.5 kg) per 1000 ft^2 (93 m^2) can be applied to dehydrate and kill coccidia oocysts and helminth eggs. Litter is spread evenly throughout the house to a minimum depth of 4 in (10 cm). Litter from empty brooding houses may be added to ‘top dress’ litter in finishing houses. After the turkeys are in the house, caked litter that builds up along feed lines and around drinkers needs to be removed and replaced.

Hens and toms are provided with at least 2 ft^2 (0.2 m^2) and 3 ft^2 (0.3 m^2) of floor space respectively. Stocking densities of 6-10 lbs/ ft^2 (29-49 kg/m^2) are recommended and should not exceed 15 lbs/ ft^2 (73 kg/m^2) when environment and management are ideal. Stocking density in summer may need to be lower than it is in cooler months. Higher stocking densities are possible with controlled ventilation housing compared to naturally ventilated housing. Overcrowding results in increased mortality, lower weights, decreased feed utilization, and downgrading at processing.

For a few days after the turkeys arrive from the brooder house, it helps for the grower to keep feeders full to encourage them to eat, and to frequently walk the birds so they can quickly adjust to their new surroundings. The turkeys will not need this much attention when they become accustomed to their new environment, and the amount of feed in feeders can be reduced to minimize spillage.

Light influences activity, eating, drinking, and growth. Excess light contributes to aggressive behaviors and persecution. Lighting programs vary; 8-10 hours of darkness are recommended with a minimum of 4 hours of darkness. Intermittent lighting programs in which lights come on and off every few hours during the night are sometimes used in an effort to stimulate eating and increase growth.

During finishing, turkeys should be checked at least twice daily; more frequently if there is a problem. Time spent with the flock provides added benefits because turkeys socialized by frequent contact with people are healthier and more productive than turkeys that are not well socialized. Movement through the birds needs to be slow and unhurried. Fast movement or poor socialization causes the turkeys to become frantic, and injuries can result from their efforts to escape a person's presence by attempting to fly. If the flock is close to processing, injuries result in increased downgrading of the turkeys because of scratches, bruises, and even possible wing fractures. Healthy, socialized turkeys are alert and inquisitive. They follow behind the person checking the flock and peck at their boots and clothing. Adult tom turkeys may not be checked as frequently prior to processing because of aggressive behavior towards people.

As turkeys drink right after they eat, feeders and drinkers should be located close to each other (8-12 ft; 2.4-3.7 m). Bell drinkers ("plassons") are spaced about 30 ft (9.1 m) apart; each one is sufficient for 100 birds. Feeders and drinkers need to be adjusted to the average shoulder height every 2-3 days because of the turkeys' rapid growth. In hot weather, allowing water lines to drip slightly at the end outside of the house will help keep cool water in the lines. Water temperatures above 86°F (30°C) reduce consumption by the birds. Obviously dirty drinkers are cleaned, but it is not practical to attempt daily cleaning. Any waterers that are leaking are repaired or replaced. Similarly, grossly contaminated or caked feed is removed and discarded. Water levels are adjusted to 0.5-0.75 in (1.3-1.9 cm) and feed levels set at a depth of 2-3 in (5-7.6 cm).

Drinkers can be rotated to prevent heavy caking of litter by moving them in a 3- (triangle) or 4-point (square) pattern using extra hooks from which the drinkers can be suspended. If litter around a drinker is excessively wet, the height of the drinker and depth of water in the drinker lip is checked and adjusted. Soaked litter needs to be removed and replaced as quickly as possible. Drinkers that are leaking must be shut off and repaired as soon as they are found. Controlling moisture in the house with ventilation under ideal conditions is difficult enough, let alone when unnecessary extra water from faulty drinkers has been added to the environment.

Proper ventilation minimizes ammonia and dust, and helps control litter moisture. Ideal litter moisture is between 25-40%, but it varies widely depending on the location in the house. Litter moisture below 25% predisposes to dusty conditions and aspergillosis, while ammonia and fly multiplication occur when levels are above 40%. Excessively moist conditions provide ideal conditions that favor the survival of enteric pathogens including bacteria, viruses, and coccidia. Adjustments to the ventilation can be done during daily flock checks. These should be done as early as possible so that the result(s) of the change(s) can be confirmed as correct. It may be necessary to return to the house later to check on the changes. As a general rule of thumb, if conditions in the house feel good to the grower, they are probably about right for the turkeys as well. Fans are adjusted to achieve recommended temperatures and air exchanges.Turkeys are more susceptible to high heat and humidity than chickens and must be kept as cool as possible during periods of excess heat. Keeping the galvanized roof of the finishing house in good condition by covering rusted areas with reflective paint will help reduce heat buildup in the house. Circulating or box fans, with or without supplemental misting, may be needed to get sufficient air movement over the turkeys. Evaporative cooling using misting systems, cool pads, and sprinkler systems on the roof can be useful during periods of extremely hot conditions, especially when relative humidity is low. If birds are being finished in tunnel houses, they have evaporative cooling, but still need to be managed to minimize heat stress. Automated in-line generators and alarm systems are essential for solid-wall

tunnel houses to provide electricity and alert the grower when there is a power failure. During a power failure, heat buildup reaches lethal levels in as short as 20 minutes and can lead to loss of the entire flock if power to run the fans is not restored quickly. Back-up generators and alarms should be tested at least once every month to make sure they respond when the power is turned off and fuel levels in the generators should be checked.

A thorough search for dead birds and their removal must be done every time the flock is checked, as these are potential sources of disease for the rest of the flock. Disposal of dead birds occurs by burning, composting, or rendering unless they are needed for diagnostic purposes. Burial does not work well on most farms because scavengers dig up carcasses and effluent from decomposing carcasses may contaminate the aquifer. Mortality is recorded on a standard form and reported to the company. Excess mortality events (>1/1000), without an obvious cause, should be reported. If mortality is extremely high (>1/100), this constitutes an emergency, and should be reported to the integrator immediately along with preventing traffic from coming on or off the farm until the cause is identified and possibility of a foreign animal disease has been ruled out. Disposal of hundreds of dead turkeys near market age can present problems as they usually have to be taken to a landfill that will accept them. If mass depopulation is needed, in-house composting may be an alternative, but heat from composting can be a fire hazard if carcasses are too large. Communal disposal or dead bird pickup sites are frequently responsible for spreading disease in an area and are not recommended.

In addition to dead birds, cull birds should be identified and euthanized if they are non-responsive to stimuli, do not move away when approached, cannot get to food or water, are a disease risk for the flock, are severely persecuted by other birds, are not marketable, or for humane reasons. Birds do not show pain as we do, so one's judgment has to be used to determine euthanasia for humane reasons. Several methods of euthanasia are available, but no method is completely satisfactory. After suitable training, cervical dislocation and blunt force trauma are commonly used to euthanize smaller and larger turkeys respectively. Other methods of euthanasia are not readily available to producers (American Veterinary Medical Association, 2007). Recently the Turkey Euthanasia Device, a non-penetrating captive bolt stunning device, has become available to euthanize larger birds by blunt force trauma (*http://www.turkeyeuthanasiadevice.com/*).

Light hen, heavy hen, and tom flocks finish their production cycles at around 14, 18, and 20 weeks of age respectively. Typical average weights are 14-15 lbs (6.4-6.8 kg) for light hens, 18-20 lbs (8.2-9.1 kg) for heavy hens, and 40-45 lbs (20.4 kg) for toms, but vary widely based on company and region. These weights and ages match those when the turkeys are most efficient with respect to rate of growth and feed utilization. Transferring turkeys from finishing houses to coops on live-haul trucks so they can be taken to a processing plant is termed "load-out". Load-out is done at night to decrease stress on the birds, to move the birds when temperatures are cooler, and to have the turkeys at the processing plant the following day. Turkeys are often put on continuous light for up to a week to prepare them for load-out. Feed lines are turned off several hours before load-out so the turkeys can consume feed remaining in the pans. Approximately 12-14 hours before the turkeys are scheduled to be processed, feed lines are raised. This empties the digestive tract of the turkeys prior to processing to minimize contamination from fecal material and ruptured crops. Water is generally not restricted. A weight loss of around 10%, termed "shrink", occurs between load-out and processing, mostly from emptying of the digestive tract.

2.2.6 Mortality

Mortality includes birds that die and those that are culled (see above). It results from a variety of causes including failure to adapt after hatching, infections and infectious diseases, genetic disorders, developmental defects, accidents, and other non-infectious disorders. In well-managed flocks, the majority of deaths result from non-infectious causes. Losses are greatest during the first week of life, but should not exceed 2%, unless poults are from either young or very old breeders, in which case it may be as high as 4-5%. Poults from young breeders are smaller, not as developed, and have greater difficulty starting. After the first week, mortality should be less than 0.5% weekly. Investigation of daily mortality exceeding 0.1% or weekly mortality exceeding 1% should be done. In tom flocks, mortality gradually increases after 16 weeks and may reach 1% per week by the time they are processed because of increased aggression as they approach sexual maturity and musculoskeletal disorders. Total mortality depends on the type of turkey and duration of the production cycle. Hens usually finish with total mortality of 5-6% while total tom mortality is 10-12%.

Losses from mortality accrue from the value of the turkey when it dies, which includes the feed it has consumed, and potential product market value. The most expensive mortality occurs when birds die en route to the processing plant;

least expensive mortality results from losses just after placement. When evaluating mortality, value of the turkey at the time it dies needs to be considered rather than just total mortality.

2.2.7 Flock Records

Several records are kept on each flock including poult placement ticket, feed delivery tickets, service technician's flock evaluations, mortality chart, processing results, and flock close-out record. Some companies also use a biosecurity log to record who goes onto a farm, where they came from, when they arrive and leave, and purpose of their visit. Poult placement tickets provide information on the number delivered, conditions, breed, and breeder flock source, permitting traceback to specific breeder flocks. Feed delivery tickets document the time, amount, and type of feed delivered to the flock. Flocks are periodically visited and evaluated by service technicians, employed by the company, to provide growers with advice and technical information. They also handle routine management and health issues. An evaluation form is completed and provided to the grower at each visit. Mortality is recorded daily by the grower on a standard form and periodically reported to the company. A final summation of the flock's overall performance that incorporates the various records that have been kept on the flock is generated via a computer to provide all of the relevant production and economic information. This often is used to compare flock performance among similar flocks marketed during the same time period.

2.3 FEEDING AND NUTRITION

With average growth rates of toms over 2 lbs (1 kg) and hens around 1.25 lbs (0.6 kg) per week, several different rations are required during the production cycle to provide for the needs of the turkeys and to minimize costs. Programs with 5-7 or more different feeds are fed for 2-4 weeks each. The duration that each feed is given depends on the type of turkey (hen or tom) and growth and development of the turkeys. If their weights are less than the goal, they can be kept on an earlier feed longer to encourage possible compensatory growth.

Feeds must be readily available, palatable, and of good quality. Adequate feeder space for the age of the turkey and a constant supply of feed are essential. Turkeys that do not have feed develop loose, watery, discolored droppings that can rapidly cause litter to deteriorate and "slick over". Feed lines may be broken down by the turkeys and, when feed does arrive, turkeys become frantic trying to get to the feed and often become injured in the resulting mêlée. Also, feed restriction can predispose to feather picking and persecution ("cannibalism"). Height and depth of feed in the feeders need to be constantly adjusted to prevent feed wastage. Eating spilled feed from the litter predisposes to crop mycosis (candidiasis). It is important to examine new feed on arrival to see if it looks the way it should with respect to color, odor, and form, e.g., crumbles for young birds and pellets for older birds. When a flock started on a new load of feed relative to when an excess mortality event occurs, is important to know during a disease investigation.

Although taste is not considered well developed in turkeys, they still respond to feeds and sometimes may refuse to eat them. Smell and texture are likely involved in feed acceptance. Starter feeds composed of good firm crumbles of the correct size (<3mm) are important for young poults. Poults are attracted to bright light and have a preference for green color (Ferket and Gernat, 2006). Spraying green food coloring, putting inducements such as fine grit, rolled oats, or finely minced "greens", or shining bright lights on the feed may help stimulate newly hatched poults to begin eating. Also, brightly colored marbles placed on feed and in water are occasionally used. Turkeys may appear to be eating, but are actually just picking at the feed and not eating it. A better way to determine if the turkeys are actually eating is to catch a number of turkeys and palpate the crop at the base of the neck on the bird's right side to determine if it contains food.

As turkeys grow, they are switched to progressively larger pellets. Excessive fine particles ("fines") in the feed reduce consumption and may also contribute to deficiencies, as fines contain a greater proportion of minerals compared to crumbles or pellets. Although it is labor intensive, periodically dumping fines out of feed lines, putting them back into the hopper, and refilling the feeders will stimulate eating. It is a poor practice to turn off feed lines and leave fines in the feeders for turkeys to clean up. Similarly, manually cycling feed lines off and on stimulates feeding. Lighting programs that have periods of light and dark during the night increase feed consumption, but require careful management.

Feeding grit is not as common as it used to be because commercial pelleted rations are easily broken down. However, the practice still remains useful, especially if birds engage in litter or feather eating. Grit enhances growth and development of the ventriculus ("gizzard"). Crushed granite works well, but limestone or crushed seashells also may be used, although the mineral in them is not required if the birds are being fed a commercial ration. Size of grit needs to be appropriate for the size of the bird. Grit is first given at 1-2 weeks of age (2-5 lbs; 1-2 kg per 1000 turkeys) and every 4-6 weeks thereafter at double the initial rate.

2.3.1 Feed Cost and Consumption

Feed accounts for approximately two-thirds of the total cost of production. Small differences in utilization (feed conversion ratio) result in significant economic differences because of the volume of feed required for millions of turkeys in an integrated company. Cost of turkey feed depends on the cost of the main ingredients - corn, soybean meal, and fat. Corn makes up 47-69%; soybean meal 35-18%, and fat 3-6% of starter and finisher diets respectively. Collectively, corn and soybean meal account for 82-87% of ingredients in feeds fed to commercial turkeys. Soybeans contain a trypsin inhibitor that is detrimental to the growth of young turkeys, but is destroyed by heating. The amount of urease, which also is destroyed by heating, is used to determine how well soybeans have been processed. High potassium levels in soybeans can cause diarrhea when used in all-vegetable diets.

Feed conversion ratio varies with the density of the diet. Turkeys eat to fulfill their energy requirements. Balancing protein, especially essential amino acids, with energy is necessary to have a diet that meets the needs of turkeys. Feed conversion ratios for light hens and toms fed typical commercial diets range from 2.0-2.2 and 2.6-2.8 respectively. Approximate feed consumption for light hens, heavy hens, and toms to 14, 18, and 20 weeks respectively is 42 lbs (19.1 kg) , 63 lbs (28.4 kg), and 111 lbs (50.2 kg). Measures of productivity include average daily gain, cost per unit of production, and breast meat yield. Target weights, feed consumption, and conversion ratios are summarized in Table 6.

Table 6. Weekly Target Weights, Feed Consumption, Feed Conversion Ratios, and Average Daily Gain for Commercial Hen and Tom Turkeys.

	Hens						Toms				
Week	Weight (lb)	Weight (kg)	Feed (lb)	Feed (kg)	Conv. Ratio		Weight (lb)	Weight (kg)	Feed (lb)	Feed (kg)	Conv. Ratio
1	0.35	0.16	0.41	0.19	1.17		0.36	0.16	0.38	0.17	1.06
2	0.76	0.34	0.93	0.42	1.22		0.76	0.34	0.86	0.39	1.13
3	1.49	0.68	1.93	0.88	1.30		1.57	0.71	1.89	0.86	1.20
4	2.41	1.09	3.22	1.46	1.34		2.80	1.27	3.54	1.61	1.26
5	3.56	1.61	5.05	2.29	1.42		4.42	2.00	5.83	2.64	1.32
6	4.96	2.25	7.40	3.36	1.49		6.35	2.88	8.67	3.93	1.37
7	6.60	2.99	10.34	4.69	1.57		8.52	3.86	12.25	5.56	1.44
8	8.38	3.80	13.64	6.19	1.63		10.93	4.96	16.42	7.45	1.50
9	10.32	4.68	17.51	7.94	1.70		13.52	6.13	21.29	9.66	1.57
10	12.23	5.55	21.85	9.91	1.79		16.32	7.40	26.83	12.17	1.64
11	14.23	6.45	26.80	12.16	1.88		19.19	8.70	32.88	14.91	1.71
12	16.20	7.35	31.80	14.42	1.96		22.12	10.03	39.63	17.98	1.79
13	18.07	8.20	36.94	16.76	2.04		25.09	11.38	47.03	21.33	1.87
14	19.82	8.99	42.04	19.07	2.12		28.07	12.73	54.81	24.86	1.95
15	21.39	9.70	47.13	21.38	2.20		31.04	14.08	63.00	28.58	2.03
16	22.88	10.38	52.35	23.75	2.29		33.92	15.39	71.82	32.58	2.12
17	24.15	10.95	57.35	26.01	2.37		36.74	16.66	81.04	36.76	2.21
18	25.28	11.46	62.66	28.42	2.48		39.46	17.90	90.66	41.12	2.30
19	26.31	11.93	67.86	30.78	2.58		42.11	19.10	100.63	45.65	2.39
20	27.29	12.38	73.29	33.24	2.69		44.66	20.26	110.63	50.18	2.48
21	-		-	-	-		47.07	21.35	121.18	54.97	2.57
22	-		-	-	-		49.35	22.38	132.07	59.91	2.68

Average daily gains: light hens (14 weeks) - 0.2 lb, 92 g/day; heavy hens (18 weeks) - 0.2 lb, 92 g/day, toms (20 weeks) - 0.32 lb, 145 g/day

Source: Aviagen Turkeys and Hybrid Turkeys performance goals

2.3.2 Age and Sex Nutritional Requirements

Young turkeys respond to protein, especially levels of the essential amino acids methionine and lysine. Ten amino acids are essential and must be provided in the diet to avoid restricting growth (Table 7). Limiting amino acids in diets include lysine, methionine, and threonine. Synthetic methionine and lysine are added to diets to supplement what is in feed ingredients. Other essential nutrients include linoleic acid, water- and fat-soluble vitamins, and minerals. Nutrition-associated problems in turkeys include foot deformities, footpad (plantar) dermatitis, and poor feathering associated with lack of B-vitamins that can be destroyed by high heat during pelleting. Spontaneous fractures of leg bones are associated with early diets where the specific nutrient(s) involved have yet to be identified.

Table 7. Essential Amino Acids

Arginine	Methionine*
Histidine	Phenylalanine
Isoleucine	Threonine*
Leucine	Tryptophan
Lysine*	Valine

*Most likely to be limiting amino acids

In contrast to young turkeys, older turkeys respond more to higher energy levels, which are often provided by adding higher levels of fat to finishing diets. Antioxidants are added to fat to minimize rancidity. The level of rancidity can be determined by a peroxide test. Protein levels decline and energy levels increase in different feeds during the production cycle. Hens and toms receive the same feeds, but the duration each one is fed to each sex is different. A typical feeding program for commercial turkeys using an 8-diet program is presented in Table 8.

Table 8. An 8-Diet Program for Feeding Commercial Turkeys.

Diet	1	2	3	4	5	6	7	8
Protein* %	27.5	26.0	23.5	21.5	19.5	18.0	17.0	16.0
ME; kcal/lb	1293	1338	1383	1452	1580	1576	1597	1610
ME; kcal/kg	2850	2950	3050	3200	3325	3475	3520	3550
Lysine %	1.62	1.49	1.39	1.25	1.07	0.98	0.89	0.80
Methionine	0.65	0.59	0.53	0.47	0.41	0.41	0.38	0.38
Methionine & cysteine %	1.05	0.96	0.90	0.81	0.71	0.68	0.66	0.63
Calcium %	1.40	1.40	1.30	1.20	1.10	1.00	1.00	0.90
Phosphorus %	0.75	0.75	0.65	0.60	0.55	0.50	0.50	0.45
Hens, weeks fed	0-4	4-6	6-8	8-10	10-12	12-14	14-16	16-14
Toms, weeks fed	0-4	4-6	6-9	9-12	12-14	14-16	16-19	19-22

* Protein and energy levels are balanced. As energy increases, protein is also increased to provide sufficient essential amino acids because feed consumption will go down.

Source: Hybrid Nutrient Guidelines, 2011 Commercial Program [8 phases].

After selection at around 16 weeks of age, feeds for breeder turkeys are lower in protein and energy than commercial turkey feeds to help control growth. It is important that feeds contain all essential nutrients to support development. To prevent over-conditioning, hens are put on low density conditioning (holding) rations and their weights are closely monitored. Feeding is adjusted to average flocks weights. A few weeks prior to moving to the laying house, breeder replacement hens may be given a pre-lay ration, but, the value of this practice is controversial. The laying ration, containing 2.6-2.8% calcium and 0.35-0.40% available phosphorus, is provided when hens are moved to the laying house and light stimulated. With onset of egg production, feed intake decreases as egg production increases, which results in hens losing up to 2 pounds (1 kg) body weight. Weight loss is apparently essential for optimal egg production. Later, as feed consumption increases, hens gain weight and may be as much as 2 pounds (1 kg) heavier at the end of lay than they were at the beginning of lay. If hens are to be molted and kept for a second egg-laying cycle ("recycled"), this additional weight needs to be lost before they are brought back into egg production.

2.3.3. Feed and Water Intake

Feed consumption varies with temperature. It increases when temperatures are below the turkey's comfort zone 50-60°F (10-16°C) and decreases when temperatures are higher. Summer and winter rations often differ from each other to account for these differences in consumption. Composition of rations is adjusted to ensure that levels of essential amino acids are adequate. Best feed conversion occurs at higher temperatures around 75-80°F (24-27°C).

Water is essential for feed consumption and growth. As with feeders, adequate water for the age of the turkeys needs to be available. Turkeys do not eat if they do not have water. The rule of thumb is that turkeys consume approximately twice as much water as they do feed, e.g. one quart (0.95 l) of water per pound (0.45 kg) of feed, but in reality this relationship is highly variable. Toms consume more water than hens. Water must be cool and potable. Water consumption increases considerably with increased ambient temperature, feed ingredients, especially sodium and crude protein, and in the early stages of disease. Measuring water consumption daily using a water meter can be useful in identifying early stages of a problem. Approximate water consumption by age and sex is presented in Table 9.

Table 9. Estimated Daily and Weekly Water Consumption per 1000 Commercial Hen and Tom Turkeys at 68-77°F (20-25°C).

Daily Water Consumption

Age	Gallons	Liters	Age	Gallons	Liters	Age	Gallons	Liters
1	15/15	55/55	9	147/176	557/667	17	179/263	680/994
2	26/28	99/107	10	166/202	629/764	18	- /264	- /1000
3	35/43	132/162	11	174/221	660/836	19	- /265	- /1003
4	48/62	182/236	12	176/235	666/889	20	- /266	- /1006
5	66/85	250/320	13	177/245	669/926			
6	81/108	307/410	14	177/252	671/954			
7	100/131	377/494	15	178/257	674/971			
8	120/152	454/574	16	179/261	677/989			

Weekly Water Consumption

Age	Gallons	Liters	Age	Liters	Liters	Age	Gallons	Liters
1	102/102	385/385	9	1030/1234	3900/4670	17	1257/1839	680/994
2	182/198	690/750	10	1162/1412	4400/5345	18	- /1849	- /7000
3	246/300	930/1135	11	1220/1545	4620/5850	19	- /1854	- /7020
4	337/436	1274/1650	12	1231/1643	4660/6220	20	- /1860	- /7040
5	462/592	1750/2240	13	1236/1712	4680/6480			
6	568/758	2150/2870	14	1242/1765	4700/6680			
7	697/914	2640/3460	15	1247/1796	4720/6800			
8	840/1062	3180/4020	16	1252/1828	4740/6920			

Increase the above values by 20% for every 5°F (2.8°C) increase in ambient temperature between 75-90°F (24-32°C). Water consumption decreases over 90°F (32°C) because activity of the turkeys decreases.

Source: NRC *Nutrient Requirements of Poultry*, 9th ed.

2.3.4 Least Cost Feed Formulation

Numerous alternate energy and protein sources from grains other than corn, or manufacturing by-products are available to use (NRC Nutrient Requirements for Poultry, 9th edition) depending largely on cost and availability. Computer programs calculate replacement value of non-traditional feed ingredients to arrive at a feed that contains everything required for growth and development, but also is least expensive to manufacture and use. Alternate grain sources, especially wheat, barley, and rye, and soybean meal, contain anti-nutrients (non-starch polysaccharides) which reduce their usefulness for feeding, increase ingesta viscosity that slows digestion and absorption, and cause wet, sticky droppings which can lead to foot pad lesions. Addition of enzymes (β-glucanase, arabinoxylanase, cellulase, and xylanase) to the feed is often used to overcome these problems. Wheat contains very little biotin, which should be increased when wheat replaces part of the corn in a ration. Older varieties of milo (sorghum) contained high levels of tannins that bound proteins and could not be used for feeding young birds, but newer varieties with low tannin levels have been developed and are grown today. Milo also is low in xanthophylls, which results in pale, white carcasses. When using milo, it may be necessary to add pigments to the diet if a more yellow carcass is desired.

Phosphorus is expensive. As much as 60-70% of the phosphorus in plants is bound by phytic acid and unavailable to turkeys as they lack the necessary enzymes. Phytases are used to release the bound phosphorus. In addition, trace minerals bound by phytic acid also are released and made available. Phytase is measured in units; 500 units of phytase will free one gram of phosphorus.

2.3.5 Feed Mixing and Delivery

Usually a complex has one large feed mill that is responsible for manufacturing all feeds. Sometimes, the mill also makes feeds for other domestic animals, e.g. pigs or chickens. It is useful to know what feed ingredients, especially ones that may cause a deficiency or toxicity, are in the mill, including ones that may be used for other animals. Feed mills are typically located centrally and adjacent to a railroad. They have their own rail siding to permit buying grain by the train load (80 or more cars is common). Mills have storage capacity for main ingredients, but rarely is the reserve more than enough for a few days' feed production. All steps in the manufacture of feeds are controlled using specialized computer programs. Feeds are accurately produced, unless there is an unrecognized mechanical failure in a bin.

Most commercial feeds are pelleted at high temperatures, 70-90°C (158-194°F), using steam. Advantages include improved growth and feed utilization, increased nutrient availability, decreased waste, improved palatability, decreased selective eating, ease of handling, and killing of vegetative organisms (including *Salmonella*). However, it is possible for feed to be pelleted at a lower temperature, which needs to be verified if pelleted feed is suspected to be the source of a microorganism. Pellets are formed using a pellet mill. Feed is heated, compressed, and forced under pressure through a die that determines the diameter of the pellet. A roller around the die "nips" off the feed extruded through the die. After pelleting, up to 10% fat can be sprayed onto pellets. When pellets have cooled, thermolabile products such as enzymes or probiotics are applied. Pellet quality depends mainly on the composition of the feed. Some ingredients bind together well to form good quality pellets, whereas others do not. Fines are sifted out and reprocessed.

2.3.5.1 Feed Delivery to Farm

After feed is made, it is loaded by weight into feed delivery trucks. These trucks have a trailer divided into compartments. Each compartment can be loaded with a different feed or different amount of feed. At the farm, an auger on the truck delivers the feed through the top of a feed bin. Feed deliveries are a biosecurity concern. Trucks are usually decontaminated when entering and leaving the farm. Decontamination on the farm is generally done by the driver using a sprayer provided at the entrance to the farm. More elaborate facilities that provide cleaning and disinfection for all feed trucks are often at or near the feed mill. These facilities have automatic, drive-through spraying with either a drive-through bath or undercarriage sprayers. Drivers should not go into the flocks or, in most instances, get out of the truck. If they do need to leave the truck, they should put on disposable personal protective gear and leave it on the farm when they have finished off-loading the feed. A service technician monitors the amount of feed remaining and orders feed, although in some situations, this may be the responsibility of the grower. Feed remaining after birds have left either a brooding facility or finishing house is picked up and either reprocessed or delivered to another farm. Feed associated with a toxicity problem needs to be destroyed. Usually, this feed is placed into a municipal land-fill.

2.3.5.2 Feed Storage and Delivery to Turkeys

Each house usually has two feed bins located outside on a concrete pad, next to a drive for the feed delivery truck. Two feed bins per house make it possible to put fresh feed in one bin while older feed is being finished from the other bin. Two bins prevent mixing of fresh and old feed, and allow deliver of a full load of feed. If feed is being weighed, a smaller bin with a scale is used to measure the amount of feed before it is given to the birds. Feed bins on breeder farms may be located just inside the perimeter of the farm boundary line so feed bins can be filled over the fence without the truck having to enter the farm.

Bins are made of corrugated galvanized metal rings that are joined together. Each ring holds a certain amount of feed. Capacity of the bin can be increased or decreased by changing the number of rings. How much feed remains can be estimated by tapping on the bin and listening for the hollow sound of the empty part of the bin. The roof is slanted to permit visualization of the fill hole in the top used to put feed into the bin. A hinged lid covers the fill hole and a chain extends from the lid to permit it to be raised and lowered without having to climb to the top of the bin. The lid must fit properly, be undamaged, and be closed each time after feed is delivered. The lid should be designed so that it is not blown open by the wind. A ladder extends along the side of the bin to permit access to the lid in case it is necessary to see inside or to clean out the bin. On the bottom of the bin is a cone (center draw hopper) that also contains a known amount of feed. An auger at the bottom of the cone carries feed through a tube into the house. Between the cone and auger is a sliding plate that can be opened or closed to direct feed from one bin or the other. An access port on the auger housing permits examination of feed, feed sampling, removal of foreign material that may jam the auger, and pick up of left over feed. Potential problems with feed storage are overheating during the summer with loss of nutrients, moisture accumulating in the feed and causing bridging so that the feed does not flow easily down the cone to the auger, and foreign material in the feed that gets into the auger and stops it from operating. A steel ball is often put into the cone to help prevent feed from bridging.

Feed flows by gravity from the bin to the auger and is moved into the house where it goes through a drop tube into a hopper on the end of the feed line. A switch that responds to the weight or volume of feed in the hopper automatically turns the auger on and off to keep feed in the hopper at all times. If the switch fails, either the hopper becomes empty causing the feed line to run continuously, or feed will flood the hopper and empty onto the floor. Making sure hoppers are working properly is an important part of daily maintenance. Like the feeder bin cone, a metal ball is often placed into the hopper to prevent bridging and help feed flow freely. At the bottom of the hopper is a boot that connects with the feed line. The feed line consists of a spiral rotating “chain” within a tube. Feed is moved through the tube by the rotating chain. Spaced along the feed line are feeders that are attached to openings on the bottom of the tube. They contain cones that can be raised or lowered to control the level of feed in the pans. After feed floods the pan, it backs up into the cone and feed line to stop the flow of feed to the pan and direct it to other feed pans further along the line. Feeders progressively fill until the end of the feed line is reached where the control feeder is located. It automatically switches the hopper on and off depending on the amount of feed it contains. It is important for turkeys to eat feed from the control pan similarly to the other feed pans in order to keep feeders filled.

2.3.5.3 Feed Records

A feed ticket accompanies each batch of feed delivered to the house. A copy of the feed ticket is left on the farm. On the ticket is the date and time, information about type of feed, amount of feed delivered, medication(s) added to the feed, concentration of medication(s), and purpose(s) of medication(s).

2.4 TURKEY MOVEMENT

Various segments of the turkey industry are constantly on the move. While this is necessary for producing the turkeys, it also increases the risk of spreading infectious agents. For breeding, semen is collected and taken from the stud farm to the hen breeder farms for insemination. Crews responsible for cleaning and disinfection, vaccination, load-out, transfer of turkeys from brooding to finishing, and insemination move among farms to do their work. Service technicians travel to farms to oversee production, advise on management and health, conduct pre-placement audits to make sure brooder houses are properly prepared, and assist with placement of poults. Ideally, farm visits by service technicians are limited to two a day, but often it is necessary for them to check more flocks. Any farms with disease problems are done last, unless it is an emergency.

2.4.1 Day-old Poult Delivery

Flocks are assembled in the hatchery as poults complete servicing. After resting overnight in the holding room, poults are loaded into a special poult transport vehicle (sometimes called a “poult bus”) that provides ventilation and a temperature controlled environment for the poults during the move. Proper ventilation is critical to the health of the poults. Loading of poults is done early in the morning and they are taken to the farm where they will be placed. Poults can tolerate long shipping distances that last a day or more, but for most companies, farms are usually located within 2 hours of the hatchery. After poults have been delivered, the poult delivery vehicle is cleaned, disinfected, and prepared for the next delivery. Poult delivery depends on the hatching schedule, but typically they are delivered to farms on Tuesday, Wednesday, Friday, and Saturday.

2.4.2 Transfer to Finishing

In staged production, turkeys are simply walked from the brooding house to the finishing house as described previously. However, now that most brooding is done off-site, the birds must be loaded into coops at the brooder hub and taken to the finishing farm. Placing turkeys into coops at the brooder hub is similar to the way turkeys are loaded out for processing (see 4.3) except the trailers on which the coops are mounted are lower to the ground, coops have less headroom, and coops can be tilted hydraulically. At the finishing farm, turkeys are off-loaded by backing the trailer into the house, opening the coop doors, raising the back of the coop so that it tilts outwardly, and allowing the turkeys to slide out of the coops onto the litter.

Load Out

Load Out Cooping

2.4.3 Load-out and Transfer to Processing

Load-out is done using a special machine called a "turkey loader" that has a conveyor belt for transferring turkeys from the house to coops mounted on a live-haul truck trailer. The turkey loader can be raised and lowered to adjust to the different levels of coops. On the day the flock is to be removed from the farm, the loader is hauled to the farm where it is placed just inside an end door of the finishing house where transfer of the turkeys will take place. The other end is placed alongside the coops on the live-haul truck when it arrives. A catch pen, constructed with movable panels and stakes, funnels the turkeys into the loader in the house. Turkeys are gently driven into the catch pen where they move onto the conveyer belt, which takes them to the coop. Individuals referred to as "coopers" stand on either side of the loader and move the turkeys into the coops. Coordinating movement of the truck and loader makes it possible to move the turkeys into coops with minimum handling. The number of turkeys per coop depends on their type and size, size of the coop, environmental conditions, and distance to the processing plant. Typically, coops are in 5-7 levels and range in height from 14-19 in (36-48 cm).

2.4.4. Steps in Processing

At the processing plant, trailers with coops loaded with turkeys are placed into a holding shed where air is circulated by large fans and misting may be used if temperatures are high. Trailers are pulled into the plant when it is time for the birds to be processed. The location and height of the trailer is periodically adjusted to permit turkeys to be manually removed from the coops and hung by their feet and legs in shackles that are attached to a moving chain. The area is kept darkened and a bar contacts the breast of the birds to help keep them quiet, reduce wing flapping, minimize distress, and reduce parts condemnations due to hemorrhages, bruising, or broken wings. The chain moves the birds into the stunning area and bleed-out tunnel where they receive an electrical shock with alternating current (150-200 m/amps, 90 volts, 10-15 seconds) to induce unconsciousness followed by severing at least three of the four major vessels in the neck. Birds die of cerebral anoxia before they regain consciousness. Blood drains from carcasses as they move through the tunnel to the scald tank, where they are immersed in hot water (~140°F, 60°C) for 2-2.5 minutes, after which they go to pickers that remove feathers with a set of whirling rubber fingers. When defeathering has been completed, shanks are removed by cutting the legs through the hock joints and carcasses are rehung by the head and legs on a separate chain referred to as the evisceration line. Having two separate chains to interrupt the flow of carcasses through the plant between defeathering and evisceration is necessary to prevent carcasses from being held in the scald tank if the evisceration line has to be stopped.

Evisceration begins with a circular cut around the vent and vacuuming of the terminal gut contents, followed by a J-cut in the body wall and drawing of visceral organs out of the carcass. Automation is becoming more frequent in turkey processing plants, but it is still less common than in broiler processing plants. Carcasses and viscera are inspected by a USDA inspector, and parts judged to be adulterated are removed and condemned. Carcasses are either passed, passed with trimming done by plant personnel, removed from the line for reprocessing, or condemned. Reprocessing to clean up a carcass or remove parts to be condemned is done either on the reprocessing line or at special stations, depending on the reason the carcass was removed from the processing line. Reprocessing may occur for fecal or crop content contamination, bile staining, bruises, fractures, airsacculitis, or osteomyelitis. Green discolored livers are used at processing as an indicator of osteomyelitis.

Plant personnel remove the giblets and do any final trimming before the carcass enters the chiller where the internal temperature will be lowered to ≤40°F (4.4°C). After chilling, the carcass is either bagged, along with a giblet pack for sale as a whole bird, or cut up for further processed products. Generally, hens are sold as whole birds and toms provide cut up products and other manufactured foods. Processing yields for turkeys range from 81 to 83% for light hens and toms respectively. Value-added turkey products are increasing, but are not as common as chicken products, largely because turkey has yet to become a staple for fast-food markets. Once processing has been completed, product is stored frozen at a maximum temperature of 0°F (-17.7°C) until it is shipped. Minimum temperature for product to be sold as fresh (never frozen) turkey is 26°F (-3.3°C).

An alternative to electrical stunning is use of controlled-atmosphere stunning. In this procedure, coops of birds travel through chambers containing mixtures of gas comprised of carbon dioxide, nitrogen, and argon. Anoxia results in either unconsciousness or death. This method is considered to provide welfare benefits and is being used more frequently in Europe, but there are technical issues associated with it and it has not been widely adopted in the U.S..

2.5 MOVEMENT OF OTHER PRODUCTS

2.5.1 Mortality

It is preferable to keep mortality on the farm. Dead bird disposal is regulated and in most poultry producing areas must be done within 24-48 hours. Options for on-farm disposal of dead birds include incineration, composting, or burial. Procedures must conform to air and water quality standards to prevent pollution, and dead birds need to be kept away from scavengers, pets, and other livestock (e.g. not feeding dead birds to pigs). Incineration is the most costly disposal method, but it is also provides the highest level of biosecurity because all mortality is handled on site. Incinerators meeting air emission requirements are expensive, and fuel costs continue to rise making incineration costly, especially when large birds are involved. Different states may have different regulations regarding air quality emissions that can affect use of certain incineration techniques. Burn rates for typical incinerators are 100-200 lbs per hour.

Composting can be highly effective, but requires careful management. If done properly, the resulting compost makes a good soil amendment for crops and pasture. In some States, composted carcasses cannot be spread on pastures where cattle will graze because of the possibility of botulism. Two cubic feet (56.5 cm^3) of primary and secondary composting space is needed for each pound (0.45 kg) of carcass. Temperatures need to be monitored to ensure that composting is occurring. They should reach 130-150°F (54-66°C) within 24-48 hours of loading the composter. Composting temperatures established by the Environmental Protection Agency for pathogen reduction are 128°F (53.3°C) for 5 days, 131°F (55°C) for 2.6 days, or 158°F (70°C) for 30 minutes. Although high temperatures, above 150°F (65.5°C) only require a short time and are highly effective in controlling pathogens, they are not recommended, as aerobic organisms necessary for composting are also killed. On-site composting provides the best biosecurity, but some companies provide central composting facilities.

Burial, or use of disposal pits, tends to be least costly, but cannot be used in many areas because of potential contamination of ground water and regulations. Ground water contamination can be a source of disease for poultry and other animals. It also is common for scavengers to dig up buried carcasses and spread infectious agents around the farm or to adjacent farms. Other methods of on-farm dead bird disposal, including refrigeration/freezing of mortality for disposal after the flock is processed, extrusion, and lactic acid fermentation, are being explored but have not been widely adopted.

Rendering is a method of dead bird disposal in which mortality is picked up on a scheduled basis, delivered to a common pick-up site, or delivered directly to the rendering plant where carcasses are processed. It is only available in limited areas. Traveling among farms to a communal dead bird drop off-site or to the rendering plant increases the risk of disease spread. In addition, there are concerns about feeding animal protein back to animals. For these reasons, rendering is currently used less frequently as a method of dead bird disposal than it was previously.

2.5.2 Litter and Manure

Turkeys produce slightly over a pound of manure per pound of feed, which is approximately 75% moisture. Manure mixes with litter through activity of the birds, but tends to be concentrated along feed lines and around drinkers. As it dries, it forms a hard layer on the surface referred to as "cake". In addition to manure, litter contains shavings or other organic material on which the birds were started, feathers, and spilled feed. Litter in finishing houses contains manure from several flocks and is rich in nutrients, especially nitrogen that has value as fertilizer. However, nitrogen is depleted from litter as it is stored and composted, reducing its value as fertilizer.

Finishing houses are usually cleaned out annually and the litter spread onto fields. Contract arrangements are necessary if the litter is to be put onto land that is not owned by the grower and applications are strictly regulated. Land application requires knowing the volume of litter, level of nutrients in the litter, nutrient requirements of the crop(s) to be fertilized, and existing nutrients in the soil. Litter must be applied in a manner that will not result in contamination of waterways from runoff and the crop(s) will need supplemental fertilizer not provided from the litter. Excess phosphorus and buildup of heavy metals (zinc, copper, arsenic) used in production of turkeys and concentrated from multiple flocks are concerns for land application of litter. Most litter is applied to crop land, but there are efforts to convert litter into energy either on-farm or communally. It is a poor practice to apply litter on fields immediately adjacent to other poultry operations, as beetles in the litter migrate to nearby houses and some infectious agents can be spread in the dust generated when the litter is applied.

Litter from brooder houses has less nitrogen since it contains manure from only a single flock. It has limited value as a fertilizer and is more expensive to apply to land compared to finishing litter. It can be transferred to finishing houses to replace litter that was removed or supplement existing litter, or it can be used for composting mortality as it has a high carbon:nitrogen ratio.

PART II: RESPONSE TO A HIGHLY CONTAGIOUS FOREIGN ANIMAL DISEASE

Both Newcastle disease (END) and high pathogenicity avian influenza (HPAI) are nationally and internationally reportable diseases that affect turkeys. In the U.S., infections with low pathogenicity (lentogenic) avian paramyxovirus 1 viruses are still commonly referred to as Newcastle disease, whereas, internationally, infections with these strains are called avian paramyxovirus 1 infections. Infections of birds with high pathogenicity (mesogenic, velogenic) avian paramyxovirus 1 viruses are termed Exotic Newcastle Disease (END) in the U.S., while internationally these are called just 'Newcastle Disease'. Strains of low pathogenicity avian influenza (LPAI) viruses that have either H5 or H7 surface hemagglutinins are reportable because they can suddenly mutate from a low to a high pathogenicity virus. Compared to chickens, turkeys are more resistant to ND virus infection but more susceptible to infection with AI viruses. Neither END nor HPAI is endemic in the U.S. so they are referred to as "foreign" or "exotic". LPAI occurs with some regularity in U.S. commercial and breeder turkey flocks in areas of intense swine production or where there are large numbers of migratory waterfowl. Waterfowl and pigs are frequent sources of AI viruses for turkeys (Capua and Alexander, 2009).

Clinical signs of mild ND or LPAI virus infections are similar and may range from inapparent to a mild respiratory disease characterized by nasal discharge, snicking, rales, dyspnea, conjunctivitis, and sinusitis. Mortality is usually low, but concurrent factors such as age, poor air quality, impaired immunity, and co-infections with bacteria, mycoplasmas, or other viruses can markedly increase mortality. Turkeys typically exhibit decreased activity, huddling, anorexia, and diarrhea. Egg production drops, production of abnormal eggs, and nil to low mortality are seen in affected breeders. Lesions include swollen sinuses, often containing caseous exudate, rhinitis, conjunctivitis, tracheitis, and pulmonary congestion and edema. Swollen kidneys, visceral gout, and multifocal necrosis and hemorrhage in the pancreas also are occasionally seen. Pneumonia, pericarditis, airsacculitis, and splenomegaly are seen when these diseases are complicated by other factors. Yolk peritonitis is commonly seen in breeders, often accompanied by acute oophoritis and salpingitis (Pantin-Jackwood and Swayne, 2009).

Exotic ND in commercial U.S. turkey flocks is extremely rare. However, turkeys are susceptible to experimental infection and become infected when they are commingled with other birds that have the disease (Piacenti, et al. 2006). Clinical signs and gross lesions are similar for END and HPAI.

HPAI is a multi-systemic disease that affects most organs in the body. Early indications of HPAI in both commercial and breeder turkeys are a sudden drop in feed consumption and excessively high, unexplained mortality that may approach 100%. Premonitory clinical signs are usually not observed, but as the disease progresses, turkeys become anorexic, inactive, and non-responsive to stimuli or their environment. Nervous signs characterized by dropped wings, incoordination, tremors, opisthotonos, recumbency, and paddling often occur prior to death. Terminally the birds may flip over and die on their backs. Gross lesions result from necrosis of vascular and lymphoid tissues. Edema, hyperemia, and hemorrhage occur in many organs, but tend to be most obvious in the lungs, proventriculus, ventriculus, pancreas, gut-associated lymphoid tissue, subcutaneous tissues, and fat deposits. Spleens are often enlarged with multifocal necrosis. Similar lesions are seen in breeders along with acute ovarian regression, oophoritis, salpingitis, and yolk peritonitis. There may be no gross lesions in turkeys that die peracutely. Images of poultry affected with HPAI, END, and other diseases can be viewed at *http://partnersah.vet.cornell.edu/avian-atlas/*.

Early diagnosis and containment are critical for minimizing the impact of an END or HPAI outbreak. All individuals from farm workers to management need to be familiar with the clinical signs and know how to respond if either of these diseases is suspected. Abrupt onset of high mortality with near 100% morbidity is likely to be the earliest indication, especially for HPAI because of the susceptibility of turkeys to avian influenza viruses. A history of LPAI infections in other flocks in the area or unusual mortality among free-living birds, especially waterfowl, may precede an HPAI outbreak. END may not be as obvious, as turkeys are more resistant to infection and vaccination, which is practiced in many turkey producing areas, may modify the response to ND virus infection.

Daily mortality of 0.1% should raise the likelihood of a disease problem, but may not trigger an investigation. Mortality of 1% in any group of turkeys should be investigated to determine the cause. If mortality exceeds this and approaches 10%, an emergency should be declared and the problem investigated immediately. If there is no obvious cause for the deaths (e.g., heat, accident, adverse weather, or poisoning) and there are indications of a possible foreign animal disease, the farm should be shut down and no traffic allowed on or off the farm. The possibility of a foreign animal disease is reported to management while the person investigating the disease stays on the farm to be sure it is secure and waits for a Foreign Animal Disease investigator to arrive. Regulatory authorities, usually the State Veterinarian, are contacted by management. They will send a specialist trained in foreign animal diseases to investigate the problem. It is important that birds not be taken off the farm to a corporate or state diagnostic laboratory. If a disease emergency is declared, and a quarantine established, moving birds to a laboratory will only widen the quarantine zone. Appropriate samples will be collected and submitted to a facility that specializes in diagnosis of foreign animal diseases. Usually, preliminary results to determine if the flock has either END or HPAI are available within 24 hours.

Identification of flocks with LPAI is more problematic as clinical signs are variable and not specific. Often LPAI infection is inapparent and only detected from routine serology for AI done at processing. All flocks submitted for disease diagnosis should be screened for possible LPAI.

2.6 BIOSECURITY

Biosecurity is the preventative measures taken to reduce the risk of infectious diseases being introduced into an animal population. When biosecurity is not implemented, or when there is a lapse in biosecurity, a susceptible host or population may be exposed to infectious organisms. Some infectious diseases may be detrimental to the health and well-being of the animals, or present a food safety risk. Diseases that are reportable by state and/or federal governments can have a broader impact; possibly affecting trade, movement of birds and product, or require an organized response to contain the disease. Therefore, procedures are put into place in turkey flocks to either exclude known risk factors or minimize risk when it is unavoidable.

2.6.1 Biosecurity Plan

A biosecurity plan provides instructions on how to mitigate biosecurity risks for everyone within a company or site. Development of specific procedures in the plan is based on risk assessment; evaluating frequency, likelihood, impact, and controllability of certain biosecurity risks. Documented biosecurity procedures within the plan should be practical, clear, and effective. Most biosecurity procedures have an associated cost, so a cost/benefit analysis is usually performed before implementation. Biosecurity plans frequently change based on new information, monitoring of existing procedures, or changing biosecurity risk factors. Compliance, a critical aspect of a biosecurity plan, is improved by using checklists; sign-off sheets, incentives for good compliance, and/or disincentives for poor compliance.

Biosecurity plans are structured in many different ways. One method of developing a biosecurity plan is based on three steps–conceptual, structural, and operational biosecurity. Conceptual biosecurity involves evaluating the potential location of new poultry operations including regional density, proximity to other poultry/animal facilities, flyways, prevailing winds, potential for flooding or other adverse weather events, and movement of poultry in the region. Structural biosecurity involves fixed cost elements of the facility including layout and design such as impervious surfaces, adequate drainage, perimeter fencing, changing/employee space, shower facilities, and vehicle wash stations. Operational biosecurity involves the routine operations and specific farm practices such as rodent, insect, and wild animal control, limiting access of people to the farm, requiring personal protective equipment, cleaning and disinfection, litter management, and disease surveillance.

2.6.2 Pests, Wild Birds, and Other Animals

Procedures need to be in place to control rodents, insects, and other animals that may transmit infectious diseases to a turkey flock. Bait stations are used to control rodents and insects. It is important that bait is not accessible to the turkeys. When used, rodent bait stations are routinely checked and rebaited when needed, and placed properly along the edge of a wall where rodents typically run. Bait stations are most effective in preventing disease transmission when used on the exterior of buildings and clearing vegetation around the house by at least 18 in (0.5 m) is useful for preventing rodents. Housing should be checked for areas where wild birds or other animals could enter the flock and holes should be patched if needed. Placing feed bins on cement slabs and removing any spilled feed deters rodents and wild birds that may be attracted to the feed. Allowing pets on farms, even if they are used for rodent control, is considered a poor practice as they can become infected with diseases carried by rodents and transmit them to the turkeys. Similarly, permitting pets to scavenge dead birds may result in their becoming carriers and spreading an infectious agent to other flocks on the farm or nearby farms.

2.6.3 People

Several procedures are useful in minimizing the risk of people introducing infectious diseases into turkey flocks. Employees should have clean clothes. Clean cloth or disposable coveralls and hair covering is recommended. Some facilities may have a liquid or dry bleach footbath that should be clean and utilized if it is to be effective. A footbath station may include a cover, scrub brush, and/or cement slab to minimize organic contamination. Gloves and/or ability for employees to clean their hands (sanitizer or sink) are recommended. Especially with breeders, facilities may include shower-in/shower-out facilities where all people are required to at least shower in and put on clean clothes prior to entering the farm. Employees travelling to multiple farms each day need to consider age and health status of the flocks when determining the order of farm visits. Employees must avoid all other avian contact, especially other poultry and wild waterfowl. A logbook for all people entering the farm helps to ensure that they meet requirements for not having been in contact with other poultry within a specified time. Accurate logbooks can be useful in determining what farms need to be quarantined in the event of a disease outbreak. Visitors, especially if they enter the flocks, should be minimized. Clearly visible signs warning away visitors need to be posted at all entries. Locks and fences are also useful in preventing unwanted visitors from entering the farm or houses.

Foot Bath

Breeder Farm Biosecurity

2.6.4 Cleaning and Disinfection of Facilities, Equipment, and Vehicles

Equipment is cleaned and disinfected prior to being brought onto a farm or moved between flocks. Also, the house is cleaned or cleaned and disinfected between flocks as indicated. Vehicle access to farms may be restricted, or allowed with guidelines, e.g., restrictions on distance from the farm and cleaning and disinfection. When cleaning surfaces, vehicles, and equipment it is important to remove organic material first before disinfection, as most disinfectants do not work well in the presence of organic material. Important properties of the disinfectant should be known such as range of activity, contact time required, corrosiveness, and human health implications.

Plans for disposing of carcasses and litter need to be in place and followed. Methods of disposal include spreading litter on fields, composting, incineration, burial, or rendering of carcasses (see 5.1). Not all of these options may be available, based on state and local regulations and proximity to ground water sources. Rendering and litter trucks present a significant biosecurity risk when moving among farms and appropriate precautions need to be taken.

2.6.5 Surveillance

Surveillance for disease is an important part of any biosecurity plan because it helps to assess the effectiveness of the biosecurity procedures and permits an infectious disease to be isolated to a single house or farm. Surveillance can include evaluating farm data records, testing birds serologically, fecal floatations, environmental sampling for microorganisms, and necropsy of mortality. Data records that include basic flock information (source, numbers placed), mortality, production parameters, feed deliveries and consumption, service technician reports, and water consumption need to be kept for each flock and consulted if there is a health problem. Changes in any parameter can indicate onset of disease. Although mortality may be necropsied periodically to evaluate the flock, a spike in mortality warrants a disease investigation and possible submission of birds to a diagnostic laboratory.

2.7 PROVIDING ANIMAL CARE

2.7.1 Feed

In the event of a foreign animal disease, provisions for feeding unaffected flocks in the quarantine zone need to be provided. How this is done will depend on whether the feed mill is located within or outside of the quarantine zone. If the entire farm distribution of the complex and feed mill are within the quarantine zone, then the only consideration is for feed delivery trucks to avoid, as much as possible, routes that take them by affected farms. Feed will not be delivered to flocks confirmed to have the disease as those flocks will either be depopulated or scheduled for depopulation. Feed being given to affected flocks is destroyed on the farm (see 8.2).

Dedication of feed delivery trucks to either deliver feed to farms within the quarantine zone or farms outside of the quarantine zone is possible when only part of the farms are within the quarantine zone. Within the Control Area, single feed deliveries are preferred over delivering feed to several farms. Routes and farm deliveries need to be recorded in the event that additional flocks develop the disease. As feed delivery trucks leave a farm, they must be carefully cleaned and disinfected, especially if they are leaving the quarantine zone and returning to the feed mill.

2.7.2 Water

Water is provided from municipal or on-farm sources. No special provisions for delivering water are needed.

2.7.3 Ventilation

No changes from normal ventilation are indicated. Ventilation can be shut down just prior to mass euthanasia of an affected flock, but should not cause extreme discomfort or result in death of the birds. There is no indication that either END or HPAI viruses survive very long in the environment, and airborne transmission is unlikely.

2.7.4 Light

No special provisions for lighting are needed. Dimming lights prior to mass euthanasia may help calm the turkeys.

2.7.5 Environmental Temperature

No special provisions are needed beyond those for normal production as described above.

2.8 ON-FARM WASTE HANDLING

Containment areas consist of the infected premises (flock/farm), the Control Area, and the buffer-surveillance zone. While illustrated as concentric circles of approximately 2 miles (3.2 km) for the control zone and an additional 4 miles (6.4 km) for the buffer-surveillance zone in guidelines, they actually conform to the geography, political boundaries, and movements within the company or companies with the affected farm or farms in contact or close proximity to it. Criteria for issuing permits which allow movement of products within, between, or out of zones, need to be in place and agreed on prior to an outbreak. As a rule, nothing moves on or off a farm with a known or suspected infected flock except what is essential for disposing of the flock and subsequent cleaning and disinfection.

2.8.1 Litter and Manure

Houses are closed and litter containing the manure remains in the house for at least 2 weeks after depopulation. If possible, heating the house is done to accelerate destruction of the virus. Moving litter right after a diseased flock has been removed puts other flocks at risk, as viable virus is still present in the litter. Avian influenza viruses are destroyed in litter by heating to 135°F (56°C) for 90 minutes or 140°F (60°C) for 10 minutes. Composting litter in the house, which results in temperatures higher than those needed to destroy avian influenza virus is recommended, especially if it is combined with in-house composting of dead birds. A negative test of the litter for viable AI virus may be required prior to it being permitted for removal from the house. When litter is removed, it must be transported in covered trucks that are thoroughly cleaned and disinfected afterwards. Regulations for litter application on land remain unchanged.

2.8.2 Residual Feed

Residual feed from an infected flock is removed from the feed lines, hoppers, and bins and added to the litter. It cannot be removed from the farm or used to feed other birds. Feed may be transferred from a flock that has tested negative to another flock within the same containment zone, but not outside the containment area.

2.8.3 Mortalities

Mass euthanasia is done using carbon dioxide, although fire foam is showing promise as a better method (Rankin, 2010).

Catastrophic losses, regardless if they are from heat, accidents, weather events, END, or HPAI, require extraordinary measures. Permission to bury or incinerate large numbers of birds because of an emergency may be granted, but more often, these measures remain unavailable. Movement to a landfill where carcasses will be buried is an option, but not all landfills accept animal disposal and the costs of transporting and using the landfill may be high. Information on possible use of landfills needs to be determined prior to a crisis.

A cost effective method is in-house composting, which can be used when birds die or are euthanized in the house. Birds are piled into one or more rows down the middle of the house, covered with at least 2 feet of litter, and left for 2 weeks. It is recommended that daily temperatures be taken using a probe to be sure composting is occurring. Composting temperatures are sufficient to kill most infectious agents. When the temperature of the mortality compost drops, it is turned in the house to aerate the compost, or it is removed to a secondary composting facility on the farm where the process can be continued until it is complete. Sampling the compost and negative tests for HPAI or END viruses may be required before it can be removed from the house. Cleaning and disinfection of the house are done after the compost has been removed from the house.

2.9 SURVEILLANCE

2.9.1 People

Avian influenza viruses are highly transmissible. Movement of people among farms is the most common means by which the virus is transferred from one flock to another. Access to the containment zone is restricted to essential personnel and only necessary movement within the zone is allowed. Regular visits to flocks by service technicians are stopped and replaced by telephone consultations. All personnel are required to follow strict biosecurity procedures for entering and leaving a premises. Disposable personal protective equipment (PPE) should be used and left on the farm. Any non-disposable items must be disinfected, double-bagged, and the outer bag disinfected prior to removal from the farm and disinfection later in a secure area. Personnel need to shower and change clothes after leaving a farm. A record of personnel movement is kept.

Avian influenza can infect people and may even cause death. Appropriate protective gear including a respirator (N-95 or better) and goggles should be worn for one's personal safety. People entering a positive flock need to be healthy without symptoms of possible human influenza, and they should be up-to-date on their vaccination for seasonal flu. Clinical signs of influenza in people include conjunctivitis, fever, and respiratory disease. While seasonal flu vaccination does not protect against avian influenza, it does minimize the possibility of mixing between human and avian strains of the virus. If any workers in contact with infected flocks develop symptoms consistent with influenza, they must be seen immediately by a physician and tested for influenza. Workers may be put on prophylactic antivirals, but the value of this procedure is controversial. Taking antivirals can provide a sense of false security and relaxation of personal protection.

Cancelling local and regional poultry sales and shows during a foreign animal disease outbreak is a prudent measure to prevent potential spread of the disease to other areas.

2.9.2 Vehicle Traffic

Vehicle access to the quarantine zones is also restricted. This includes movement of animals other than turkeys including other poultry and livestock. Movement is by permit only. Control points along roads into and out of the area may be needed. Vehicles are cleaned and disinfected when leaving an affected farm and when leaving each zone. Portable disinfection stations may be set up to facilitate control of vehicle decontamination. Particular attention is given to the inside of vehicles (they should be either uncarpeted or have rubber flooring that can be easily disinfected), wheels, tires, and undercarriage. Routes by which vehicles travel are recorded and, if available, a GPS monitoring device is placed in each vehicle.

In the event of an H5 or H7 LPAI outbreak, controlled slaughter of flocks may be permitted. Flocks should be processed as soon as possible even if they are not at the normal age. Flocks in the containment area that are too young for processing may need to be euthanized to depopulate the area in preparation for repopulation and release of the quarantine.

2.9.3 Disease Monitoring

Daily mortality for all flocks within the containment area is reported by telephone and any reports of increased mortality are investigated by a foreign animal disease specialist. Extensive sampling of the compost, litter, and environment is done after depopulation. Negative tests for these samples within 24 hours are indicative the disease is not present, but a premise is not declared free of the disease until two consecutive negative tests that are at least seven days apart have been obtained.

Routine surveillance of poultry flocks, including turkeys, for both HPAI and LPAI is done in most poultry producing areas. Birds associated with live poultry markets, birds in the NPIP program (breeders), small hobby ("backyard") flocks, and waterfowl are also tested. In the NPIP program, testing 30 breeders per flock provides 95% confidence that not more than 10% of the flock has AI. Breeder flocks that test negative are identified as "U.S. H5/H7 Avian Influenza Clean". Currently 98% of all turkey breeders in the U.S. are tested annually. Six samples are submitted from commercial flocks within 3 weeks of processing. Flocks testing negative are identified as "U.S. H5/H7 Avian Influenza Monitored". Approximately 90% of commercial turkey flocks are currently being tested. Serum samples are examined for antibodies to AI and tracheal samples from birds submitted for diagnosis of a respiratory disease or an acute egg drop are tested for AI virus.

Commercial influenza rapid antigen tests that provide results in <15 minutes can be used on the farm for preliminary testing. Positive results are meaningful, but negative results should not be interpreted that the flock is not infected. While these tests have high specificity, sensitivity is low because relatively high amounts of virus are needed for the test to be positive (i.e., false negatives are more common than false positives).

2.9.4 Sample Collection

Monitoring is best done by placing mortality in a sealed plastic bag in a bin next to the roadway so that going onto the farm is unnecessary ("barrel surveillance"). Oropharyngeal or tracheal swabs from at least five dead or culled birds are collected. If no dead birds are found on the morning of the sampling, and there are no cull birds from the flock that need to be tested, samples are collected from 11 randomly selected turkeys per flock. Swabs are tested by real time, reverse transcriptase polymerase chain reaction (rRT-PCR) or rapid antigen capture immunoassay. The latter can be done on site to provide a rapid preliminary diagnosis in less than 15 minutes. Samples for virus isolation are collected in a suitable viral transport medium, usually Minimum Essential Medium (MEM) or Brain Heart Infusion (BHI) Medium that contains antibiotics and antifungals to discourage growth of contaminants. Up to five swabs of the same type and source can be pooled into one tube of viral transport medium. If cloacal swabs are also being collected, they should be kept separate and not pooled together with tracheal swabs. Virus isolation takes 3-10 days, but is necessary for confirmation and determination of the virulence and molecular characteristics of the virus. Priority for sampling is given to flocks experiencing clinical signs, especially high mortality, flocks in the Control Area, and flocks in the buffer-surveillance zone that are within 48 hours of processing.

2.9.5 Sample Submission

Samples are submitted to an animal disease diagnostic laboratory with at least BSL-2+ containment facilities that have the ability to test for foreign animal diseases. These laboratories form the National Animal Health Laboratory Network and are overseen by the National Veterinary Services Laboratory in Ames, Iowa.

For an example of a detailed plan to deal with both LPAI and HPAI and the necessary information and permissions required to be in place prior to an outbreak, the reader is referred to the *North Carolina Response and Containment Plan for Highly Pathogenic and Low Pathogenic Avian Influenza. http://www.ncagr.gov/vet/aws/documents/NC_New_AI_Plan_DRAFT_6-22-09_HPAI_LPAI.pdf.*

USDA-APHIS HPAI Response Plan Summary is available at *http://www.aphis.usda.gov/newsroom/hot_issues/avian_influenza/contents/printable_version/SummaryHPAI-Response092007Draft.pdf* and the Standard Operating Procedures for HPAI can be found at *http://www.aphis.usda.gov/newsroom/hot_issues/avian_influenza/contents/printable_version/HPAI_SOP_24.pdf*

Comprehensive information on control of foreign animal diseases can be found in the United States Animal Health Association book Foreign Animal Diseases ("Gray Book") *http://www.aphis.usda.gov/emergency_response/downloads/nahems/fad.pdf*.

Acknowledgements

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This FAD PReP Industry Manual was produced in collaboration with USDA-APHIS-VS National Center for Animal Health and Emergency Management by the Center for Food Security and Public Health, Iowa State University of Science and Technology, College of Veterinary Medicine through a cooperative agreement.

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Acknowledgements

- Dr. Jean-Pierre Vaillancourt
  University of Montreal
- Dr. Harry van de Hoef
  Hybrid Turkeys

A special thanks goes to the primary breeder companies who have provided a wealth of information online on how to raise healthy and profitable breeder and commercial turkeys. Their websites are *http://www.aviagenturkeys.com/us/home.aspx* and *http://www.hybridturkeys.com/*.

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Page 48	***(Top)*** Descendants of early domesticated turkeys (*Pavo creollo*) can still be found in rural areas of southern Mexico. *Photo source: Dr. Jean-Pierre Vaillancourt, University of Montreal* ***(Second from top)*** Bronze turkeys resulted from crossing European strains with the Eastern wild turkey (*Meleagridis gallopavo silvestris*). Selection of Bronze turkeys for body weight resulted in the Broad-breasted Bronze turkey, which became the basis of commercial turkey production. Broad-breasted White turkeys subsequently replaced the bronze-colored strains and are now the type of turkey grown for meat production. The original Bronze turkey is still grown by heritage turkey growers, but the numbers are limited. *Photo source: Jeannette Beranger, American Livestock Breeds Conservancy* ***(Third from top)*** Broad-breasted White turkey hens, 12 weeks of age, in a commercial flock. Almost all turkeys grown commercially in the U.S. are Broad-breasted White turkeys. *Photo source: Oberlin Brinker, North Carolina State University* ***(Bottom)*** Figure 1. Primary trading partners purchasing U.S. turkey in 2010 were Mexico, China, Canada, Russia, Hong Kong, Taiwan, Dominican Republic, and Panama. Mexico accounted for over half of all turkey exports. *Content provided by: Dr. Michael Martin; Graphic illustration by: Dani Ausen, Iowa State University*
Page 49	Table 1. Differences Between Commercial Turkeys and Broilers. *Graphic illustration by: Dani Ausen, Iowa State Univeristy*
Page 50	(***Top***) Figure 2. U.S. commercial turkey production in 2010. Approximately 260 million turkeys are produced annually, mostly in the North-central, Central, Mid-east, and Mid-Atlantic regions of the US, and California. During 2010, combined production of three states Minnesota, North Carolina, and Arkansas, accounted for 43% of total US production. *Content provided by: NASS, USDA; Graphic illustration by: Dani Ausen, Iowa State University* ***(Center)*** Table 2. Top Turkey Producing States in the US in 2010. *Content provided by: USDA, National Agricultural Statistics Service, 2010 Summary; Graphic illustration by: Dani Ausen, Iowa State University* ***(Bottom)*** Table 3. Top Turkey Producing Companies in the U.S. in 2010 (Live Weight Processed). *Content provided by: 2010 Watt Poultry USA; Graphic illustration by: Dani Ausen, Iowa State University*
Page 51	***(Top)*** Narragansett tom turkey, one of 8 recognized breeds of heritage turkeys. *Photo source: Dr. Michael Martin* ***(Center)*** Heritage turkeys being raised in a free-range system in North Carolina for holiday markets. *Photo source: Dr. David Ley, North Carolina State University* ***(Bottom)*** Figure 3. Structure of a typical vertically integrated turkey company. *Content provided by: Dr. Michael Martin; Graphic Illustration by: Dani Ausen, Iowa State University*
Page 52	Table 4. Annual Production of Turkey in the U.S. *Content provided by: USDA, Economic Research Service, National Agricultural Statistics Service; Graphic illustration by: Dani Ausen, Iowa State Univeristy*
Page 54	Figure 4. As many as generations go into producing commercial turkeys. Individual lines are purebred so the final generation is a three- or four-way cross. It takes about 4 years for pedigree genetics to be realized in the meat birds. Very high selection pressure is applied to primary breeders, particularly males. Each pedigree tom ultimately produces over 8 million commercial turkeys and just over 94.5 tons of turkey meat, while each pedigree hen produces around 800,000 commercial turkeys and nearly 9.5 tons of turkey meat. *Content provided by: Jihad Douglas, Derek Emmerson, and Dr. Yan Ghazikhanian, Aviagen Turkeys, Inc; Graphic illustration by: Dani Ausen, Iowa State University*
Page 55	Stud farm. Tom turkeys are kept in pens and ejaculated 1-2 times per week to collect semen. Light intensity is high and emits light enriched in both red and blue colors. *Photo source: Drs. Don McIntyre and Harry van de Hoef, Hybrid Turkeys*
Page 56	Squatting hens. When hens are receptive to mating, they squat down and spread their wings. This should not be interpreted as an indication of lameness. *Photo source: Drs. Don McIntyre and Harry van de Hoef, Hybrid Turkeys*

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Page 57 *(Top*) Table 5. Vaccines Used in Turkey Breeder Hens. *Graphic illustration by: Dani Ausen, Iowa State University*

(Bottom) Turkey hen breeding farm. A nest box is provided for every 4 to 6 hens. Semi-trap nest boxes prevent more than one hen from entering the nest box. These are manual nest boxes; eggs are gathered several times a day. A net above the nest boxes is lowered in late afternoon and raised in early morning to prevent hens from sleeping in them overnight. The drinker is called a Plasson drinker after the manufacturer. Hens can easily drink from the drinkers but can also walk under them. *Photo Source: File Photo, Poultry Health Management Team, North Carolina State University*

Page 58 ***(Top)*** Broody hen control. Marked hens are showing signs of early broodiness. They will be moved to brooder pens where their environment and routine will be changed until they begin squatting again or go broody. If a hen becomes broody, she will not lay eggs again until after a molt. *Photo source: File Photo, Poultry Health Management Team, North Carolina State University*

(Center) Semen collection from tom turkey. Stroking the tom and applying pressure to the vent will express semen, which is collected, pooled, prepared, and used to inseminate the hens. *Photo source: Drs, Don McIntyre and Harry van de Hoef, Hybrid Turkeys*

(Bottom) Insemination of a hen. A measured amount of semen containing a calculated number of viable spermatozoa is drawn up in a thin tube (straw), which is inserted in the vagina. Semen is expressed near the sperm-host glands. *Photo source: Drs. Don McIntyre and Harry van de Hoef, Hybrid Turkeys*

Page 60 Turkey hatchery. Following servicing, boxes containing the poults are stacked and organized into flocks in a warm, dimly-lit, holding room to allow the poults to rest overnight (left). Poult delivery. Early the following morning, poults are delivered to the brooding facility in special vehicles ("poult buses") that provide ventilation and temperature control (right). *Photo sources: Dr. H. John Barnes (left); Dr. Jocelyn Romano, North Carolina State University (right)*

Page 61 Brooder house setup. Many variations exist on how houses are set up to brood poults after placement. Seen here are double rings that surround two conventional gas brooder stoves ("pancake brooders") that would accommodate up to 600 poults. Green feeders are supplemental and will be gradually removed as poults learn to go to the feed line (currently raised up near the ceiling). Water is being provided by a double line of nipple drinkers with cups. The house is freshly bedded and has been thoroughly cleaned. This house is on a "brooder hub" used for off-site brooding of poults (top). Radiant gas brooder stove. Radiant heat stoves are more efficient than traditional convection brooder stoves because they heat the floor and birds directly rather than the air. Radiant brooder stoves cover a wider area so brooder rings have to be larger and stoves are suspended high above the brooding ring (bottom). *Photo sources: File Photo, Poultry Health Management Team, North Carolina State University (top); Dr. Annika Hoffman, North Carolina State University (bottom)*

Page 62 *(Top*) Brooding, day 4. Supplemental feeders and drinkers are removed gradually as poults transition to eating and drinking from automatic water and feed lines. Green supplemental bucket feeders and a jar drinker are seen here. Some feeders have been moved away from the brooder stove. *Photo source: File Photo, Poultry Health Management Team, North Carolina State University*

(Bottom) Brooding, week 4. Young turkeys are eating from drop feeders on the feed line. The bottom of the feed hopper is in the upper left. Feed level in the pans is kept low to prevent spilling of feed. Line running along the top of the feed line can be electrified ("shocker wire") to keep birds from perching on the feed line. (left). Brooding, week 4. Young turkeys are drinking from an automatic Plasson bell drinker. Lip of the drinker has been adjusted to shoulder height of the birds and the amount of water in the circular trough is low to prevent it from being spilled. (right). *Photo Source: File Photo, Poultry Health Management Team, North Carolina State University (both)*

Page 64 Figure 5. Nutrient Budget. Everything that constitutes the turkey's structure and most of its function comes through the digestive tract via nutrient intake, digestion, and absorption. Essential functions and tissues preferentially receive nutrients followed by tissues that are not essential for survival. *Content provided by: Dr. H. John Barnes; Graphic illustration by: Dani Ausen, Iowa State Univeristy*

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Page 65	Range turkey flock. Turkeys used to be produced during the summer on open range, primarily for the holiday season. Small turkey flocks for niche markets are still raised this way, but finishing on range is rarely used anymore for commercial flocks. Turkeys, especially toms, become quite colorful because of sun exposure. *Photo source: File Photo, Poultry Health Management Team, North Carolina State University*
Page 66	Tunnel finishing house. Most new houses use tunnel ventilation. Houses have tight construction and large fans pull air through evaporative cooling pads to minimize heat stress. Dual feed tanks provide several options on how feed is delivered to the farm and fed to the birds. *Photo source: Dr. H. John Barnes*
Page 67	Finishing, week 18. Tom flock nearing market age. Tom flocks finish their production cycles at around 20 weeks of age. Typical average weights of toms at processing are 40-45 lbs (18.1 - 20.4 kg). *Photo source: Dr. Annika Hoffman, North Carolina State University*
Page 69	Table 6. Weekly Target Weights, Feed Consumption, Feed Conversion Ratios, and Average Daily Gain for Commercial Hen and Tom Turkeys. *Content provided by: Aviagen Turkeys and Hybrid Turkeys performance goals; Graphic illustration by: Dani Ausen, Iowa State University*
Page 70	(***Top***) Table 7. Essential Amino Acids. *Graphic illustration by: Dani Ausen, Iowa State University* (***Bottom***) Table 8. An 8-Diet Program for Feeding Commercial Turkeys. *Content provided by: Hybrid Nutrient Guidelines, 2011 Commercial Program [8 phases]; Graphic illustration by: Dani Ausen, Iowa State University*
Page 71	Table 9. Estimated Daily and Weekly Water Consumption per 1000 Commercial Hen and Tom Turkeys at 68-77°F (20-25°C). *Content provided by: NRC Nutrient Requirements of Poultry, 9th ed; Graphic illustration by: Dani Ausen, Iowa State University*
Page 72	(***Top***) Feed mills are typically located centrally and adjacent to a railroad. They have their own rail siding to permit buying grain by the train load (80 or more cars is common). Mills have storage capacity for main ingredients, but rarely is the reserve more than enough for a few days of feed production. *Photo source: Dr. David Rives, Prestage Farms* (***Bottom***) Feed delivery truck. Feed delivery trucks have a trailer divided into compartments. Each compartment can be loaded with a different feed or amount of feed. At the farm, an auger on the truck delivers the feed through the top of a feed bin. *Photo source: Dr. Annika Hoffman, North Carolina State University*
Page 74	Turkey load out. A turkey loader (right side of picture) is placed just inside an end door of the finishing house. The other end is placed alongside coops on the live-haul truck trailer. A catch pen, constructed with movable panels and stakes, funnels turkeys into the loader in the house. A conveyor belt on the loader transfers turkeys from the catch pen to the coops (top). "Coopers" stand on either side of the loader and move the turkeys into the coops (bottom). *Photo source: Dr. Annika Hoffman, North Carolina State University (both)*
Page 75	On-farm incinerator. Incineration is the most costly method of disposing of dead birds, but it is also provides the highest level of biosecurity because all mortality is handled on site. *Photo source: Dr. H. John Barnes*
Page 78	Footbath. Footbaths should be clean and utilized if they are to be effective. Organic material tends to neutralize most disinfectants. A footbath station may include a cover, scrub brush, and/or cement slab to minimize organic contamination. If the footbath is located inside, dry bleach is a good disinfectant to use (left). Breeder farm biosecurity. A shower-in/shower-out facility provides the only personnel entrance onto the farm. The six-foot chain-link fence topped with strands of barbed wire surrounds the farm (right). *Photo sources: Dr. H. John Barnes (left); File Photo, Poultry Health Management Team, North Carolina State University (right)*

Glossary

All In/All Out
Management system in which all birds are placed on a farm at the same time and they are all removed from the farm at the same time; provides a period of "down time" between flocks when there are no birds on the farm

Barrel Surveillance
Examination of fresh mortality that has been placed into a plastic bag and a barrel by the roadway for foreign animal disease sampling

Beard
A tufted mass of long, black, hair-like bristle feathers that extends from a specialized area of skin on the lower neck; length of the beard determines trophy status of wild turkeys; some hens may also have beards but they are small

Brooder Hub
Farm dedicated to brooding that provides turkeys to finishing farms at around 5 weeks of age; off-site brooding; one brooder hub supplies turkeys to several finishing farms

Brooding
The period in the production cycle when poults are in the brooder house; they will require supplemental heat for 2-4 weeks depending on environmental temperatures

Broodiness, Broody Hen
Hen in the early stages of ceasing to produce eggs. A number of procedures are used to identify affected hens and prevent them from going out of production.

Cake
Hard, dry crust composed of manure, moisture, and litter that forms on the litter surface especially around feeders and drinkers where turkeys defecate most frequently

Candidate
Young replacement breeder that has the desired characteristics for becoming a parent breeder

Caruncle
Fleshy, round protuberances on the unfeathered skin of the neck

Conditioning
10 to 12 week period between selection and transfer to the laying house when breeder hen candidates are maintained on 6 to 8 hours of light

Coopers
Individuals on the platform of a turkey loader who place turkeys into coops

Cracking
Everting the vagina of the breeder hen in preparation for insemination

Culls
Birds that are non-responsive to stimuli, do not move away when approached, runted or markedly stunted, cannot eat or drink, are a disease risk for the flock, are severely persecuted by other birds, are not marketable, or need to be removed from the flock for humane purposes

Curtain House
Part or all of the house wall is open but covered by a curtain that can be raised or lowered to control ventilation; fans often supplement air movement

Glossary

Dark-Out House
Light-proof housing used for conditioning replacement breeder hens

Demand Organs
Tissues that are critical for survival and normal function, e.g., brain, heart, lungs, digestive organs, etc.

Dewlap
Fold of skin that extends from the lower beak to the middle of the neck

DOA
Acronym for "dead-on-arrival", birds are dead when they arrive at the brooder hub, finishing farm, or processing plant; flocks with respiratory disease or adverse environmental conditions during load out and hauling are associated with more DOA birds at processing

Down Time
Interval between when a house or farm is cleaned and disinfected and the next flock is placed. Minimum recommended down time is 10 days. Longer the down time the more opportunity there is for infectious agents to die.

Exotic Disease
Disease that does not occur naturally in the U.S.. Syn. Foreign disease

Exotic Newcastle Disease (END) Virus
An avian paramyxovirus 1 that has an intra-cerebral pathogenicity index (ICPI) of at least 0.7, or has multiple basic amino acids at the hemagglutinin cleavage site typical of a virulent Newcastle disease virus. Viruses previously classified as mesogenic, viscerotropic velogenic, and neurotropic velogenic are included.

Extender
Sterile diluent used to dilute semen to the optimal concentration of spermatozoa for insemination

Finishing (Grow-Out)
The period of time in the production cycle between brooding and processing; turkeys are in the finishing house on a finishing farm

Finishing Farm
Farm dedicated to growing the turkeys from brooding to processing. Syn. Grow out farm.

Flags
Poles with one or more strips of plastic or cloth attached to the end used for moving turkeys

Flip-Over
Young poults less than a few days old that get over on their backs and cannot right themselves

Floor Eggs
Eggs not laid in the nest that usually are more soiled and contaminated than nest eggs

Flushing
Common name for diarrhea in a flock. May result from enteric disease, nutrition, or following a period of feed deprivation.

Foreign Animal Disease
Disease that does not occur naturally in animals in the U.S.. Syn. Exotic disease

Glossary

Frame
Common name for the skeleton of a turkey; used to select potential breeders

Germinal Disc
Small white spot on the yolk where fertilization and embryo development occurs. Syn. blastodisc

Gobble
Distinctive sound made by an adult male turkey

Gobbler
Common name for an adult male turkey. Syn. Stag (European), Tom (North American)

Hen
Female turkey that is no longer a poult; term used for both immature and mature female turkeys

Hatcher
Specialized incubator that provides specific conditions for hatching, typically during the last 3 days of incubation

Hatchery
Facility that is dedicated to the storage, incubation, and hatching of fertile eggs to produce poults

Hatch Residue
Material left behind in hatching trays after the poults have been removed

Heritage Turkey
Specific pure breeds of turkeys recognized in the Standard of Perfection judging guide including Black, Bronze, Narragansett, White Holland, Slate, Bourbon Red, Beltsville Small White, and Royal Palm. Term may also be used to describe other color varieties. Characteristics are ability to mate naturally, long reproductive period, ability to thrive in free-range systems, and slow growth

High Pathogenicity (Highly Pathogenic) Avian Influenza (HPAI) Virus
H5 or H7 avian influenza viruses that have an intravenous pathogenicity index (IVPI) in 6 week old chickens >1.2, causes mortality in at least 75% of intravenously inoculated 4-8 week old chickens, has multiple basic amino acids at the hemagglutinin cleavage site typical of a virulent influenza virus, or can infect cell cultures in the absence of trypsin

Hospital Pen
Separate area where weak, flip-over, and other poor growing poults can be placed for recovery; they have access to fresh feed and water, but are kept at a lower temperature

Incubator
Machine that provides conditions necessary for normal embryo development, typically during the first 25 days for turkeys; may be single-stage (contains a single age group of eggs) or multi-stage (continuous flow of different age groups of eggs); common name = setter

Intracerebral pathogenicity index (ICPI)
Ten one-day-old SPF chicks are inoculated intracerebrally with 0.05 ml of a 1:10 dilution of allantoic fluid from infected chick embryos and observed for 8 days. Each day, chicks are scored as 0 (normal), 1 (sick), or 2 (dead). An average score of 0.7 or higher during the observation period confirms an avian paramyxovirus 1 is Newcastle disease virus.

Glossary

Intravenous Pathogenicity Index (IVPI)
Ten 4-8 week-old SPF chickens are inoculated intravenously with 0.1 ml of a 1:10 dilution of allantoic fluid from infected chick embryos and observed for 10 days. Each day, chickens are scored as 0 (normal), 1 (sick), 2 (severely sick), or 3 (dead). An average score of 1.2 or higher during the observation period confirms an avian influenza virus is highly pathogenic

Livability
Percent of flock placed at hatch that is processed; opposite of mortality. Livability + mortality = 100.

Load-Out
Process of removing turkeys from the finishing farm to take them to the processing plant

Low Pathogenicity (Low Pathogenic) Avian Influenza (LPAI) Virus
An avian influenza virus that does not meet the definition of a high pathogenicity avian influenza virus

Lux (lx)
A standard measurement of light intensity, one lux is the amount of light cast by one lumen over a square meter; one foot candle equals 10.8 lx

Milking
Process of collecting semen from male turkeys to be used for insemination

Mis-Sex
A poult that was identified as the wrong sex in the hatchery, typically these will make up less than 2% of a flock

Morbidity
Percent of the flock showing clinical signs

Mortality
Percent of the flock placed at hatch that is not processed; opposite of livability. Mortality + + Livability = 100.

Multiplier Breeders
Parent breeders that produce commercial turkeys; usually owned by the integrator

Nutrient Budget
Distribution of nutrients for maintenance, immune stress, demand organs, and supply organs

Off-Sex
Toms from the hen line parents (females from the tom line are retained by the breeder company)

Oocyte
Immature female reproductive cell in the ovary; ovulated and becomes an ovum after meiosis

Ovum
Haploid female reproductive cell that develops from an oocyte after the second polar body is formed during meiosis; occurs in the infundibulum of the oviduct

Persecution
Purposeful persistent harassment and infliction of injury on a bird by one or more birds in the flock; commonly erroneously called cannibalism

Glossary

Photorefractory
Hen or tom does not respond to light stimulation by sexual development or production of eggs or spermatozoa; normal in the juvenile bird

Photosensitive
Hen or tom responds to light stimulation by developing secondary sex characteristics or behavior and initiates production of eggs or spermatozoa

Photostimulation
Increasing the duration, intensity, and/or wavelength of light exposure to bring a flock into active reproduction

Pipping
Internal: penetration of the beak through the shell membrane into the air cell; External: penetration of the beak through the shell in preparation for hatching

Polar Body
Small nuclear remnant of meiosis in the ovum that results from asymmetrical cell division, contain excess chromosomal material and typically degenerates

Poult
Young turkey of either sex; there is no agreement on the age at which a turkey should no longer be called a poult; generally young turkeys that are still being brooded are called poults. It is inappropriate to call a young turkey a chick.

Poult Bus
Vehicle that transports poults from the hatchery to the brooding facility

PPE
Acronym for Personal Protective Equipment worn to protect against contamination and spread of infectious agents from one flock to another and to protect against infection with zoonotic agents

Primary Breeders
Lines of breeders owned and managed by the primary breeding company that produce the pedigree, great-grandparent, and grandparent generations

Range Turkeys
A production system that was common when turkey consumption was seasonal. After brooding, flocks were placed on pastures with shelters, feeders, and drinkers during the summer and marketed in the fall. Range production of commercial turkeys has been replaced by year-round confinement rearing.

Recycle
Hens in a second lay cycle following a molt; term also used for a molted hen

Replacement Hens/Toms
Young parent breeding stock that is being raised to replace existing parent breeders after their production cycle has been completed

Semen
Fluid and spermatozoa produced by the male reproductive tract

Servicing
Procedures done to poults in the hatchery to prevent diseases and trauma and prepare the poults for placement on the farm; includes sex determination, beak trimming, toe trimming, and injections of nutrients or pharmaceuticals

Glossary

Settable Eggs
Normal sized and shaped, clean fertile eggs that can be placed into the incubator and are likely to hatch

Setter
Common name for an incubator

Shrink
Amount of weight lost between load-out and processing.

Skins
Eggs that are laid without a shell; usually only the flattened shell membrane remains

Slicking Over
Litter that rapidly becomes wet and slimy when a flock develops diarrhea ("flushing")

Snick, Snicking
Noise made when turkeys have an upper respiratory disease, equivalent to sneezing in mammals

Snood
An elongated, erectile appendage in the form of a tapering cylinder located in front of the eyes that hangs over the side of the head; prominently displayed by dominant males

Spermatozoon (- zoa, *pl.*)
Haploid male reproductive cell that unites with the ovum to produce an embryo; commonly called sperm

Spermatocrit
Percentage of packed spermatozoa in semen; compared to mammals, avian spermatocrits are very high because of the concentrated nature of avian semen

Sperm Holes
Multiple perforations in the vitelline membrane caused by spermatozoa entering the yolk; used as an indicator of fertility and normal spermatozoon function; a minimum of 50 sperm holes indicate fertility

Sperm Host (Storage) Glands
Specialized glands located at the base of tubules in folds at the junction of the shell gland and vagina that can maintain the viability of spermatozoa for as long as 2-3 weeks

Squatting
Characteristic sitting position with lowered wings that signals a turkey hen is receptive for breeding

Stag
Male turkey, term used primarily in Europe. Syn. Tom.

Straw
Thin tube used for inseminating the hen with semen from a tom

Strutting
Male breeding display, tail is erect and fanned out, wings are drooped, and often a "booming" sound accompanies strutting

Stud Farm
Farm where breeder toms are kept

Glossary

Supply Organs
Tissues that are not essential for survival and normal function, e.g., muscles

Tights
Hens out of production, refers to the small, round, dry, contracted vent of these birds

Tom
Male turkey that is no longer a poult; term is used for both immature and mature male turkeys. Syn. Stag.

Tunnel House (Ventilation)
Solid wall housing that has evaporative cooling in one end and fans in the other end; negative pressure ventilation

Turkey Loader
Specialized machine that has a conveyor belt and can be raised and lowered to match coops on a trailer; used to transfer turkeys from a brooder hub to a finishing farm and from the finishing farm to the processing plant

Vent Sexing
Method to determine the gender of a poult by everting the vent and determining the presence or absence of a primordial phallus

Chapter 3: Egg Industry

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PART I: UNITED STATES EGG PRODUCTION

3.1 SCOPE OF THE EGG INDUSTRY

3.1.1 Laying Hen Numbers and Location

Producing eggs for human consumption is a major agricultural industry in the United States. In the 1950s and 1960s, egg production was concentrated in the southeastern United States where producers put up inexpensive houses and utilized regulated railroads to bring in feed and ship eggs all over the country. As railroads were deregulated, southeastern producers lost their economic advantages and much egg production moved to the Midwest. Most commercial egg production now occurs in the Midwest, eastern areas of the United States, and in California. According to the American Egg Board, 192 egg producing companies with flocks of 75,000 hens or more account for 95% of all layers in the United States. In 2010, there were 61 companies with 1 million-plus layers and 13 of those companies own 5 million-plus layers. In 2009, the average number of laying hens in this country was 280 million with an average daily rate of lay of 75%. Large commercial producers tend to be highly automated, however, hand gathering is still practiced on some larger operations in western states where labor is readily available. The leading egg-producing states are listed in Table 1. The five largest egg production companies in the United States own approximately 50% of all egg-type chickens in the USA. These companies are listed in Table 2.

Table 1. Leading Egg Production States (2012)

National Ranking	*State*	*Millions of Layers in Production*
1	Iowa	52.3
2	Ohio	26.9
3	Pennsylvania	24.4
4	Indiana	22.8
5	California	18.9

Table 2. Leading Egg Production Companies (2012)

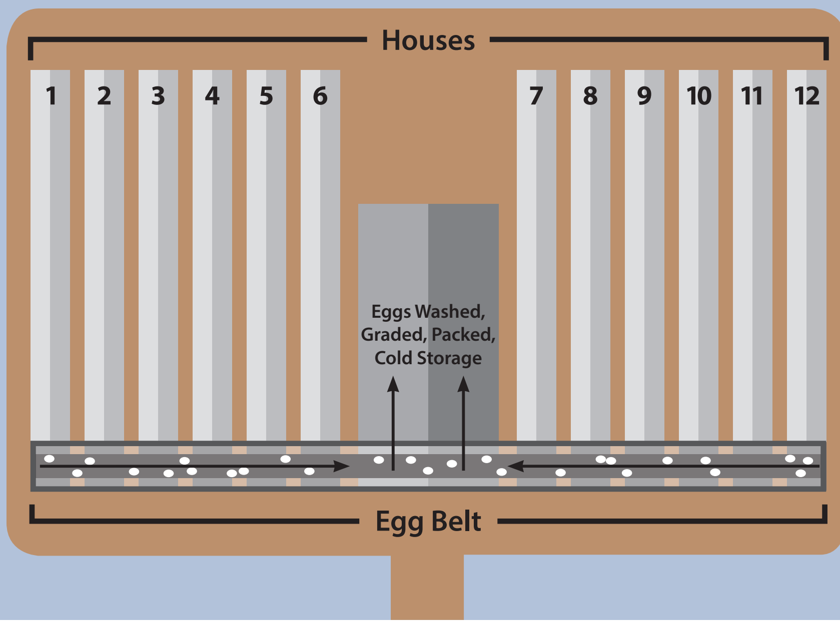
National Ranking	*Company*	*Millions of Layers in Production*
1	Cal-Maine Foods	33.5
2	Rose Acre Farms, Inc.	23.7
3	Moark, LLC	14.9
4	Daybreak Foods	13.5
5	Rembrandt Enterprises	13.4

3.1.2 In-Line Egg Farms

In-line egg operations are characterized by an automated egg collection system that carries eggs directly from chicken houses to the egg processing plant (building). These farms produce, process, pack, and ship eggs at one location. Large commercial "in-line" farms containing 50,000 to 6 million laying hens produce over 85% of table eggs in the United States. The average number of chicken houses in a large, integrated egg production complex is

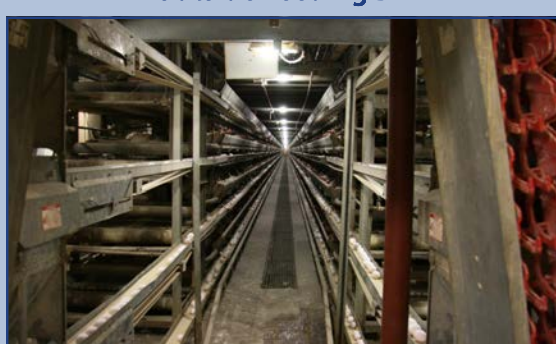
10 and a complex may consist of 15 or more houses. Each house contains 50,000 to 350,000 laying hens. In-line chicken houses are highly-automated and eggs are moved on egg conveyor belts through enclosed passageways in a line to a processing building where eggs are processed within 24 hours after being laid. During processing, eggs are washed to remove fecal material and stains from shells, rinsed with a sanitizer, dried, candled to remove eggs with defects such as cracks or blood spots, weighed by computerized electronic scales, sorted by size, graded, and packed into cartons by automated equipment. Automated, high speed machines may process up to 400 cases of eggs per hour. A large number of chickens is required on the farm to keep machines operating at capacity. The day on which USDA-graded shell eggs were packed is shown on the carton by a Julian date.

Figure 1. Egg Laying House

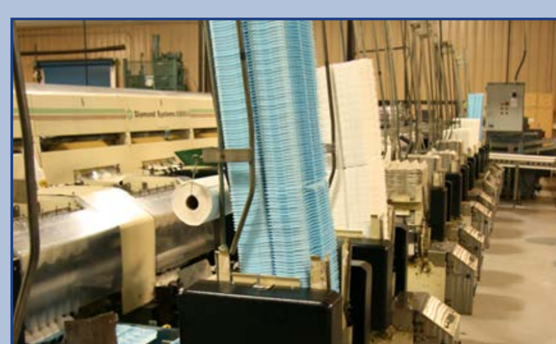


Outside Feeding Bin

Outside Fans on Chicken Houses



Aisle Between Rows of Chickens



Empty Cartons

3.1.3 Off-Line (Nest Run) Egg Farms

"Nest run" or "off-line" egg farms do not have a processing facility and typically consist of one or two chicken houses which lack processing equipment. Nest-run egg operations currently range from about 75,000 to 500,000 hens and eggs are collected in henhouses either by hand or by egg belt and moved to the egg room. In the egg room, they are placed on egg flats (fiber or plastic) and are then packed onto farm pallets or sometimes farm racks. Off-line eggs are packed "as is" without having been washed, sized, and/or candled for quality. Full pallets are placed in a refrigerated cold storage room. Nest run eggs may be held at their production farms for 2 to 4 days under refrigerated conditions after being laid, though some farms may ship the eggs quicker without the need of refrigeration.

3.1.4 Niche Market Egg Farms

Niche market farms account for less than 10% of eggs produced in the U.S. but account for the majority of egg production farms. These farms include small and large cage free, aviary-housed, free range, organic, and nutraceutical operations, and such farms may have several hundred to several thousand hens. In some cases, these farms house up to 50,000 to 75,000 hens. Smaller farms with less than 10,000 laying hens are likely to hand gather the eggs, but larger farms depend on mechanical gathering using egg collection belts to gather eggs from nests. Eggs produced on niche market farms may be marketed at the farm, brought to market by the farmer, or picked up by a processor.

3.1.5 Capital Investment

A typical Midwest multi-age, in-line egg production facility contains 1.5 to 4.0 million laying hens. With a 75% average rate of lay and eggs priced at $0.95 per dozen, 1.25 to 3.0 million eggs produced each day have a market value of $98,960 to $237,500. Typical modern in-line egg production operations in the Midwest may have chickens in cages with 67 square inches per bird, grading and packing equipment, egg-breaking machines to produce liquid whole eggs, and rooms for packing, cooling, and storing eggs. Capital investment for this type of facility ranges from $24 million for an operation with 1 million chickens ($24/hen) to $80 million for a 4 million bird complex ($20/hen). Maximum egg storage capacity in cooler rooms at most egg production premises is limited to the number of eggs produced during a period of 48 hours.

3.2 LIFE STAGES AND POULTRY HUSBANDRY NEEDS

3.2.1 Production Cycles of Egg-Type Chickens.

Large commercial egg operations require coordination between the hatchery, pullet growing farms, egg packing plant, and feed mill. Pullets needed to replace spent hens represent the second largest cost of egg production. In a typical production system, companies purchase day-old pullets from hatcheries that are owned and operated by genetics companies with direct sales to egg producers. Pullets are raised in wire cages in brooder/grow-out buildings on rearing farms owned by the production company or by a contract pullet grower. The size and number of rearing houses required depends upon the size and number of layer houses being supplied with replacement pullets and the number of egg production cycles in the laying house. A single rearing house can supply 3 layer houses in a single cycle (no molt) system, 5 layer houses in a two-cycle (one molt) system, and 7 layer houses in a three-cycle (2 molt) system. Day-old chicks are initially placed in cages on one or two tiers, but around 4 weeks of age the flock is subdivided and chicks are moved into cages on the remaining one or two tiers. At 16-17 weeks of age, pullets are transferred to cages in a laying house where they will stay for the remainder of their productive life. Moving at this age provides adequate time for pullets to recover from the stress of moving. Light stimulation to encourage onset of egg production should not begin until one week after pullets have entered the laying house. Egg production begins around 18-19 weeks of age. The length of the productive life of a laying hen depends upon the number of egg production cycles utilized on the egg farm. Typically, the productive life of laying hens ends at 78-80 weeks in a one-cycle system, at 102-106 weeks in a two-cycle system, and at 140 -150 weeks in a three-cycle system. Approximately 80% of laying hens in the USA are molted at least once. Annual egg production per hen has risen from 213 in 1962 to 281 in 2009.

3.2.2 Replacement Pullets

3.2.2.1 Brooder House

Brooder houses should be cleaned and disinfected at least 2 weeks prior to arrival of chicks. Effectiveness of this process should be documented by visual inspection and by environmental cultures to detect *E. coli* and *Salmonella.* Heavy, water-proof paper placed on the floor of wire cages allows chicks to walk without falling through spaces between wires, helps to control temperature and reduce drafts, and permits feeding off the paper. Day-old chicks cannot regulate their body temperature, so it is critical to provide proper environmental temperatures (92-95 F).

Humidity during the first week should be at least 50% to prevent dehydration. Access to water from cup or nipple drinkers is facilitated by lowering water pressure so that a hanging drop of water is visible to the chicks. Feed should be placed on cage papers in front of trough feeders which should be completely filled with starter feed before chicks are placed in the cage. It is very important that pullets destined for alternative housing systems be raised in the same system. Pullets must know how to move about the system and how to find feed and water when placed in the laying house.

3.2.2.2 Physiological Development of Pullets

It is critical that pullets have the correct body weight and correct body composition at the onset of lay so egg production and shell quality can be sustained during the production period. Laying hens that are too small lack the calcium and protein reserves necessary to sustain egg production. During the first 6 weeks of life, the digestive tract and immune system develop. From 6 to 12 weeks of age, the skeleton achieves 95% of its adult size and muscle is formed. Between 12 and 18 weeks of age, the reproductive tract develops. Egg production generally begins between 19 and 21 weeks of age depending on body weight and the lighting program. Low body weights and stress can delay the onset of egg production.

3.2.2.3 Flock Uniformity

Beginning at 4 weeks of age, 100 pullets should be weighed each week to monitor average body weights and uniformity. Uniformity is represented by the percentage of pullets within 10% of the average body weight of individuals within the flock. Uniformity at 16 weeks of age is an important indicator of pullet flock quality. Grow-out programs strive to attain 85-90% body weight uniformity. Changes in feed formulations (starter to grower to developer) should be based upon achieving target body weights.

3.2.2.4 Lighting

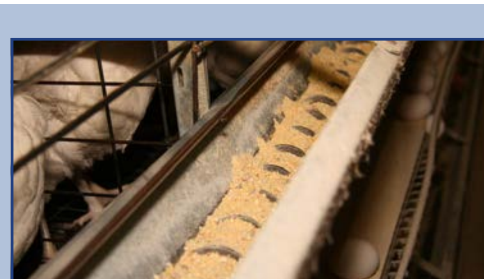
The intensity and duration of light during brooding and grow-out directly impacts growth and onset of sexual maturity. Day length can be used to prevent or delay onset of egg production in underweight pullets or to encourage early onset of egg production. Most brooder/growout houses are light-proof and all light exposure comes from electric light bulbs. Typically, pullets are exposed to 20-22 hours of light with an intensity of 30 lux during their first week of life. During the second week, the number of hours of light is reduced to 20 and the intensity is reduced to 5 lux. Subsequently, the number of hours of light per day is slowly reduced to 10-12 hours by 9 to 10 weeks of age. Typical lighting programs provide a constant 10-12 hour day length until 18 weeks of age. If optimum average pullet weights are attained, light stimulation begins at 17-18 weeks with initial weekly increases in day length of 30 minutes followed by adding an additional 15 minutes of light each week until 16 hours of light per day is attained. If maximum egg size is desired, reducing day length by 15 minutes per week between 10 and 15 weeks and delaying light stimulation until 19 or 20 weeks of age will delay sexual maturity until pullets have heavier body weights resulting in larger eggs, fewer cloacal prolapses, and fewer eggs over the production cycle. To promote greater feed consumption, the light period can be reduced more slowly to provide more feeding time. To maximize egg numbers, chickens can be exposed to early light stimulation at 15-16 weeks of age which results in egg production 7-10 days earlier than normal and smaller eggs during the production cycle.

3.2.3 Laying Hens

3.2.3.1 Feed and Water

Water pipes and feed troughs extend the length of the cage rows and provide feed and water to chickens in each cage. One or two nipple or cup drinkers in the rear or upper part of each cage are attached to a water pipe. Feed troughs pass along the front of each cage and feed is mechanically moved along the trough by a chain or auger system. Feed troughs are filled automatically and are regulated by a time clock.

Watercup and Nipple



Feed Auger at a Laying Site

3.2.3.2 Egg Collection

Sloped wire mesh floors extend outside of the cages and allow eggs to roll beneath the feed trough onto an egg conveyor belt which extends the length of the cage rows and transports eggs out of the laying house to the processing facility.

3.2.3.3 Light

Most light programs for laying hens during egg production consist of 16 hours of light with 10 to 30 lux at bird level and 8 hours of darkness. If light intensity is not sufficient, egg production is impaired. If light intensity is too great, cannibalism, cloacal prolapse, and nervousness may increase. Dirty light bulbs reduce light intensity and need to be cleaned and burnt out light bulbs should be promptly replaced.

3.2.3.4 House Temperature

Automated, computer-controlled environments maintain proper temperature, light, and humidity. Optimum environmental temperatures range from 57 to 79°F. Temperatures outside this range adversely affect feed conversion, egg production, egg quality, and water consumption. Controlled ventilation and insulation are necessary to maintain proper temperatures and humidity.

3.2.3.5 Mortality

Normal mortality ranges from 0.05%/week in young to mid-age layers, and on up to 0.18%/week in older age flocks. In addition to age, normal mortality can be influenced by bird strain, management, and housing style. Depending primarily on age, a mortality rate of 0.15-0.20%/week is a threshold signal for producers to take "diagnostic action" in young to mid-age laying hens.

3.3 FEEDING AND NUTRITION

3.3.1 Feed Cost and Consumption

Feed is the largest cost of egg production (approximately 60%). Each one million laying hens on a farm require approximately 120 tons of feed per day, 7 days per week. Ration formulas are tailored to meet the physiological needs of egg-type chickens and optimize their performance during each stage of growth and egg production.

3.3.2 Strain and Age Nutritional Requirements

Feed ingredient quality, strain of layer, and egg size requirements are used to develop a feeding program. Different genetic strains of egg-type chickens have different growth profiles and rations must be formulated to meet the requirements of each strain. Separate rations are formulated for pullets prior to the onset of sexual maturity (indicated by comb development) and for adult hens during the first egg production cycle, molting, and the second egg production cycle. First production cycle rations include pre-lay (3 weeks prior to 5% egg production); pre-peak (5% to 50% egg production); peak (50% egg production to 3 weeks post-peak); and post-peak. Second egg production cycle rations include prelay, peak, and post-peak. Phase feeding can be used to reduce the nutrient content of feed as egg production and associated nutritional needs decline. Laying hens are usually fed a mash feed.

3.3.3 Feed Intake, Egg Weight, and Body Weight

Feed intake determines nutrient intake and egg weights provide information about the adequacy of nutrient intake. Feed intake and egg weight are monitored throughout the laying period. Feed intake declines with inadequate space per bird, after beak trimming, during periods of heat stress, because of inadequate hours of light, following some vaccination procedures, and when consuming high energy rations. Adjusting the intake of protein, methionine or methionine plus cystine, and/or energy can be used to manage egg size. Feed formulations are adjusted as necessary to attain chicken body weight, body weight uniformity, egg production, and egg weight objectives.

3.3.4 Least Cost Feed Formulation

A professional nutritionist establishes feeding specifications, monitors performance, and revises the program as necessary for most egg production companies. Computer software utilizes data concerning nutrient requirements of the chickens at specific stages of their life cycle, nutrient content of available feed ingredients, price of available feed ingredients, ingredient restrictions, and nutrient restrictions to generate a ration formula which will meet nutritional needs at the least possible cost. Computers are used to formulate diets so that some strains of laying hens can produce a dozen eggs on less than 3 pounds of feed and require less than 2 pounds of feed to produce 1 pound of eggs.

3.3.5 Feed Mixing and Delivery

The mixing system and coordination of delivery are important to a successful feeding program. Feed is mixed in automated mills and delivered in covered hopper trucks to feed tanks at the egg farm. Ingredients are stored in separate bins, weighed with a computerized batch control system, and mixed under the direction of the batching system. Neither feed ingredients nor finished feeds are seen during the mixing process, so feed ingredients should be sampled at the mill before delivery and inspected at the farm upon delivery. Layer feed is not pelleted and tends to segregate, especially large particles of calcium, so a blend of several samples should be used for analysis. Saving samples from each feed delivery for 3 months is recommended.

3.4 LAYING HEN FACILITIES

3.4.1 Cages

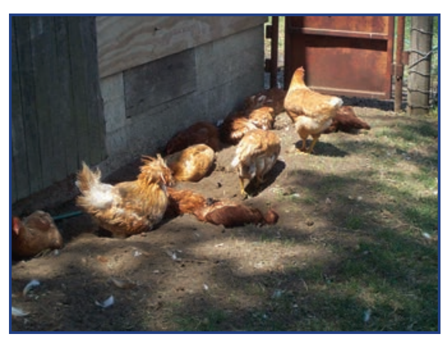
Cage systems or "battery cages" are used to house 95% of laying hens in the United States. "Battery" refers to a collection of cages. Most cages on commercial egg farms hold 5 to 10 laying hens. Cage systems consist of enclosures constructed of wire mesh arranged in rows and stacked in multiple (4 to 8) tiers in "high rise" or manure belt houses. Approximately 71% of commercial chicken houses in this country are "high rise" houses with two levels - chickens on the upper level and a manure pit on the lower level beneath the cages. Fully or partially offset cages with wire mesh floors in a stair-stepped "A" frame configuration allow droppings to fall into a deep pit below the cages without passing through cages in lower tiers. Partially offset cages use a dropping board or plastic shield to protect chickens in cages on lower tiers. In high-rise houses, manure forms cones beneath each row of cages and manure removal may occur only once per year. About 22% of chicken houses are "manure-belt" houses with a conveyor belt below each tier of cages. In manure-belt houses, manure is removed daily and stored in a separate building. Watering, feeding, and egg collection are completely automated.

3.4.2 Enriched Colony Cages

Chickens in "enriched" or "furnished" cages have access to curtained nest boxes, perches, an abrasive strip to reduce excessive growth of claws, and an area for pecking, dust-bathing, and scratching. Dust pans are frequently placed on top of the nest boxes. Enriched colony cages house 40-60 hens and provide approximately 50% more space per hen than traditional cages.

3.4.3 Cage-Free

Cage-free systems include both floor-raised (deep litter) and aviary systems. Chickens in cage-free systems are kept indoors but do not reside in cages and have access to communal nest boxes with automated egg collection, perches, and litter. Floor-raised chickens are kept on a single level (the floor) which consists of 1) a slatted-floor area over a shallow manure pit or manure belt and 2) a litter area over a solid floor. Feeders, waterers, and low perches are placed on the slatted floors. Chickens in aviary systems have access to multiple tiered plastic-slatted or welded wire platforms on each side of the house separated by a solid floor covered with litter. Feed, water, perches, light, and automated nests with egg belt collection are usually available on the tiered platforms. Drinkers are frequently placed in front of the nests to encourage chickens to use the nests. Each tier may have a manure belt. Platforms are "stair-stepped" so that chickens can easily jump from one level to the next. Approximately 5% of eggs produced in the United States are from cage-free systems.



3.4.4 Free Range

Chickens in free range systems have at least some time each day when they are given access to an outdoor area. Most free range chicken houses have doors along the sides which are opened later in the day after most eggs have been laid and closed in the evening. The outdoor area may range from an open pasture to a fenced perimeter area extending along the sides of the house. About 1.8% of laying hens in the United States are raised under organic, free range conditions.

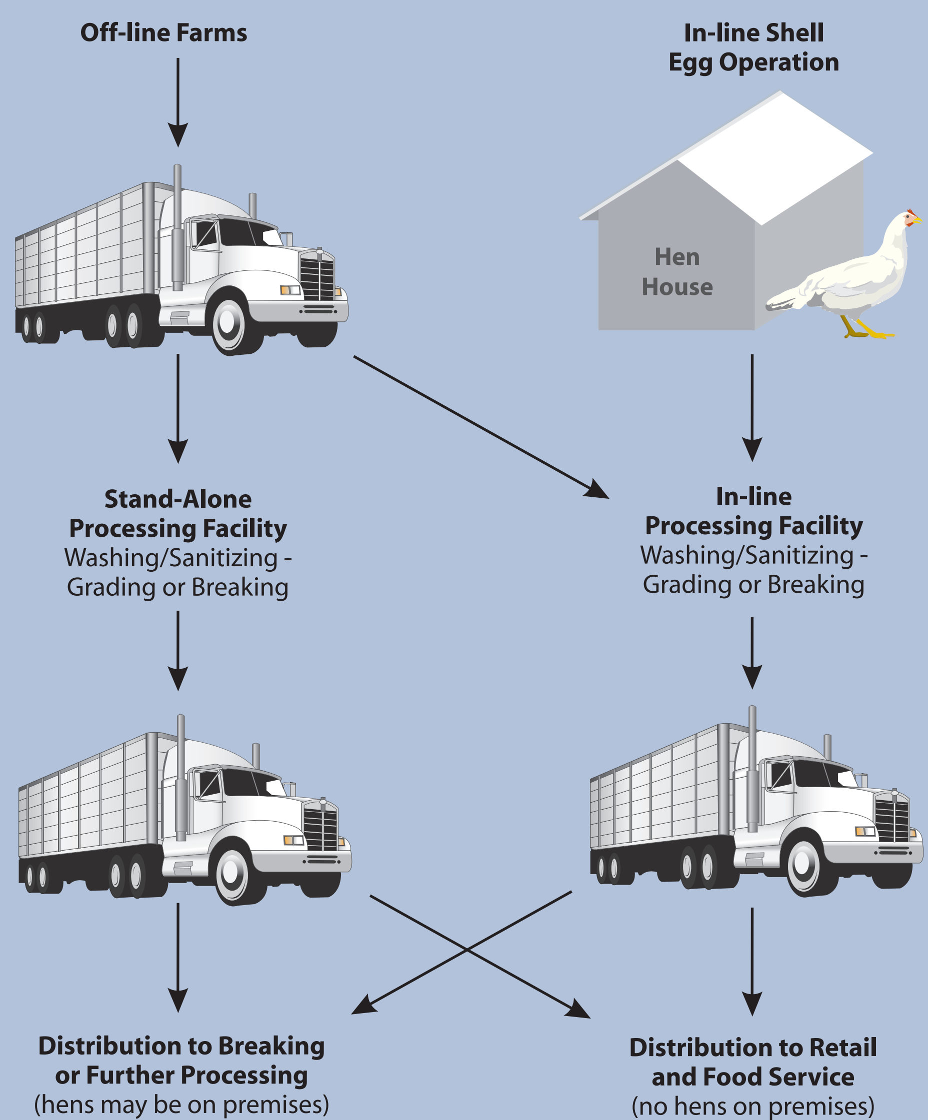
3.5 WHOLE SHELL EGGS PROCESSING AND MOVEMENT

3.5.1 Sources of Whole Shell Eggs

3.5.1.1 In-line Eggs

Highly computerized egg processing equipment accepts eggs entering the egg processing plant on conveyor belts and automatically washes, candles, weighs, and places eggs into cartons containing different sized eggs (small, large, extra-large, or jumbo). The capacity of egg processing equipment influences the number of laying hens on a farm. Egg producers strive to have sufficient numbers of hens to keep the processing equipment operating at full capacity during an 8-hour shift. Some in-line egg operations purchase eggs from off-line farms so that the egg processing equipment can be more fully utilized. Egg processing plants require a dry storage room to hold packing materials, a room for the processing equipment, and a cold storage room to hold eggs after they have been placed in cartons.

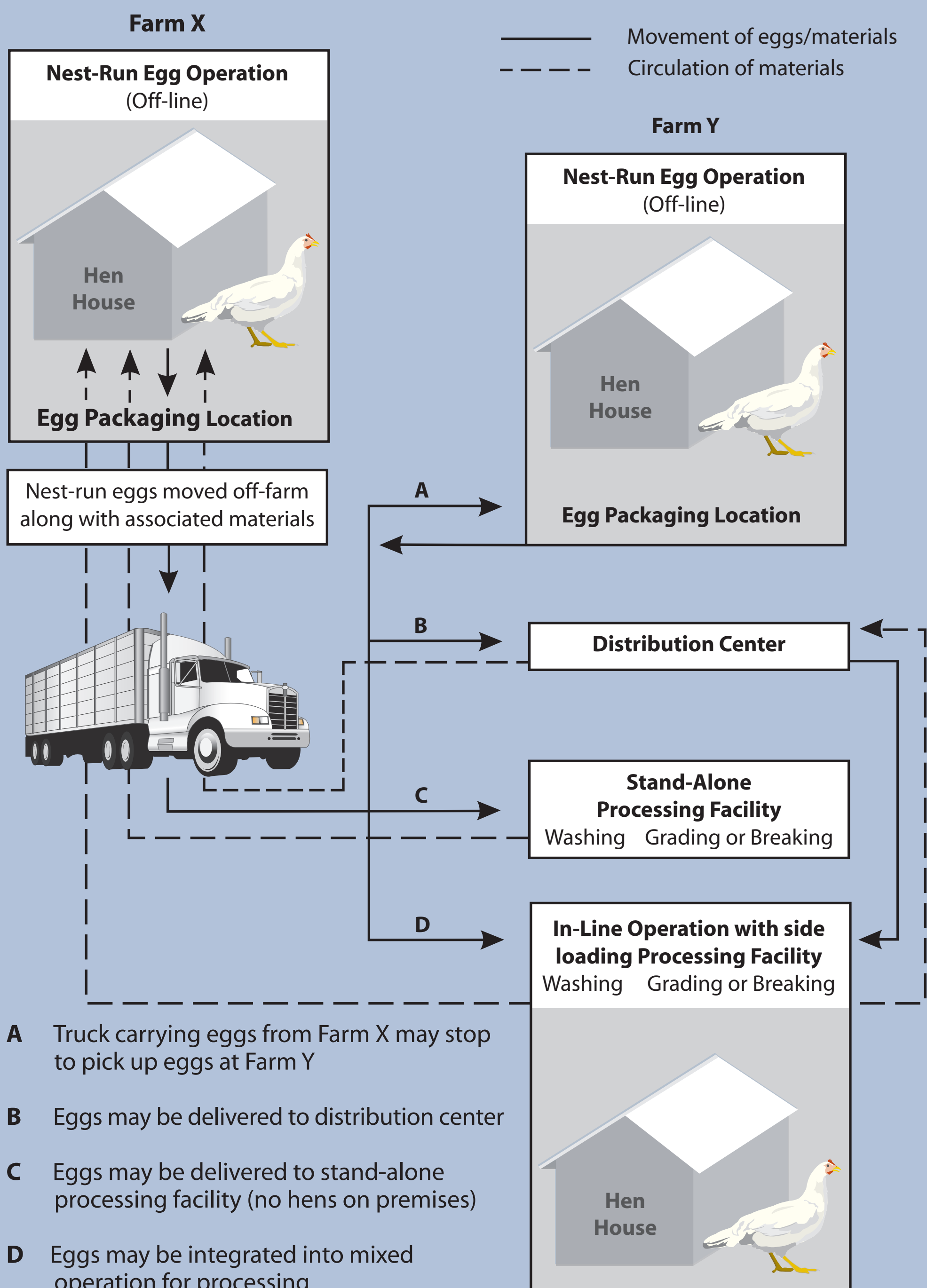
Figure 2. Pathways of Shell Egg Processing and Distribution



3.5.1.2 Off-line (Nest Run) Eggs

At least 20% of eggs are packed off-line. An in-line egg operation may receive eggs from one or more off-line operations and this process is called "side loading." Nest run eggs from off-line farms may be transported to the "transfer room" of an in-line facility. In the transfer room, shell eggs from off-line operations are removed from their bulk packaging (pallets, racks, and flats) and introduced via vacuum lifts to an egg conveyor belt prior to washing. Nest run eggs are merged with eggs from the in-line facility on the egg conveyor belt. Nest-run eggs may be marketed via the "spot market" or as part of contractual agreements made between producers and processors of shell eggs or egg products.

Figure 3. Nest-Run Egg Production and Processing



A Truck carrying eggs from Farm X may stop to pick up eggs at Farm Y

B Eggs may be delivered to distribution center

C Eggs may be delivered to stand-alone processing facility (no hens on premises)

D Eggs may be integrated into mixed operation for processing

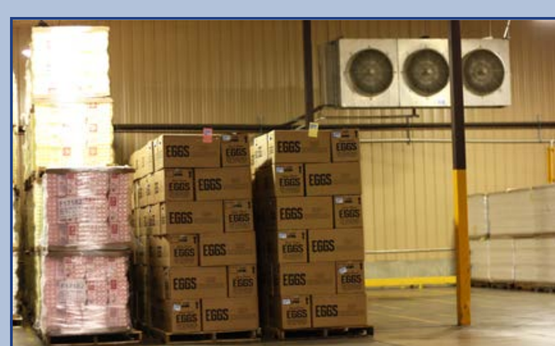
3.5.2 Steps in Whole Shell Egg Processing

Approximately 70% of eggs produced in the United States are sold as whole shell eggs. Shell egg operations include 1) washing; 2) sanitizing external egg surfaces; 3) candling/inspection of shell eggs; 4) weighing, grading and packaging shell eggs; and 5) storage and transport to market. Egg washer conveyors move eggs into the egg washing machine where they are washed with detergents. Contamination of internal contents is minimized during washing by prohibiting immersion of eggs in the wash water and requiring that the temperature of the wash water be maintained at 90°F or higher, and at least 20°F warmer than the temperature of the eggs to be washed. USDA's Agricultural Marketing Service recommends an egg washing temperature of 110°F which improves egg cleaning. Immediately following the detergent wash, shell eggs are sanitized by rinsing with potable water containing an approved sanitizer, such as chlorine or quaternary ammonium compounds. Chlorine rinse water must contain between 100 ppm and 200 ppm chlorine. Sanitizing the external surface of the egg does not remove pathogens that may be present in the albumen or yolk, such as *Salmonella enteritidis*. After the sanitizing rinse and drying, egg processors have the option of coating the surface of shell eggs with a food grade mineral oil to conserve albumen quality. Candling is a process wherein eggs are passed over an intense light that allows internal and external defects to be detected. Eggs with internal defects are identified by workers or by computerized detection equipment and removed for disposal as inedible egg products. Eggs with external defects, such as fecal material on external shell surfaces, are removed from the line for rewashing. Eggs are weighed individually by specialized computer-controlled machines and automatically directed into separate packing lanes based on individual egg weights. Eggs may be placed on cardboard, foam or plastic flats or in cartons containing 12, 18, or 30 eggs. Egg cases can be stored on site in a cold storage room or immediately transported to distributors or customers. Cold storage rooms must be refrigerated and capable of maintaining an ambient temperature no greater that 45°F (7.2°C). Shell egg cooler rooms must be equipped with accurate thermometers to monitor cooler room temperatures and a device to measure relative humidity. Humidifying equipment capable of maintaining sufficient relative humidity to minimize shrinkage should be used. Shell eggs destined for breaking plants may be temporarily held at a warehouse or go directly to an egg breaking facility. U.S. egg producers pack about 140 million cases of eggs each year.


Egg Washing System


Candling of Eggs


Egg Packaging System



Eggs in Cartons and in Boxes

3.6 EGG BREAKING AND LIQUID EGG MOVEMENT

3.6.1 Sources of Breaking Eggs

Egg breaking operations process approximately 30% of eggs produced in the United States. Breaking facilities can be located on the farm where the eggs are produced (in-line and on-site) or at some other off-site location. Egg breaking operations may obtain eggs from company-owned farms or purchase eggs from other egg producers who have surplus eggs. All eggs produced on company-owned farms are sent to breaking and high quality eggs from these farms result in high quality finished products. Eggs purchased from other egg producers have traditionally consisted of undersized, oversized, cracked, dirty, or stained eggs.

3.6.1.1 In-Line Eggs

In-line operations may produce washed, sanitized, and graded shell eggs for retail or food service customers and concurrently send eggs to a breaking plant. Surplus, small, and under-grade eggs may be diverted to a company-owned, on-site breaking facility or transported to a stand-alone regional breaking plant at another location. Eggs are collected from individual barns and carried to on-site breaking plants via a collection of belts and conveyors. Large in-line egg farms with breaking plants may have up to 4 million laying hens on the premises. Some in-line operations have equipment arranged so that shell eggs from other farms can be side loaded and merged with eggs produced on their own farm. In contrast, other in-line facilities break only eggs produced on that farm.

3.6.1.2 Off-line (Nest Run) Eggs

Nest run eggs can be delivered to either an in-line egg operation with a breaking plant or taken to a stand-alone, centrally located egg breaking plant that receives shell eggs for breaking from multiple farms. Nest run eggs are usually held in bulk until they are broken.

3.6.2 Egg Breaking Machines and Products

3.6.2.1 Steps in Egg Breaking

The primary steps associated with egg breaking are 1) washing the shell eggs; 2) sanitizing external shell surfaces; 3) candling/inspecting the shell eggs; 4) breaking the shell and separating the contents; 5) screening and chilling liquid eggs; and 6) storage and transport for further processing.

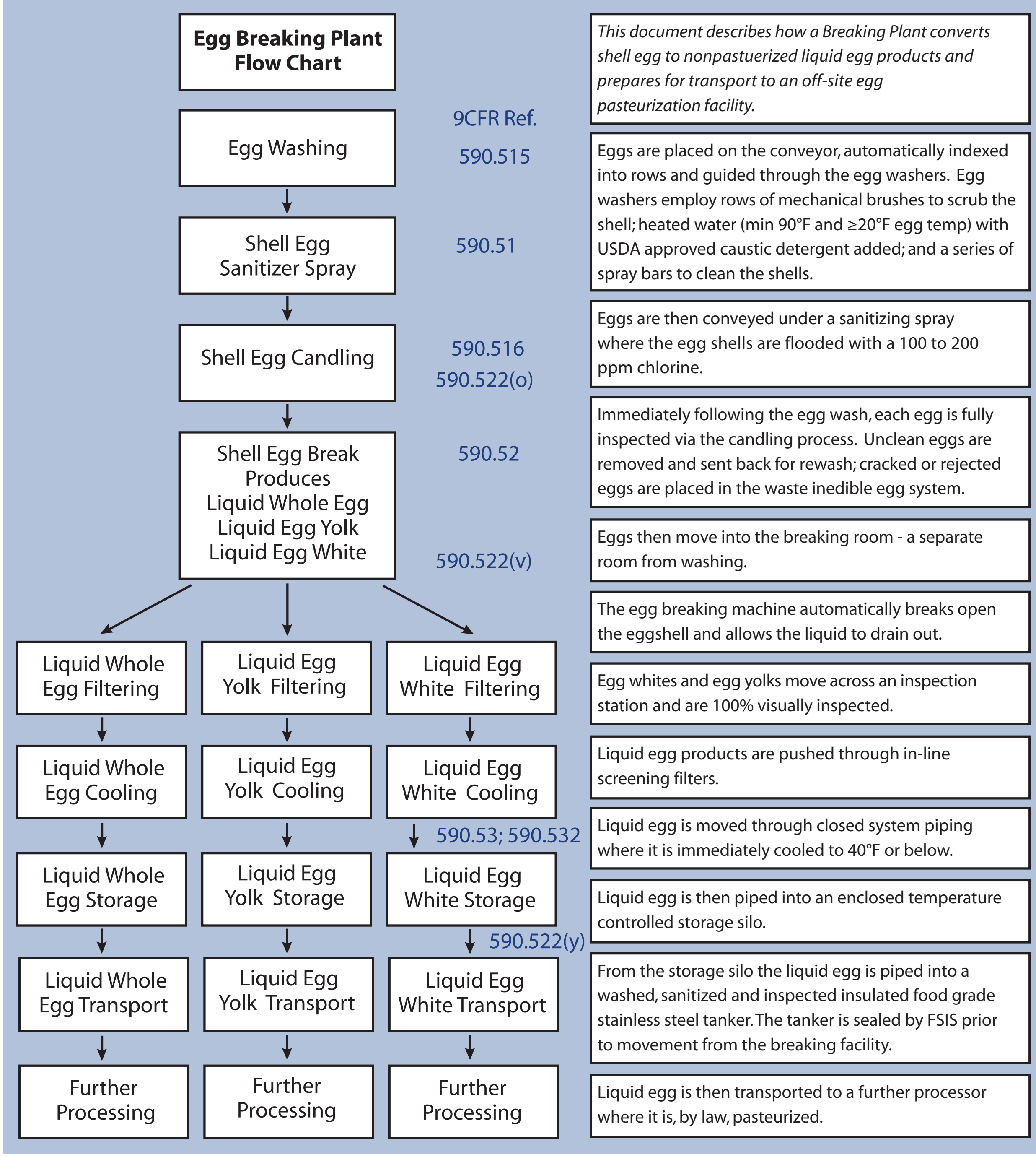
3.6.2.2 Breaking Machines

Breaking machines are located in a separate room from the transfer and washing processes. Breaking machines are mechanical devices designed to open individual shell eggs in a series of operations that allow control and inspection of each individual egg. Individual eggs are picked up by the machine, the shell is broken, and contents of each egg are secured in an individual "cup" for inspection. High speed machines have the capacity to break up to 140,000 eggs per hour.

3.6.2.3 Non-pasteurized Liquid Egg Products

Machines may be set up to produce liquid whole eggs (natural proportions of yolk and white), liquid yolk, and/or liquid egg whites. Production of liquid yolk and liquid white is known as "separation". Liquid egg is collected as separate streams of whole egg, whites, or yolk and pumped through screens that remove shell fragments and break down native structures of the yolk membrane and egg white. The screening process results in homogeneous fluids that are transferred via stainless steel-enclosed pipes through a heat exchanger where the temperature of liquid egg components is reduced to ≤ 40°F prior to accumulation in chilled storage tanks. Non-pasteurized liquid egg (NPLE) is held in chilled and agitated storage tanks until transfer for further processing at the breaking location or at an off-site facility. Approximately 425,000 eggs are required to fill a single 50,000-pound liquid egg tanker truck. Regardless of the plant location, all shell eggs are converted to liquid egg for further processing as depicted in Figure 4.

Figure 4. Egg Breaking Operations.



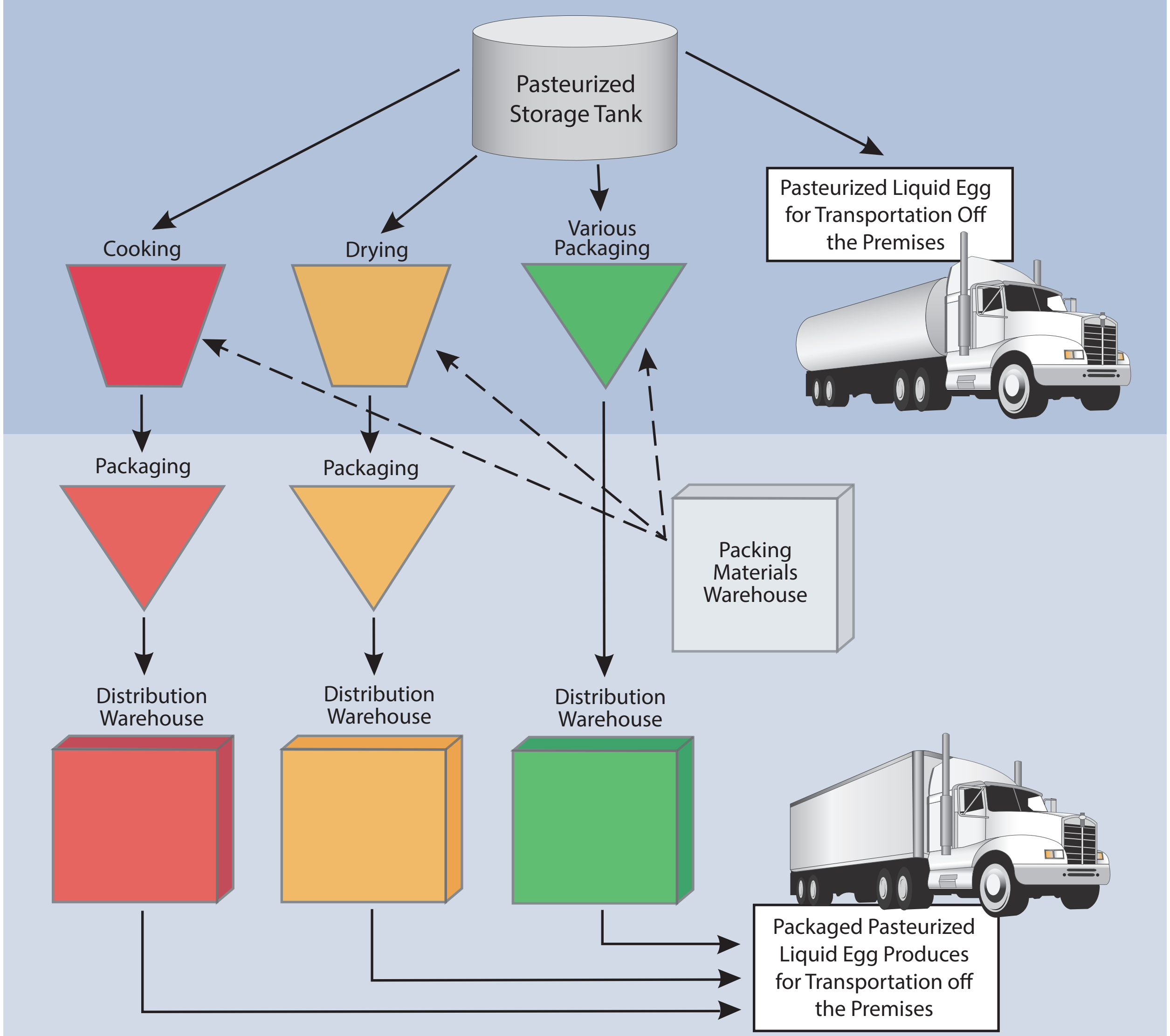
3.6.3 Non-pasteurized Liquid Egg Products Movement

Non-pasteurized liquid egg products are transported under Food Safety and Inspection Service (FSIS) seal in large insulated tanker trucks or in smaller containers such as "totes" or plastic "lined barrels." Transfers to tankers, and/or other containers, are accomplished using sanitary enclosed transfer lines and pumps. FSIS inspectors inspect the condition of the tanker or containers prior to loading NPLE, monitor the transfer of NPLE to transport tankers or containers, provide documentation that will accompany the NPLE in transport, and seal the tanker or transport vehicle. At the receiving destination, FSIS inspectors are required to receive the NPLE, break the seal, and document the condition of the contents when received. Tankers are offloaded via flexible lines that connect the tank truck to pumps and stainless steel receiving lines and storage tanks. Totes are generally emptied by attaching a line with a pump to transfer the liquid contents to enclosed lines. Product in barrels may be emptied via pumps or barrel-dumps, and the NPLE is then handled via enclosed process lines.

3.6.4 Pasteurized Liquid Egg Products Movement

Pasteurization of liquid eggs is required by law and may occur at an in-line or off-line breaking plant. Pasteurized liquid egg may be moved from the pasteurized storage tank at an in-line breaking plant by pumping it directly into large tanker trucks and transported off the premises for further processing at a different location. Alternatively, pasteurized liquid eggs at a stand-alone centrally located egg breaking plant can be moved through internal pipes for further on-premises processing such as cooking, drying, and packaging. Pasteurized liquid egg products from stand-alone plants are moved to appropriate distribution warehouses to be transported to customers at a later time. The journey of liquid egg product after pasteurization until it is put on conveyance trucks to be transported off the premises is shown in Figure 5.

Figure 5. Liquid Egg Handling



3.7 MOVEMENT OF OTHER PRODUCTS

3.7.1 Manure

During egg production, the amount of manure produced each day is approximately equal to the quantity of feed consumed. Manure from laying hens may contain more than 70% moisture. High-rise and manure belt chicken houses use manure-drying systems to reduce the volume and weight of manure and to minimize odors caused by ammonia production. High-rise chicken houses provide space for manure storage on the lower level, beneath the cages. Droppings fall through the wire mesh floors of cages on the upper level into a manure storage area on the lower level. Drying occurs as air moves over manure cones that form beneath each row of cages. Manure is typically removed from the lower level during warm months of the year when the ground is not frozen. In manure-belt houses, droppings fall through the wire mesh floors onto a manure conveyor belt. In these houses, manure is removed on a regular basis (daily, twice weekly, or weekly) and stored in a separate building where drying and composting occurs. Manure is a valuable source of organic matter, nitrogen, and phosphorus for plants and is used as a fertilizer for crops. Manure disposal usually occurs by spreading on crop land or grassland.


Manure Pit


Manure Storage on a Laying Farm

3.7.2 Egg Shells

Shells are a by-product of normal egg grading and processing activities. Eggs with leaking shells, dirty eggs, or eggs accidentally broken and recovered from equipment, floors, or other surfaces during processing are separated into shells and inedible liquid egg product. The mixture of eggs, egg contents, and shells is pumped through a centrifuge where shells are removed from liquid egg contents. The centrifugation process physically reduces shells to small pieces of shell and shell membranes. Shells from egg breaking machines are continuously conveyed to a centrifuge. Wet centrifuged shells may be collected in trucks or bins for transport to off-site drying, to a landfill, to land application, or they may be continuously conveyed to an on-site dryer.

Shell drying is usually conducted using horizontal drum dryers. Centrifuged shells are conveyed into the drum dryer where they are mixed with air heated to temperatures in the range of 1,000 to 1,500°F. The body of the dryer rotates around its long axis imparting a tumbling action to the shells so that there is constant mixing of shells with hot air. During this process, water is evaporated such that the moisture content of the dried shells/membranes is reduced to less than 8%. The exit temperature of the shells and exhaust air is in the range of 210 to 220°F. Dried shells are an excellent source of calcium and phosphorus in proportions required by laying hens and are frequently included in laying hen rations. Also, dried shells may be transported to off-site locations for land applications or other industrial uses.

3.7.3 Inedible Liquid Egg

Inedible liquid egg is a by-product of normal egg grading and processing activities and may include eggs whose shelf life has expired or processed eggs that do not meet specifications. A mixture of eggs and shells may be collected in barrels and held under refrigeration for transport to a dedicated processing facility or the mixture may be pumped through a centrifuge where the shells are removed from the liquid egg (see 7.2 above). Inedible liquid egg has the composition and physical characteristics of whole liquid egg and generally is partially diluted with water used to clear the lines. It may also contain non-egg ingredients such as salt, sugar, gums, starch, and non-fat dried milk that are normal ingredients in egg product formulations. Liquid inedible egg is generally chilled and held at temperatures below 45°F until transported to drying facilities or processed. Inedible liquid egg is by definition not suitable for human consumption, but may be suitable for animal food. Egg products inspection regulations require all inedible egg to be denatured (typically by adding a food grade dye) to prevent accidental use for human food. See 9 CFR 590.45 or 7 CFR 57.45.

3.8 REGULATION OF SHELL EGG AND EGG BREAKING OPERATIONS

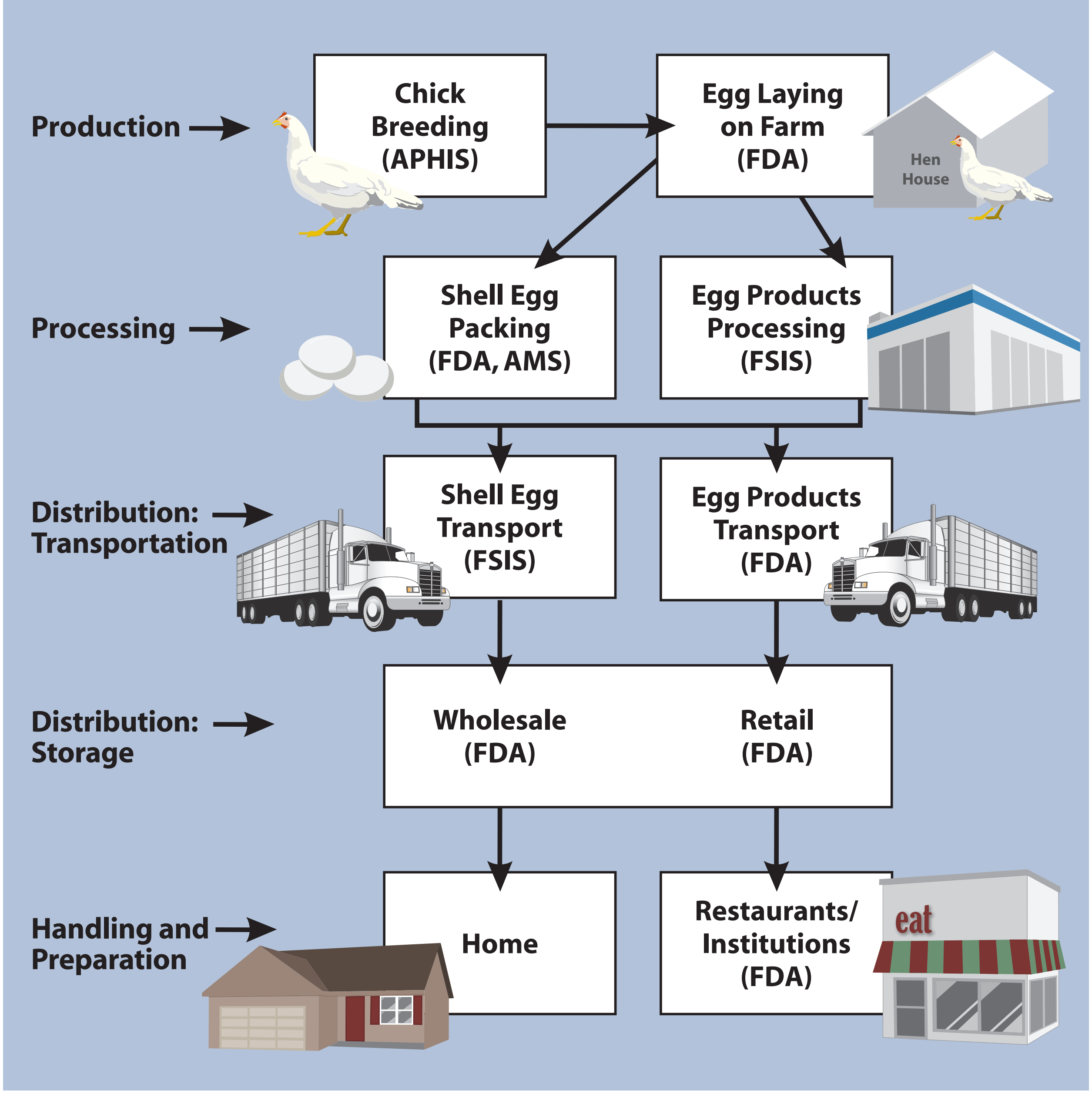
3.8.1 Egg Farms and Laying Hens

Federal regulations concerning laying hens and eggs are written to ensure food safety by preventing contamination of food with particular pathogens, such as *Salmonella* spp. Regulation of chickens producing eggs for human consumption is the responsibility of the Food and Drug Administration (FDA). On July 9, 2009, FDA published in the Federal Register a final rule entitled "Prevention of *Salmonella Enteritidis* in Shell Eggs During Production, Transportation, and Storage." The regulation became effective on July 9, 2010 for producers with 50,000 or more laying hens and will become effective on July 9, 2012 for producers with 3,000 or more laying hens. The Egg Safety Rule is intended to reduce *Salmonella enteritidis* (SE) and requires a) monitoring of pullets, b) minimum biosecurity standards, c) rodent and insect control, d) cleaning and disinfection of poultry houses, e) refrigeration of eggs on the farm (45°F or less), f) environmental monitoring, and g) record keeping.

3.8.2 Shell Eggs

Regulation of shell eggs is shared among various Federal agencies and State governments, or shell eggs may be processed according to industry-generated protocols. Federal authority to regulate egg safety is shared by the Department of Health and Human Services' (HHS') Food and Drug Administration (FDA) and the United States Department of Agriculture's (USDA's) Food Safety Inspection Service (FSIS). In addition, USDA's Animal and Plant Health Inspection Service (APHIS) supervises the National Poultry Improvement Plan which certifies poultry breeding stock and hatcheries as SE-free and USDA's Agricultural Marketing Service (AMS) conducts a surveillance program to ensure proper disposition of restricted shell eggs (Figure 6).

Figure 6. Egg Safety from Production to Consumption



FDA has jurisdiction over the safety of foods generally, including shell eggs, under the Federal Food, Drug, and Cosmetic Act (FFDCA; 21 U.S.C. 301 et seq.). Under the Public Health Service Act (PHSA; 42 U.S.C. 201 et seq.), FDA also has the authority to prevent the spread of communicable diseases, including the authority to regulate foods when the foods may act as a vector of disease, as in the case of SE in eggs. FDA is responsible for: (1) investigating SE outbreaks, reported by CDC and State/local health departments, due to foods in interstate commerce, (2) performing trace backs to identify the source of the implicated eggs, (3) testing flocks, (4) diverting eggs from SE-positive flocks, (5) collecting flock data to help track the spread of SE among layer flocks, and (6) promoting better quality control.

USDA has primary responsibility for implementing the Egg Products Inspection Act (EPIA; 21 U.S.C. 1031 et seq.). Under EPIA, FSIS has primary responsibility for the inspection of processed egg products to prevent the distribution of adulterated or misbranded egg products. The AMS offers a voluntary shell egg grading program (7CFR56) which includes minimum facility sanitation and construction requirements as well as daily oversight of egg wash and rinse water temperatures, sanitizer strength, and cold storage temperatures. Also, AMS oversees a shell egg surveillance program that places limitations on restricted eggs, such as eggs that are cracked, dirty, contain blood, leak fluid, or are inedible (7CFR57). The shell egg surveillance program prevents the movement or sale of adulterated or misbranded eggs for human food. Eggs in cartons bearing the USDA shield have been graded and checked for weight and the carton must include a code which identifies the packing plant and day of packing. Shell egg operations that do not fall under 9CFR590 and choose not to participate in the voluntary AMS shell egg grading program typically adhere to state regulations or follow industry-generated protocols. State regulations vary, and many states rely on industry protocols rather than regulating shell operations at the state level.

3.8.3 Breaking Plants and Egg Products

FSIS is responsible for inspection of egg breaking plants and the inspection of liquid, frozen, and dried egg products used by food manufacturers, food service, institutions, and retail markets. FSIS mandates specific washing and sanitization conditions for eggs prior to breaking (9CFR590) and all plants breaking eggs under 9CFR590.24 are required to have continuous inspection by an FSIS inspector. Inspectors must be onsite whenever breaking equipment is operating unless specifically exempted. FSIS requires a label that indicates refrigeration of egg products is needed.

Egg products may be shipped between official plants as either unpasteurized (raw) or pasteurized egg products in bulk tankers. When bulk shipments of liquid egg products are handled in this manner they are required by regulation [9 CFR 590.410 (b)] to be shipped under USDA seal (cannot be a company seal) and be accompanied with a FSIS PY-200, Egg Products Inspection and Grading Certificate. The USDA commodity specification for the egg product requires a tamper evident seal to be applied to tanker shipments. Seals applied to such shipments are normally embossed with an alpha-numeric code. Alpha-numeric codes on seals and proper sealing of tankers are verified by an FSIS inspector prior to shipment. Individual seal codes are documented on USDA certificates accompanying shipments.

Bulk Tanker shipments of pasteurized liquid egg products to non-official outlets (further processors or manufacturers that are not official FSIS plants) are not required to be shipped under USDA seal and certificate. FSIS highly recommends for biosecurity purposes and to maintain the integrity of these shipments that the shipping plant seal/ secure the shipment to maintain product integrity and protect the product against tampering.

PART II: RESPONSE TO A HIGHLY CONTAGIOUS FOREIGN ANIMAL DISEASE

3.9 BIOSECURITY MEASURES

3.9.1 Biosecurity Concepts

Biosecurity encompasses procedures that reduce the probability of disease outbreaks and includes two components: bioexclusion prior to an outbreak (keeping pathogens out) and biocontainment after an outbreak (keeping pathogens from leaving an infected premises to prevent disease transmission). Components of a comprehensive biosecurity plan include conceptual biosecurity, structural biosecurity, and operational biosecurity. Conceptual biosecurity refers to selecting the location of an operation to provide isolation of the premises. Poultry farms should be geographically separated from other poultry units. Relationship of the farm site to lakes, ponds, rivers, public roads, hatcheries, and feed mills needs to be considered. Disease agents may be blown or carried by various vectors and fomites to adjacent premises. Structural biosecurity requires that buildings in a complex be separated into quarantinable units by erecting fences and building roads in appropriate places. Decontamination equipment, showers, and change rooms should be installed for employees. Houses, food storage areas, and water tanks should be constructed to exclude free-flying wild birds, rats, and mice. Operational biosecurity consists of management decisions and routine procedures intended to prevent introduction of infectious disease agents.

3.9.2 Farm Outside Areas

Footwear disinfection stations, site-provided footwear, or site-provided foot covers should be available outside all external entrances. External entrances to chicken houses and the processing plant should be kept locked during non-business hours. Secure entry gates should require visitors to obtain permission before entering the premises.

3.9.3 People

Keep out unnecessary visitors and equipment and allow only essential personnel on the farm. A visitors logbook should record the a) visitor's name, b) company, c) time of entry, d) statement confirming no contact with premises containing birds or rendering activities during the preceding 48 hours, e) time of leaving, and f) a contact telephone number. Employees should receive biosecurity training and should not own or come into contact with other birds – including pet birds, domestic chickens, fighting chickens, ducks, geese, waterfowl, exotic birds, quail, partridge, or pheasants. Employees should not hunt waterfowl or upland gamebirds. Workers should wear clean, laundered, or new disposable coveralls and boots. Separate outer clothing should be assigned to individual houses. Hands should be washed and disinfected on entry and exit from houses. If drivers are required to make multiple stops at more than one individual farm in any given day, they should be prohibited from entering chicken houses or egg processing areas. Visitors must not enter chicken houses unless absolutely necessary.

3.9.4 Chickens

Records of daily feed consumption, water consumption, egg production, and mortality should be available for each flock since placement in the chicken house. In commercial egg operations, a flock consists of all laying hens within one house.

3.9.5 Pest and Animal Control

Rodents and insects can transmit disease between houses on a premises and between premises. They can also serve as a reservoir of disease whereby an infectious agent survives from one flock to the next. Rodent and insect control programs must be in place to prevent transmission of infectious disease by rats, mice, other rodents, flies, beetles, and other insects. Cats and dogs must not be allowed in chicken houses and egg processing areas. Backyard poultry must be excluded from the premises and control measures to discourage the presence of wild and migratory birds should be in place.

3.9.6 Cleaning and Disinfection of Vehicles, Equipment, and Egg Handling Materials

Clean manure spreaders, tractors, truck tires, and undercarriages with a strong detergent and then apply disinfectant to kill disease-causing micro-organisms that can linger on surfaces. Equipment and tools brought to the farm must be cleaned and disinfected prior to entering the farm. Avoid lending or borrowing equipment to or from producers on other premises – equipment may carry infectious agents. Only clean, sanitized, and disinfected plastic egg flats or new disposable egg flats should be allowed on the premises.

3.9.7 Feed

Feed bins must be secured to prevent contamination by wild birds or rodents. Spilled feed should be cleaned up promptly to prevent attracting wild birds and rodents.

3.9.8 Manure Removal

Manure trucks must never go from one poultry farm to another on the same day. Manure trucks must be washed with detergent and disinfected prior to arrival at the farm.

3.10 PROVIDING ANIMAL CARE

3.10.1 Feed

During a disease response, the on-farm inventory of feed must be promptly ascertained along with the rate at which it will be depleted in order to determine when more feed will be needed. Transportation routes may be disrupted, so plans for alternate feed sources and delivery routes should be made before the situation arises. Depending on the feeding system in place, manual feeding may be required. Records should be maintained including the date, origin, and amount of the feed delivery. Ration formulations must be followed to avoid disruption of egg production. Feeder space should be sufficient to allow all birds to eat at the same time.

3.10.2 Water

Chicks, pullets, and hens should have continuous access to clean drinking water. The manufacturer's guidelines for the number and placement of drinkers should be consulted, but general recommendations for watering space for layers are as follows:

Table 3. General Recommendations for Watering Space for Layers

Age	*Minimum linear trough space/bird*	*Maximum number of birds per cup or nipple*
0-6 weeks	0.6 minutes	20
6-18 weeks	0.8 minutes	15
older than 18 weeks	1.0 minutes	12

Perimeter space needed for round waterers can be determined by multiplying linear trough space by 0.8 inches. Water pressure must be regulated carefully with automatic devices and watering cups. Manufacturer recommendations should be used initially and adjusted if necessary to obtain optimal results. Automatic watering devices may require frequent inspection to avoid malfunctions. Inspectors should test the drinking systems in at least 4 cages to be sure that they are functioning properly.

3.10.3 Ventilation

Poultry houses should be designed to provide a continuous flow of fresh air for every bird. Ventilation systems usually consist of a series of fans and/or louvered openings. Fans and louvers must both operate properly to allow adequate air flow. Sufficient ventilation to minimize levels of carbon monoxide, ammonia, hydrogen sulfide, and dust is critically important. Ammonia concentration to which chickens are exposed should ideally be less than 10 ppm and should not exceed 25 ppm. In pullet or layer houses that require mechanized ventilation, stand-by generators with alarm systems must be provided and tested regularly. Such systems should be sufficient to supply emergency power for lighting, watering, ventilation, and feeding.

3.10.4 Light

Lights should be provided to allow effective inspection of the feed delivery and water systems and the physical condition of layers in each cage. Inspection of the chickens should be conducted daily. Light intensity should be 0.5 to 1.0 foot candle for all birds at feeding levels during production. Specialized equipment is needed to measure the intensity of light.

3.10.5 Environmental Temperature

Environmental conditions within the house should allow the birds to maintain their normal body temperature without difficulty. Chicks cannot regulate their body temperature, so providing supplemental heat in brooder houses is critical. Enclosed and environmentally controlled layer houses are insulated and body heat from the chickens provides heat for the house.

3.11 PRODUCT HANDLING

3.11.1 Whole Shell Eggs

Prior to processing, confirm that the equipment is clean and ready for operation. Ensure that water levels are correct, wash water is at the target temperature (above 90 °F), chemical supply lines for detergents and sanitizers are connected, concentrations are at supplier recommendations, and the fresh water supply line is open. Sign the operation log, noting the date and time, temperature of wash and rinse, detergent concentration, and chlorine concentration in rinse. After completing all pre-operation checks, introduce eggs into the washing system. Maintain the operating log, noting the temperature of wash and rinse waters; detergent, chlorine, or other disinfectant concentrations; and condition of wash water for excessive foaming and egg buildup. Systems where detergent is manually added require more frequent monitoring of detergent or chemical strengths than those featuring automated monitoring of concentration. Chlorine in the rinse must be at or above 100 ppm and less than 200 ppm. Make corrections as required to operate the system in established ranges for temperature and chemical concentrations. Note corrective actions in the operating log. At mid-shift, drain the wash water tank and perform mid-shift cleaning. Repeat pre-operational checks before starting operations. See 7 *Code of Federal Regulations* (CFR) 56.77(f) (1–15) or 9 CFR 590.515 and 516. Additional procedures and documentation may be required when operating or receiving flocks in a Control Area defined by the State Veterinarian's office or APHIS veterinary representative.

3.11.2 Clean-in-Place Requirements for Liquid Egg Tankers, Lines, and Silos

The following procedures are recommended minimum steps for cleaning and disinfection (C&D) of plastic, washable, egg-handling materials. Minimal requirements are given to clean egg tankers, lines, and silos in relation to time, temperature, concentration, and flow. Procedures require appropriate system design to wet all surfaces. Prepare the clean-in-place (CIP) system as defined for the plant. Execute the CIP, meeting the minimal time, temperature, concentration, and flow requirements outlined in the tables below.

Table 4. Clean-in-Place Requirements for Liquid Egg Tankers

Process	*Time*	*Temperature*	*Concentration*	*Flow*
Pre-rinse	5.0 minutes	Ambient	———	———
Caustic wash	7.0 minutes	150˚F	1.5-2.5%	70 gal/min
Rinse*	3.0 minutes	Ambient	———	———
Sanitizer	2.0 minutes	Ambient	1500-2500 ppm	———

Table 5. Clean-in-Place Requirements for Liquid Egg Lines

Process	*Time*	*Temperature*	*Concentration*	*Flow*
Pre-rinse	5.0 minutes	Ambient	———	———
Caustic wash	10.0 minutes	150˚F	1.5-2.5%	≥ 5ft/sec
Rinse*	5.0 minutes	Ambient	———	———
Sanitizer	2.0 minutes	Ambient	1500-2500 ppm	———

* Apply an acid rinse as needed to remove mineral build-up (minimum 5,000ppm).

Table 6. Clean-in-Place Requirements for Liquid Egg Silos

Process	*Time*	*Temperature*	*Concentration*	*Flow*
Pre-rinse	5.0 minutes	Ambient	———	———
Caustic wash	15.0 minutes	150˚F	1.5-2.5%	70 gal/min
Rinse*	5.0 minutes	Ambient	———	———
Sanitizer	2.0 minutes	Ambient	1500-2500 ppm	———

* Apply an acid rinse as needed to remove mineral build-up (minimum 5,000ppm).

3.11.3 Liquid Egg Tanker Exterior Wash Procedure

Make sure that all openings on the tanker are closed tightly. Clean the undercarriage and tires with a high-pressure washer and appropriate detergent to remove dirt or ice. Foam the entire exterior of the tanker, undercarriage of the trailer, and tires with a soft, metal-type, general purpose foaming cleaner. Follow the manufacturer recommended procedures for this product. Let foam sit on all areas for 5 to 10 minutes. Rinse with a quaternary ammonium or chlorine sanitizer after foam. Minimum sanitizer concentration for quaternary sanitizer is 200 ppm (or per manufacturer's recommendation). Minimum sanitizer concentration for chlorine is 50 ppm. Check the concentration of the sanitizer on every tanker and record the results on the exterior wash certificate. After all areas are rinsed with sanitizer, complete the exterior wash certificate. Give one copy of the exterior wash certificate to the driver and file the other copy with the tanker unloading paperwork.

3.11.4 Egg Shells

Produce, collect, and handle shells consistent with good manufacturing practices. Clean and maintain all transport vehicles following protocols for C&D of exteriors and interiors (and cab interior if drivers are allowed outside of the cab during loading or unloading of the wet shells). Remove all debris and organic material through physical cleaning and high-pressure washing. Wash with an approved detergent and rinse with potable water. Apply an approved disinfectant, following label instructions. Clean the cab interior with approved disinfectants. Document by filling out the dryer log and provide supporting information as needed.

3.11.5 Inedible Liquid Egg

Produce, collect, and handle inedible liquid egg consistent with good manufacturing practices. Maintain inedible egg at temperatures less than 45 °F until pasteurized and dried or otherwise heat-treated. Clean and maintain all process lines, centrifuges, bins, trucks, and dryers following protocols for CIP of liquid process systems, including the interior and exterior of tankers, hand-cleaning where applicable. Clean and disinfect the interiors of trucks transporting inedible eggs in barrels or similar containers following procedures for cleaning interiors of trucks transporting nest run shell eggs. At the drying facility, pasteurize the inedible liquid egg. For inedible liquid egg with solids less than 25 percent, process with a minimum hold time of 188 seconds at 60 °C (140 °F). Maintain pasteurized inedible egg under refrigeration until dried and packaged. Maintain dried, inedible egg following good manufacturing process. Applications of inedible egg may include a thermal heating or cooking preparation procedure for feeding to animals. Thermal treatments exceeding 70 °C (158 °F) should be acceptable. Document by filling out the pasteurization log and providing supporting information as needed.

3.11.6 Manure

Manure truck drivers must remain in the truck at the pullet or layer farm and remain in the truck cab during manure loading, removal, and vehicle cleaning and disinfection. Individuals involved in manure loading, collection, removal, or vehicle cleaning should wear dedicated clothing and use dedicated equipment. These activities should be recorded in a logbook with the date, time, and the person's name. Individuals spreading manure should wear disposable plastic boots (at a minimum) and leave them outside the vehicle. Before entering a personal vehicle and leaving the farm, individuals involved in manure removal should shower (if possible), change clothes and shoes, and clean the interior of their personal vehicles.

Manure-hauling vehicles should be cleaned and disinfected before arriving at the designated location for the first time. At the farm or site entrance and exit, clean and disinfect the undercarriage and tires using a portable sprayer or similar suitable equipment. Unload the manure at the designated dump point. A designated unloading person should be present at the dump site so the driver can remain in the cab. At the end of the working day, if the truck will not be coming back to the same farm or site, it should be cleaned. Remove all visible organic matter with a pressurized sprayer. Thoroughly clean the inside and outside of the vehicle and spreader or trailer with foam or spray detergent and designated brush. Rinse with water.

3.11.7 Mortalities

Each morning, dead chickens should be removed from the cages and from the houses. The goal of carcass disposal is to facilitate decomposition of carcasses and destruction of any pathologic disease agent present while limiting the spread of disease. One method will not fit all circumstances so several carcass disposal options should be considered. Composting is accomplished by placing carcasses and carbon sources such as litter, straw or wood shavings, in simple uninsulated bins and allowing normal decay processes carried out by bacteria and fungi to occur. Additional disposal methods include incineration, on-site burial, burial in public landfills, and rendering.

3.12 SURVEILLANCE

Within 48 hours of the identification of the index case, a surveillance plan will be implemented to define the extent of the highly contagious FAD outbreak and to detect unknown but Infected Premises and new cases quickly through a combination of observation and laboratory testing. This surveillance plan may include the susceptible wildlife population in the area. Information will also be gathered for a surveillance plan to identify disease-free zones so that this portion of the plan can be implemented within seven days of the identification of the index case. Infected, Contact, Suspect and At-Risk Premises will all be involved in some level of surveillance in an effort to control and contain disease spread or determine freedom from disease. Initial surveillance of susceptible animals will be visual inspection. As soon as practical, surveillance will include laboratory testing of susceptible animals. Contact and Suspect Premises should be inspected at least three times per maximum incubation period for the disease under investigation. During the highly contagious FAD event, surveillance could include on-farm observation, testing market animals, and at slaughter.

3.12.1 People

Visitors and employees can introduce or spread disease to susceptible animals if steps are not taken to mitigate these risks prior to entry. Sanitation and hygiene practices are important to prevent disease agent spread and include wearing clean clothing, coveralls, footwear, and washing hands before and after animal contact or glove removal. If the highly contagious FAD is zoonotic, additional personal protective equipment must be worn by all those handling animals. The movement of people on and off the farm during a disease event must be documented to aid exposure assessments. Using a written log to record name, contact information, last contact with a susceptible animal species, and reason for being on farm including facilities entered/animals contacted is crucial. Prior to a disease event, records of this information may not be as readily available on all operations. During an outbreak, personnel on farm should be limited to those essential for the day-to-day operation, making it easier to trace and minimize the risk of disease introduction. For all employees, records should be kept that includes their name, address, phone numbers, emergency contact, and information pertaining to off-site animal contact. In the event of a zoonotic highly contagious FAD, public health officials may recommend human surveillance via diagnostic testing. Contacting employees will be critical. Higher risk personnel on a poultry operation are those individuals that visit multiple premises within a given day and have contact with other poultry or their housing areas. This includes employees having off-farm avian contact, veterinarians, and service providers such as individuals hired to beak trim, vaccinate, or move chickens, equipment repair personnel, rendering trucks, feed delivery persons, and sales persons. Strict adherence to biosecurity protocols should be required for farm entry and avian contact during an highly contagious FAD event.

3.12.2 Vehicle Traffic

Vehicles and equipment can indirectly expose susceptible birds through mechanical disease transmission. Installing a barrier that requires vehicles to stop before entering the premises provides an additional control point and can facilitate monitoring and recording vehicle details. Cleaning and disinfecting tires, wheel wells, and the undercarriage of all vehicles which enter or leave a farm will likely be required on all Infected or Monitored Premises. It may be prudent to park vehicles that are not required on farm off-site. People and vehicle traffic on and off an operation during a disease outbreak should be documented. A written or electronic record describing the vehicle, driver name and contact information, last farm(s) visited, and reason for visit should be maintained for tracking purposes. This could be challenging for operations without personnel living on-site.

3.12.3 Disease Monitoring

During an outbreak situation, susceptible animals on all operations must be closely monitored for clinical signs of the highly contagious FAD that meet the case definition. Poultry caretakers, especially on Contact, Suspect, or At-Risk Premises should be aware of the clinical signs and who to contact if disease is suspected. Accurate and rapid public awareness campaigns will be used to disseminate disease recognition and reporting information to animal producers and caretakers within the Control Area and Surveillance Zone. Poultry operations within the Buffer Zone will be routinely monitored utilizing slaughter surveillance, serological surveys, and investigation of reports of suspect disease. Slaughter surveillance will also occur in the Surveillance Zone. Free Area surveillance will occur through normal surveillance channels. Surveillance results and approved biosecurity protocols as a “proof of negative” status may be required for permitted movements of susceptible birds within the Control Area.

3.12.4 Sample Collections

Premises with the highest risk of infection will have birds sampled for disease testing. Handling tissues and fluids from these operations requires strict adherence to biosecurity and infection control procedures. Poultry at harvest facilities may also have samples collected. Unless otherwise specified, samples will be collected by trained animal health personnel (veterinarians, animal health technicians – private or government). Depending on the disease, specific tissues and/or fluids will be obtained on farm after performing a full post-mortem exam (whenever possible). Guidelines will be provided regarding the specific type of tissues needed, fresh or fixed, fluids (serum, whole blood), and details related to how to label and package them appropriately. See *VS Guidance 12001.1 Policy for the Investigation of Potential Foreign Animal Disease/Emerging Disease Incidents (FAD/EDI)* for more information. Personal protective equipment (PPE) such as coveralls and gloves must be worn by personnel handling the birds, tissues, and fluids. If the disease is zoonotic, enhanced PPE should include goggles and an appropriate respirator (N-95 or N-99) or a full face shield if aerosolization is not a route of human exposure. All equipment used on farm to collect and transport samples and protect the personnel should be properly cleaned and disinfected in the designated area prior to leaving the farm. Care should be taken not to contaminate diagnostic samples with disinfectant as the highly contagious FAD will be inactivated providing false negative results. See the *FAD PReP/NAHEMS Guidelines and SOP: Personal Protective Equipment (2011), Biosecurity (2011)*, and *Cleaning and Disinfection (2011)* for more information.

3.12.5 Sample Submission

Early in the disease outbreak there may be a single laboratory or a select group of laboratories that can perform the diagnostic testing. Guidance will be provided regarding sample submissions to laboratories. This may change as the outbreak continues and other laboratories are able to perform the specific tests. Contact personnel at the receiving laboratory will provide specifics related to sample submission. There are some fundamental principles that must be adhered to in the event of a highly contagious FAD investigation to ensure accurate, rapid results. Once samples are obtained, proper labeling is PARAMOUNT to ensure results are correctly reported. Submit samples with the appropriate paperwork (hard copy or electronic). This may consist of forms provided by the laboratory or animal health authority. The premises must be properly identified on all paperwork and sample packaging using a premises identification number, if available. Again, proper completion of the paperwork is essential so that the results are accurately reported to the submitting veterinarian or animal health authority. In some cases, samples could be submitted to demonstrate absence of the disease for permitted poultry movement and accurate, timely result reporting is essential. Samples obtained in the field should be properly packaged to prevent leakage (individually sealed plastic bags around each fluid tube) and thus contamination of samples within or external to the box/cooler. Completed paperwork should also be placed in a sealed plastic bag. Cold packs are recommended instead of ice for transporting samples. Be aware of environmental temperatures and provide enough cold packs to keep tissues from degrading in transport.

3.13 Appraisal and Compensation

Animal health regulatory officials will create an inventory of poultry designated for depopulation and appraise their fair-market value in order for compensation to be paid. Contaminated materials on farm (feed, bedding) will also be appraised as they may need to be disposed of in an effort to control disease spread. Facilities and equipment that cannot be properly disinfected must also be destroyed and fair market value assessed.

3.14 Mass Depopulation and Euthansia (FADS PREP/NAHEMS Guidelines and SOP)

To control disease spread, infected and exposed poultry may be depopulated by qualified personnel according to USDA-APHIS and AVMA guidelines. The method and procedures used for depopulation will depend on available resources and the population dynamics of susceptible poultry on the premises. This requires location-specific planning and preparation which is addressed in the *FAD PReP/NAHEMS Guidelines and SOP: Mass Depopulation and Euthanasia (2011).*

3.15 Disposal (FAD PREP/NAHEMS Guidelines and SOP)

Poultry carcasses and associated contaminated materials (e.g., feed, bedding) must be disposed of in a way to limit disease spread, using State or municipality approved methods. Once euthanasia is complete, specific personnel will be assigned to an operation to carry out these activities. For additional information, see *FAD PReP/NAHEMS Guidelines and SOP: Disposal (2012)*.

3.16 Cleaning and Disinfection (FAD PREP/NAHEMS Guidelines and SOP)

Facilities that housed infected poultry and equipment used in their daily care must be cleaned and disinfected to prevent the spread of disease to live poultry returned to the operation. Coordination of equipment, supplies, scheduling, and certifying work completed by the producer, contractors, or animal health response teams will be carried out by USDA-APHIS-VS. Items that cannot be adequately cleaned and disinfected will be properly disposed of once their value is determined. For additional information, see *FAD PReP/NAHEMS Guidelines and SOP: Cleaning and Disinfection (2011)*.

3.17 Wildlife Management and Vector Control

Wildlife susceptible to the highly contagious FAD can complicate disease eradication or control efforts. A coordinated effort between local, State, Tribal and federal agencies including the U.S. Fish and Wildlife Service, the Department of the Interior and State wildlife agencies is necessary to accomplish control without jeopardizing environmental ecosystems. Producers' knowledge of area wildlife and potential exposure will be vital in this assessment and management process.

3.18 International Trade

The intent of compartmentalization is to separate populations of poultry on the basis of management systems, which would allow veterinary authorities to demonstrate and maintain disease freedom in certain commercial establishments. This concept could be important for both domestic and international movement of poultry and poultry products, and thus the poultry economy. These markets are vital to the poultry industry. In the event of a highly contagious FAD outbreak affecting poultry, international trade of poultry and poultry products will be halted. Compartmentalization is a relatively new concept and has not been fully implemented anywhere. The success of compartmentalization will ultimately be the result of bilateral agreements between the importing country and the exporting country; and our individual international trading partners will need to agree to recognize compartmentalization for a specific highly contagious FAD at their discretion. Compartmentalization in the face of an outbreak where resources are directed to immediate eradication and control measures would likely result in the diversion of limited resources of the official veterinary infrastructure and prolong the duration of quarantine measures. Zoning for most highly contagious FAD is a better utilization of resources and the benefit of progress toward eradication is shared by all within the disease free zone rather than only the owners of the compartment. Although zoning remains the preferred approach, compartmentalization could help the U.S. facilitate disease control and the interstate movement of animals and animal products in the event of a highly contagious FAD outbreak and help to maintain domestic markets. In this case, using the concept of 'free' flock status to regain domestic commercial movements should be considered first. Compartmentalization parameters must be established and agreed upon with trade partners prior to the disease outbreak, internationally and between states. Successful compartmentalization is going to depend on producers, industry, and State and Federal animal health authorities developing and strengthening relationships and agreeing on procedures preceding a highly contagious FAD outbreak.

Acknowledgements

Information for the Egg Industry chapter of the Poultry Industry Manual was obtained from the following sources:

- An Assessment of the Risk Associated with the Movement of Washed and Sanitized Shell Eggs Into, Within, and Outside of a Control Area during a Highly Pathogenic Avian Influenza Outbreak. May 18, 2009 draft. (Collaboration between the Egg Sector Working Group, the University of Minnesota's Center for Animal Health and Food Safety, and USDA:APHIS:VS:CEAH)
- An Assessment of the Risk Associated with the Movement of Nest run Eggs Into, Within, and Outside of a Control Area during a Highly Pathogenic Avian Influenza Outbreak. January 12, 2009 draft. (Collaboration between the Egg Sector Working Group, the University of Minnesota's Center for Animal Health and Food Safety, and USDA:APHIS:VS:CEAH)
- An Assessment of the Risk Associated with the Movement of Pasteurized Liquid Egg and Its Products Into, Within, and Outside of a Control Area during a Highly Pathogenic Avian Influenza Outbreak. June 11, 2008 draft. (Collaboration between the Egg Sector Working Group, the University of Minnesota's Center for Animal Health and Food Safety, and USDA:APHIS:VS:CEAH)
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This FAD PReP Industry Manual was produced in collaboration with USDA-APHIS-VS National Center for Animal Health and Emergency Management by the Center for Food Security and Public Health, Iowa State University of Science and Technology, College of Veterinary Medicine through a cooperative agreement.

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Acknowledgements

- Danelle Bickett-Weddle, DVM, MPH, PhD, DACVPM
  Iowa State University
- Dr. Kenton Kreager
  Hy-Line International
- Dr. Eva Wallner-Pendleton
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Page 102 *(Top)* Figure 1. Illustration of an egg laying house. *Content provided by:Center for Food Security and Public Health, Iowa State University; Graphic illustration by:Dani Ausen, Iowa State University*
(Bottom) Outside feeding bin (top left). Outside fans on the chicken houses (top right). Aisle between rows of chickens (bottom left). Empty cartons (bottom right). *Photo Source: Andrew Kingsbury, Iowa State University (all)*

Page 104 Watercup nipple (left). Feed auger at a laying site (right). *Photo Source: Andrew Kingsbury, Iowa State University (both)*

Page 105 *(Top)* Eggs moving on a conveyer belt under the feeder system. *Photo Source: Andrew Kingsbury, Iowa State University*
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Page 109 Egg washing system (top left). Candling of eggs (top right). Egg packaging system (bottom left). Eggs in cartons and in boxes (bottom right). *Photo Source: Andrew Kingsbury, Iowa State University (all)*

Page 111 Figure 4. Egg Breaking Operations. *Content provided by: Morgan Hennesy and Janel Funk, CEAH risk assessment document for Nonpasteurized Liquid Eggs; Graphic illustration by: Katlyn Harvey, Iowa State University*

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(Center) Table 5. Clean-In-Place Requirements for Liquid Egg Lines. *Content provided by: University of Minnesota Center for Animal Health and Food Safety; Graphic illustration by: Katlyn Harvey, Iowa State University*
(Bottom) Table 6. Clean-In-Place Requirements for Liquid Egg Silos. *Content provided by: University of Minnesota Center for Animal Health and Food Safety; Graphic illustration by: Katlyn Harvey, Iowa State University*

Acronyms

APHIS	Animal and Plant Health Inspection System
AMS	Agricultural Marketing Service
C&D	Cleaning and Disinfection
CFR	Code of Federal Regulations
CIP	Clean-In-Place
EDI	Emerging Disease Incident
FAD	Foreign Animal Disease
FAD PReP	Foreign Animal Disease Preparedness and Response Plan
FDA	U. S. Food and Drug Administration
FSIS	U. S. Food Safety Inspection Service
ISU	Iowa State University of Science and Technology
NAHEMS	National Animal Health Emergency Management System
NPLE	Non-pasteurized Liquid Eggs
PPE	Personal Protective Equipment
PReP	Preparedness and Response Plan
SE	*Salmonella enteritidis*
USDA	United States Department of Agriculture
VS	Veterinary Services, a division of APHIS

Glossary

All-In-All-Out
Completely filling a room, building or site with chickens and then completely emptying it to allow for cleaning and disinfection before the next group of chickens arrives.

Ambient temperature
The air temperature maintained in an egg storage facility or a transport vehicle.

Appraisal
The assignment of a value for a specific animal, arrived at by looking at the animal and considering all of its attributes and the current value of similar animals.

At-Risk Premises
Premises that have susceptible animals but none of those susceptible animals have clinical signs compatible with the FAD. Premises objectively demonstrate that they are not Infected Premises, Contact Premises, or Suspect Premises.

Battery Cages
"Battery" refers to a collection of cages.

Biosecurity
Biosecurity encompasses procedures that reduce the probability of disease outbreaks and includes two components: bioexclusion prior to an outbreak (keeping pathogens out) and biocontainment after an outbreak (keeping pathogens from leaving an infected premises to prevent disease transmission.

Cage Free
Chickens in cage-free systems are kept indoors but do not reside in cages and have access to communal nest boxes with automated egg collection, perches, and litter.

Cleaning and Disinfection (C&D)
Practices involving a combination of physical and chemical processes that kill or remove pathogenic microorganisms – a combination that is vital for the eradication of disease.

Contact Premises
Premises with susceptible animals that have been exposed directly or indirectly to animals, contaminated animal products, fomites, or people from an Infected Premises.

Detergent
Chemical products used to disperse and remove soil and organic materials from surfaces by reducing surface tension and increasing the penetrating ability of water. This can improve a disinfectant's ability to reach and destroy microbes within or beneath the dirt. Some disinfectants (i.e., quaternary ammonium compounds) have detergent properties.

Disinfectant
A substance used on inanimate surfaces that destroys or eliminates a specific species of infectious or other public health microorganism, but not necessarily bacterial spores, in the inanimate environment. Disinfectants are regulated by the U.S. Environmental Protection Agency (EPA). Disinfection can also be achieved by physical means (e.g., heat, light).

Egg Breaking
Egg breaking consists of breaking the shell and separating the liquid egg contents (albumen and yolk) from the shells.

Exposed
Contact with birds, equipment, personnel, supplies, or any article infected with, or contaminated by, communicable poultry disease organisms.

Glossary

Exposed Premises
Premises that have been determined to be related by sound epidemiological evidence to a known infected premises, also referred to as contact premises.

Flock
All laying hens within one chicken house.

Franchise Hatchery
A hatchery which has been authorized by a franchise breeder to produce and sell products under the breeders strain or trade name.

Free Range
Chickens in free-range systems have at least some time each day when they are given access to an outdoor area

Hatchery
Hatchery equipment on one premises operated or controlled by any person for the production of baby poultry.

Highly Contagious Foreign Animal Disease (FAD)
A disease that spreads rapidly from animal-to-animal as well as flock-to-flock through direct contact, aerosol, oral, fomites, or vector-borne transmission. Highly contagious FADs may be recognized by above normal morbidity or mortality per unit time, where morbidity could be characterized solely by a decrease in production.

In-Line
In-line egg operations are characterized by an automated egg collection system that carries eggs directly from chicken houses to the egg processing plant (building).

Infected Premises
Premises where presumptive positive case or confirmed positive case exists based on laboratory results, compatible clinical signs, case definition, and international standards.

Mortality
Death of an animal; dead animals can be referred to as mortalities.

Multiplier Breeding Flock
A flock that is intended for the production of hatching eggs used for the purpose of producing progeny for commercial egg or meat production or for other non-breeding purposes.

Nest Run Eggs
"Nest run" or "off-line" eggs have been packed as they come from the production facilities without having been washed, sized, and/or candled for quality, with the exception that some checks, dirties, or other obvious under grades may have been removed.

Off-Line Egg Farms
"Nest run" or "off-line" egg farms do not have a processing facility and typically consist of one or two chicken houses which lack processing equipment. Eggs must be shipped to a processing plant at another location.

Personal Protective Equipment (PPE)
Equipment used as a barrier between an individual and a hazard that could result in an injury or occupational illness.

Poultry
Domesticated fowl, including chickens, turkeys, ostriches, emus, ducks, geese, swans, pheasants, grouse, partridges, quail, guinea fowl, and pea fowl, which are bred for the primary purpose of producing eggs or meat.

Glossary

Premises
Includes a tract of land, and all of its buildings, as well as a separate farm or facility that is maintained by a single set of services and personnel.

Primary Breeding Flock
A flock composed of one or more generations that is maintained for the purpose of establishing, continuing, or improving parent lines.

Processing of Whole Shell Eggs
Shell egg processing includes 1) washing; 2) sanitizing external egg surfaces; 3) candling/inspection of shell eggs; 4) weighing, grading and packaging shell eggs; and 5) storage and transport to market.

Pullet
Immature female chickens prior to the onset of egg production.

Quarantine
To place animals in strict isolation to prevent the spread of disease.

Quarantined Area
During an animal health emergency, areas around infected premises may be placed under quarantine. The geographical region around the infected premises is referred to as the Infected Zone and movement restrictions for susceptible species may be implemented.

Relative Humidity
Is a ratio, expressed in percent, of the amount of atmospheric moisture present relative to the amount that would be present if the air were saturated. Since the latter amount is dependent on temperature, relative humidity is a function of both moisture content and temperature.

Sanitize
To treat with a product which is registered by the Environmental Protection Agency as germicidal, fungicidal, pseudomonicidal, or tuberculocidal, in accordance with the specifications for use as shown on the label of each product.

Sanitizer
A substance that reduces the bacterial population in the inanimate environment by significant numbers, but does not destroy or eliminate all bacteria or other microorganisms.

SOP
Standard Operating Procedures that provide specific details related to various topic areas.

Strain
Poultry breeding stock bearing a given name produced by a breeder through at least 5 generations of closed flock breeding.

Suspect Premises
Premises with susceptible animals under investigation for a report of compatible clinical signs for the FAD agent.

Vector
Insects or arachnids capable of transmitting pathogens from an infected birds to another bird, usually through a bite.

Zoonotic Disease/Zoonoses
Diseases transmissible from animals to humans under natural conditions.

Chapter 4: Game Bird Industry

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Chapter 4: Game Bird Industry

PART I: UNITED STATES COMMERCIAL GAME BIRD PRODUCTION

4.1 SCOPE OF THE GAME BIRD INDUSTRY

The term "game bird" describes any species of bird that can be used for hunting, including upland game birds, waterfowl, and woodland birds, such as the American Wood Cock and Mourning Doves. However, only those species which are captive, reared in significant numbers, and raised-for-release will be discussed in this chapter.

The game bird industry, with producers organizing into national and state associations, began as early as the 1940s. However, significant growth in the industry was noted starting in the 1970s and has continued to increase into the present time. The reason for this growth is believed to be due to the rapid decline of native birds, which reduced opportunities for successful harvesting of wild game on rural lands. Decline of the native game bird population is believed to be the result of changing agricultural practices that caused a loss of habitat and cover for native game bird species. Game bird production is used to supplement wild populations while hunting preserves increase opportunities to successfully harvest game birds. Development of hunting preserves was also seen as a good use of existing agricultural land not used during fall and winter months. Game birds could be released onto crop land at the end of the growing season to derive income for the farmer over the winter.

4.1.1 Groups of Birds

Game birds can be divided into two main groups: Upland Game Birds and Waterfowl.

4.1.1.1 Upland Game Birds include birds in the order *Galliformes*, family *Phasianidae*:

Common Pheasant (*Phasianus colchicus*):

- Also known as the ring-neck pheasant (pictured left, top). It is native to Russia, but became widely dispersed throughout Europe and Asia. Pheasants were brought over to North America as early as the 1700s.

Partridges:

- There are three species commonly produced for hunting in the USA including Chukar Partridge (*Alectoris chukar*), Red-legged Partridge (*Alectoris rufa*) and Grey Partridge (*Perdix perdix*), also known as the Hungarian Partridge. Chukar Partridges originated in Eurasia, Israel, Turkey, Afghanistan, India, and Pakistan.

Northern Bobwhite Quail (*Colinus virginianus*):

- These birds are native to the New World, including the USA, Mexico, and the Caribbean.

4.1.1.2 Waterfowl include birds in the order Anseriformes, family Anatidae:

Mallard Duck (*Anas platyrhynchos*):

- Widely dispersed dabbling duck (pictured left, bottom) found throughout North America and Eurasia and introduced almost everywhere else.

4.2 GENERAL PROFILE OF THE COMMERCIAL U.S. GAME BIRD INDUSTRY

The game bird industry consists of two primary sections: production farms and hunting preserves.

4.2.1 Production Farms

Game birds are produced in almost every state in the U.S. However, certain geographic locations tend to produce more of certain species of game birds. Most Bobwhite Quail are grown in Georgia, North Carolina, South Carolina, Alabama, and Mississippi. Top pheasant producing states include Minnesota, Kansas, North Dakota, Pennsylvania, South Dakota, and Wisconsin. Mallard ducks are produced primarily along the United States coastal areas, with large releases found on the mid-Atlantic and southern states.

Game bird production in the United States is estimated to consist of 10.8 million pheasants, 40 million quail, 4 million Chukar partridges, and 1 million mallard ducks.

4.2.1.1 Types of Production

Game bird producers can be divided into full-time commercial businesses, part-time commercial businesses, and hobby operations.

1. Commercial full-time production operations
   - Most of these operations produce 20,000 to 300,000 birds annually, with a few having even more. Large commercial game bird farms are relatively few in number.

2. Hobby or part-time commercial operations
   - Most game bird farms in this category raise anywhere from 100 birds to 15,000 birds each year.

4.2.2 Hunting Preserves

Most game birds are grown for eventual release onto regulated hunting preserves. However, some are released onto public lands, while a few are sold to restaurants, food retail outlets, and live bird markets.

4.2.2.1 Types of Hunting Preserves

Regulated hunting preserves can be classified as either public or private.

1. Public Preserve
   - Approximately 80% of preserves are open to the public. They operate on set hours and anyone can show up and pay for the opportunity to harvest a game bird.

2. Private Preserve
   - An approved membership at the preserve would be required before one would be allowed the opportunity to hunt.

4.3 STRUCTURE OF THE GAME BIRD INDUSTRY

Unlike the commercial poultry industry, very few game bird operations are fully integrated vertically. The game bird industry is comprised of the following four activities: breeding, hatching, production, and operating a hunting preserve. Some businesses participate in all four areas of the industry. However, the majority specialize in only certain areas. It would be likely for a breeder to both hatch and produce birds, but it would be difficult for them to run a hunting preserve as well. Similarly, a hunting preserve could also raise birds, but it would be difficult for them to keep breeders and hatch chicks. A typical commercial game bird farm contains breeders, a hatchery, and a production facility. Some game farms also manage a shooting preserve during the hunting season. These farms may sell hatching eggs, day-old chicks, started birds, or mature birds to customers within a narrow or wide geographical area. In contrast, a typical hobby game bird farm would most likely only buy chicks or started birds to grow out to maturity. Diversification is more likely to exist in commercial operations because game birds are largely seasonal breeders and this helps generate income year round for owners. Breeding season begins in early spring and ends mid to late summer. Some operations have succeeded in lengthening egg production cycles through artificial light stimulation, but year round breeding is rare. Most farms raise more than one species of game bird, but a few produce only one species (all pheasants, all quail, or all mallards for instance). Hence, many game bird farms can be classified as multi-stage, multi-age, and multi-species operations.

4.3.1 Breeders

Only a handful of game bird producers are true primary breeders engaged in genetics. Most breeders select breeding stock from their own production birds based upon phenotypic traits, such as size, health, feather color and iridescence, and behavioral traits considered desirable for hunting. In particular, it is important to maintain the "wild" behaviors of game birds. Over the years, many varieties have been developed, especially in pheasant populations.

4.3.2 Hatcheries

Numerous producers obtain eggs from breeders, raise the birds up to sexual maturity, and then use them to produce hatching eggs for commercial bird production. In addition to breeder pens, these premises may have a hatchery on site as well as buildings and pens to raise the commercial birds. Breeders are seldom kept beyond one egg production cycle. Instead, spent breeders are frequently allowed to recondition and re-feather and then are sold in the fall for hunting.

The following season's breeding stock may be purchased from other breeders or may be selected from a portion of the commercial birds that are held back for this purpose.

4.3.3 Commercial Production

Day-old game bird chicks or ducklings are initially placed into brooder buildings, very similar to brooder houses designed for poultry, with artificial lighting, supplemental heat, feeders, and drinkers. Between 1-2 months of age (depending on the species and weather conditions) most game bird chicks are given access to the outdoors. After sufficient acclimation to the outdoors, most game birds are moved to outside pens until they are "flight ready" and can be sold to hunting preserves or released into the wild.

Outside flight pens are enclosed with netting. Inside most flight pens, dense vegetation provides cover for the birds and helps to reduce aggression within the flock. Lambs quarter, corn, and other crops may be planted based upon what grows best in a geographic area. Except for birds intended for use as breeders during the following season, almost all commercial game birds are sold for hunting. Most game birds are sold in regionalized areas, but some of the larger commercial producers deliver birds throughout the country. If any birds remain after the end of the hunting season, other market outlets are found.

Pheasant Chicks Ready for Transport

Flight Pen Vegetation

4.3.4 Hunting Preserves

Regulated hunting preserves licensed to hunt game birds are found throughout the United States. These preserves vary in size from small family operations to huge resort-like facilities complete with guided hunting, lodging, gourmet restaurants, and other activities such as fishing and sporting clay shooting.

When hunting preserves purchase birds from outside sources, game birds are held in holding pens after delivery until their release onto the hunting grounds. “Flight-ready” birds are obtained as needed and seldom held more than two weeks. Ideally, game birds in each new delivery are held in a separate pen to prevent co-mingling of birds from different sources.

Hunting preserves invest extensively to develop suitable habitat with cover crops, weed control, managed hunting paths, fence rows, and natural barriers to enhance environmental appearance and hunter safety. Larger preserves often hire full-time agronomists and wildlife managers to prepare the preserve to look managed - but not overly manicured. Hunting preserves are also regarded as tourism and recreational facilities. Many preserves have overnight accommodations with hospitality and cooking staff on site. In addition, hunting preserves often have kennels with trained dogs to retrieve and point game. Lastly, some of the larger preserves have hunting gear and clothing available for purchase.

4.4 PHEASANT PRODUCTION

4.4.1 Managing Pheasant Breeders

Choosing the right variety of bird for breeding stock is a matter of regional preference.

Pheasants are often divided into two primary types: large or small.

1. Larger pheasants are slower flyers, but are meatier and more impressive-looking due to their body size and tail length. Mongolians are an example of a large pheasant strain (approximately 3.5 lb. average). In addition to Mongolians, there is an all white pheasant which was bred primarily for meat production.
2. Small pheasants are faster flyers and more challenging to hunt. Chinese Blue Backs are one of the small varieties and the Kansas Blue Back is currently the smallest variety (approximately 2-3 lb average). Melanistic Mutants are a very dark variety.

Pheasants show sexual dimorphism. Roosters have bright iridescent feathering, a white ring around the neck, rusty colored breasts, green/blue heads with red facial marking, and long barred tails. Hens by comparison are relatively dull with dusky, nondescript feathering.

For egg production to begin, 14 hours of light are required. As with other birds, artificial light can be used to stimulate early onset of sexual maturity if the natural day length is under 14 hours. From March 1-July 1, artificial lighting is not required and most breeders rely on natural day length.

When sexually mature, hens and roosters are placed together in outdoor breeder pens. A typical space requirement for breeders is 25-30 square feet per bird. One rooster per 8-12 hens is sufficient to maintain fertility. Too many males will result in excessive fighting between roosters and trauma to hens.

Breeder pens should be devoid of cover crops to make finding eggs easier. Nest boxes lined with wood chips or straw are placed in pens, but ground eggs are still very common. On average, a single pheasant hen will lay approximately 75 eggs. A typical 75% hatch rate results in production of 50-60 live chicks per breeder hen.

Eggs should be collected at least daily, but during hot or rainy periods, egg collection should occur 3-5 times per day. Eggs are washed, sanitized, and set in the incubators.

4.4.2 Hatching Pheasant Eggs

Pheasant eggs are set every 7-14 days. Incubator temperature should be approximately 99.5°F and wet-bulb humidity set at 84%-85%. The incubation period for pheasant eggs is 24 days. At around 21 days of age, eggs are transferred into a hatcher with a temperature of 98.5°F. Humidity also increases at this time due to hatching of chicks.

Commercial pheasant chicks are usually sold straight-run. However, some chicks are sexed immediately after hatching for customers who demand males or females. Chicks are sexed by examining the patch of long down under the eyes of the rooster and hen (the down patch is much wider in the hen) or by looking for the presence of a developing wattle in the male.

4.4.3 Brooding Pheasant Chicks

After hatch, pheasants are placed inside brooder barns very similar to facilities used for raising floor poultry. Low light intensity in the brooder barn is very important in helping reduce aggression among chicks. Spot or partial house brooding is more common than heating the entire house. Room temperature is variable (85°- 88° on average) with the temperature under the hoover at 100°F. Temperatures are then dropped 5°F per week until ambient temperatures are attained.

4.4.4 Moving to Outdoor Flight Pens

Between 5-8 weeks of age, game birds are ready to be placed outdoors. Specs, also called peepers or blinders, are often placed on the birds one week prior to when they are moved outside. Specs are hour glass-shaped pieces of plastic that are placed over the cere on the upper beak. They are kept in place with a thin, long piece of plastic inserted through external nares, the nasal septum, and through holes in the specs. Specs allow birds to see to the side, but not straight ahead. They are an effective tool to reduce cannibalism. Game birds are kept in flight pens until they are ready to be sold.

4.4.5 Management/Disease Challenges in Flight Pens

Once outdoors, severe weather (heavy rains, late spring snow storms, hail, and winds) may cause some mortality. Predators, such as hawks, owls, skunks, and weasels, sometimes take a heavy toll on the flock. Sometimes nuisance birds (such as starlings and blackbirds) descend in large numbers on the netting and are a disease risk to game birds, which can be seen in the photograph below. Internal parasites are the most common diseases seen in the flight pens. Thread worms (*Capillaria* species) may cause severe weight loss and high mortality. Tracheal worms (gapeworms, *Syngamus trachea*) cause respiratory distress and elevated death loss. Noise cannons may be brought in to frighten prey and pests.

Nuisance Birds on Netting

Noise Canon

4.5 PARTRIDGE PRODUCTION

4.5.1 Chukar Partridges

Three strains of partridge are raised for production and commercial hunting, the Chukar partridge being the most common. The European Red-leg partridge is the least common. Some breeders cross Chukar females with Red-leg males to create a hybrid called a Chukar Red-Leg Cross. Chukar Partridges originated in Eurasia, Israel, Turkey, Afghanistan, India, and Pakistan and are adapted to arid and semi-arid country in higher elevations. In many western states, such as Idaho, Montana, Nevada, and eastern Oregon, the Chukar has become established as a wild game bird species.

4.5.1.1 Managing Chukar Breeders

Male Chukar are slightly larger than females and have thicker necks. The bill and tarsus of males have a deeper orange coloration. Breeding stock are generally selected between late December and early March. Chukars can be pair-mated, kept in trios or quartets (1 male to 3-4 hens), or colony mated in pens at a 1:5 ratio. Egg production averages 40-60 eggs per hen each season. Chukars are highly sensitive to excess moisture and fecal-borne pathogens, such as coccidia, and do best when raised on wire. When breeder birds are in wire cages, eggs are often collected using roll-away systems. Eggs should be collected several times a day, especially in hot or wet weather.

4.5.1.2 Hatching Chukar Eggs

Chukar eggs are set every 7-14 days. However, Chukar eggs can be stored for up to a month and still remain hatchable. The incubation period for Chukar eggs is 23 days.

4.5.1.3 Brooding Chukar Chicks

Chukars chicks are brooded similarly to methods used for pheasants (described above) but best results are attained if chicks are raised on wire after 2-3 weeks of age due to their extreme susceptibility to coccidiosis. Chicks are also highly prone to piling and subsequent suffocation, so uniform whole house heating and low light intensity during brooding are recommended. Chicks can be moved to flight pens at 8 weeks of age to condition them for hunting. Preserves often purchase Chukar partridges after 15-16 weeks of age.

4.5.2 Hungarian (Grey) Partridges

Hungarian Partridges are smaller than Chukars and have a chestnut "V" on the lower breast. In general, they are much more difficult to raise compared to other game birds, because they are very excitable and easy to stress.

4.5.2.1 Managing Hungarian (Grey) Partridge Breeders

Hungarian Partridges must be bred in pairs. Because they require more acclimation, future breeders are paired in mid-winter. They begin breeding around mid-May and stop egg production around mid-August. Typical egg production per hen is 50 eggs during a season. Each breeder hen will produce approximately 35 chicks per breeding season. The incubation period for hatching eggs is 24 days.

4.5.2.2 Brooding Hungarian Partridge Chicks

Hungarian Partridges are brooded quite differently from other game birds. Brooding occurs in small groups in heated brooder boxes with paper on the floor instead of bedding or on wire. Chicks are fed soft foods, such as chopped eggs, in addition to starter feed, during the first three days of life. Watermelon is commonly given for energy and moisture. Since chicks are tiny, feed particle size is very important and must be ground very fine. Even with extra care, high first week mortality of up to 50 % sometimes occurs. After 10 days of age, chicks are brooded in a brooder room similar to other game bird chicks. Hungarian partridges are moved out to flight pens around 8-10 weeks of age.

4.6 BOBWHITE QUAIL PRODUCTION

Bobwhite Quail are indigenous to the United States. However, as farming practices have changed, loss of habitat has resulted in a significant decline in bird numbers. The decline in wild Bobwhite Quail populations has increased the demand for commercially raised birds for stocking private and public hunting preserves as well as for meat production. Bobwhite Quail production occurs throughout the United States, but is greatest in southern states.

Several species and subspecies of Bobwhite Quail exist. The most common wild bird, and most frequently produced domesticated quail, is the Eastern Bobwhite.

4.6.1 Managing Breeding Quail

Quail breeder candidates are often raised in dimly lit and environmentally controlled buildings to prevent stress, reduce cannibalism, and encourage uniform sexual maturation. Birds are grown on 10-11 hours of light. At 19 weeks of age, light intensity is increased by 1 hour per week until 25-27 weeks of age and/or 17 hours of light per day is attained. This day length is maintained throughout the breeding cycle. Breeders achieve consistent egg production at ~ 22 weeks of age.

Housing for breeders can vary, with some producers maintaining quail in floor pens while others keep them off the ground on slatted floors. Quail breeders can be kept in large colony housing, in smaller cages housing up to 20 birds, or in small cages as pairs (maximum 1 cock bird per 3 hens). Raising birds on wire results in cleaner eggs and fewer problems with diseases, such as ulcerative enteritis, but cages must be maintained in a state of good repair. Breeder hens are beak trimmed and males may be beak trimmed (but to a lesser degree). In all systems, lower light intensity (0.5 ft candle) is desirable to calm the birds and reduce cannibalism.

Depending on the management system used (natural light only, 17 hour artificial light, or year round production with preseason lighting), numbers of eggs produced per hen may vary from 50-200+ eggs a year. At the end of the breeding season, spent quail are allowed to recondition and are sold to preserves.

4.6.2 Hatching Quail Eggs

Eggs should be gathered at least 3-5 times daily. Collected eggs should be held in cold storage at 50-65° to stop embryonic development (which occurs above 68°). Eggs are slowly pre-warmed before being placed in incubators to prevent condensation of moisture on external surfaces of egg shells.

Bobwhite Quail eggs are incubated for 23-24 days at 99.5°F and 84-86% relative humidity. During the last three days of incubation, the temperature is lowered to 99°F or kept the same and relative humidity rises to as high as 90% during hatching.

4.6.3 Brooding Quail

Quail are increasingly being raised in converted broiler houses for 17 weeks under very low light conditions on wood shavings with nipple drinkers. This management program reportedly has resulted in improved livability, less feed consumption, and fewer disease issues.

Beak trimming is often practiced, especially where lights cannot be adequately dimmed. Trimming can be done at the hatchery or at 2-3 weeks of age. Also, beak trimming may be done prior to moving quail to outside flight pens. It is important to allow beaks to re-grow prior to shipping quail to a hunting preserve.

Brooder temperatures should be 98-100°F during the first week, and then lowered 5°F each week until ambient temperatures are reached.

4.6.4 Moving to Outdoor Flight Pens

Bobwhite Quail can be raised in traditional brooders and then moved to flight pens at ~ 6 weeks of age. During their time in flight pens, it is important to not crowd the birds and to watch for evidence of cannibalism. Approximately 2 square feet per bird is recommended for flight pens. Shelter and hiding places provided by dense vegetation in flight pens is helpful in allowing quail to escape from aggressive pen mates. Bobwhite Quail are sold to private or public hunting preserves, dog trainers, or plantations.

4.7 MALLARD DUCK PRODUCTION

Mallard ducklings are raised commercially and sold to hunting preserves, primarily along the east coast of the United States.

4.7.1 Managing Mallard Breeders

Next year's breeding stock are selected from the current year's commercial flocks based on phenotypic characteristics such as feather color and quality, leg strength and conformation, body size, and overall health. Most mallards are colony mated with one drake to 4-7 hens. Each hen will produce (on average) 34 sellable ducklings in one year. Hens lay their eggs in outside nest boxes which are commonly lined with straw.

Still, the incidence of eggs laid on the ground is often high. Dirty eggs can be a problem, especially in rainy weather. The egg production cycle is generally from the first of April until mid-July. Eggs are usually gathered once a day, washed in a warm sanitizer at 110°F for a short period, and held for one week before being set. At the end of the lay cycle, breeders are allowed to molt and then are sold.

4.7.2 Hatching Mallard Eggs

The incubation period for a Mallard duck egg is 28 days. Incubation machines are set at 99.5°F with an 85°F wet bulb temperature.

4.7.3 Brooding Ducklings

After hatch, one-day-old ducklings have their right dew claw removed which differentiates them from their wild counterparts. Ducklings are placed into a heated brooder, often on vinyl-coated wire, and kept in a smaller pen for one week.

Clipping a Dew Claw

Brooding Ducklings on Wire

Older Ducks on the Pond

Ducklings are moved to a larger pen at two weeks of age where trough waterers provide access to a plentiful supply of water. At 3 weeks of age, ducklings are given access to the outdoors and multiple ponds which may or may not have overhead netting. Ducklings do not leave ponds because of their tendency to stay with hatch mates as well as the ready availability of feed. Feed must be supplied constantly to avoid problems with feather picking and aggression. Groups are segregated by age, such as five week olds or 8 week olds, until shipped to a hunting preserve.

Management steps to control disease in this type of husbandry system are important. First, because of high bird density on the ponds, water has a high organic and nitrogen load. To prevent botulism, fresh water and aeration are frequently added into the ponds.

Second, because the feeders are kept outdoors, any feed that becomes wet or spills on the ground must be removed frequently. Wet feed can become moldy and maggot-blown, encouraging botulism and mycotoxin development. Ducks are highly susceptible to both toxicities and high death losses are possible if these toxins become established.

Third, because mallard ducks are raised outdoors, often in uncovered ponds, predator losses can be quite high. Hawks, owls, weasels, raccoons, foxes, coyotes, and snapping turtles take large numbers of ducklings annually.

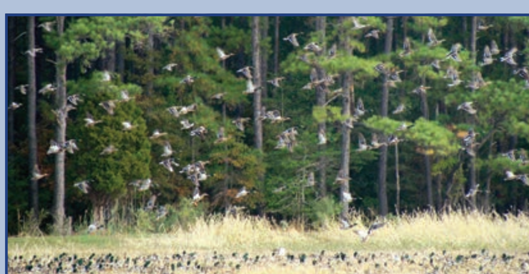
Aeration

Feeders

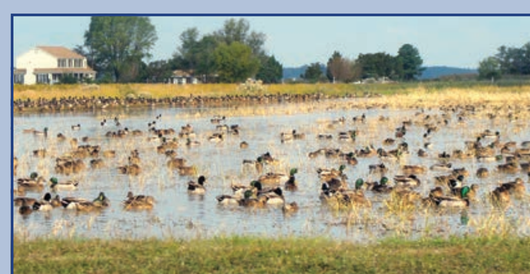
4.7.4 Mallard Duck Hunting Preserves

Commercial mallard duck hunting is allowed on state-permitted private lands. States offering these permits include Pennsylvania, Delaware, North Carolina, South Carolina, Maryland, Georgia, and Alabama. Hunting season is typically October-May 1st. It is estimated that up to 4 million mallards have been released since 1983.

Ducks are usually purchased between 6-8 weeks of age and placed on ponds or flooded crop land, but they also can be purchased as adults for release. These ducks are provided protein pellets and grains, such as milo, corn, and millet, until hunting season commences. During hunting season, supplemental feed is withdrawn and ducks must eat grains planted in fields. Deliberate baiting of hunted birds is not allowed; this minimizes co-mingling with wild waterfowl. Ducks are provided some cover and multiple ponds as resting places. Preserves are hunted once or twice per week to reduce stress and hunting pressure on the population.



Hunting Preserve



Ducks on Flooded Crop Land

4.8 NUTRITION

Nutrient requirements of game birds have not been as thoroughly studied as requirements for commercial poultry such as layers, broilers, and turkeys. Game birds nutritional requirements are often extrapolated from poultry rations. As in poultry rations, dietary formulations are different according to the age of the birds. Starter feeds, grower feeds, maintenance feeds, and breeder rations are fed. Their feeds most closely resemble turkey rations and it is assumed that game birds have higher requirements for protein and amino acids. Also, game bird feeds contain more vitamins and minerals than chicken diets. As in poultry, feed is the single highest cost to produce game birds. The end goal is to develop healthy, well-feathered, muscled, active, and athletic birds that will challenge sportsmen in the field.

There are most likely different requirements for each species of bird being raised. Ducks, pheasants, quail, and partridges probably differ in dietary needs but these differences have not been well-studied. Requirements for Ring-necked pheasants and Bobwhite Quail are given below (Table 1), but researched dietary recommendations for partridges or mallard ducks are not available.

Nutritional deficiencies are sometimes suspected in these species. Often, problems with unexplained weight gain, poor feathering, uneven growth, reduced egg production, and fertility are seen in field situations. However, it is important to note that although a balanced formulation may be originally obtained, game bird rations are more prone to degradation due to several factors:

1. Most game bird operations are not large enough to quickly use up purchased feeds. Large volumes may be purchased for economical reasons, but smaller producers may need to store this feed for several months before obtaining new feed. Feed may suffer a decline in quality, especially if stored over hot summer months.
2. Breeder formulations are kept constant throughout the breeding cycle. While there are advantages to fixed formulations (as opposed to least-cost rations used in poultry production), if consumption declines due to heat, intake of important nutrients will also be reduced. In such instances, feeding a more nutrient-dense diet may improve egg production, shell quality, and hatchability.
3. Once game birds are moved outside to flight pens, feed is obtained in outside feeders that are exposed to harsh elements, such as heat or moisture. This can lead to nutrient decline and mycotoxin development.

Table 1. Nutrient Requirements of Ring-Necked Pheasants and Bobwhite Quail as unit per kilogram of Diet (90% dry matter)*

	Ring-Necked Pheasants					*Bob-White Quail*		
Nutrients	Unit/kg Diet	0-4 Weeks	4-8 Weeks	9-17 Weeks	Breeding	0-6 Weeks	7-12 Weeks	Breeding
Protein	%	28	24	18	15	26	20	24
ME Energy	Kcal	2800	2800	2700	2800	2800	2800	2800
Calcium	%	1.00	0.85	0.53	2.50	0.65	0.65	2.40
Chlorine	%	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Sodium	%	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Nonphytate Phosphorus	%	0.55	0.50	0.45	0.40	0.45	0.30	0.70

*Nutrient Requirements of Poultry, Ninth Revised Edition, 1994. National Academy Press, Washington, D.C.

4.9 MOVEMENT OF GAME BIRDS

Products being moved can be classified according to the following categories: eggs, chicks, started birds, mature birds, and flight-ready birds.

Cardboard Chick Box

Truck and Trailer

Trucks and Trailers

Many different transport containers are used, including plastic crates, wooden crates, and cardboard boxes. Vehicles used to move game birds include small trucks with cabs, semi trucks, or specially designed trailers.

4.9.1 Eggs

Eggs are typically sold from March through July. They could be sent anywhere in the world, because eggs can remain in transit up to 5 days without major effects on their hatchability. Eggs are either picked up, delivered, or shipped using Fed Ex, UPS, United States Postal Service, or an airline.

4.9.2 Chicks

Chicks are typically sold from April through August. They can be shipped to any destination within a 3 day journey without seeing any major effects on livability. However, a 1 to 2 day trip is preferable. Chicks are picked up, delivered, or shipped by the United States Postal Service.

4.9.3 Started Birds

Started birds are typically sold from June through September. Started birds usually move regionally because they are either picked up or delivered to locations that can be reached within 24 hours.

4.9.4 Mature Birds

Mature birds are typically sold from September through mid-April. They usually move regionally. Mature game birds are either picked up or delivered to locations that can be reached within 48 hours. Hobby operations send birds much shorter distances compared to larger commercial operations because it is not cost effective for them. Due to higher costs to drive long distances, a lot of birds need to be delivered at one time to minimize the cost per bird for delivery.

4.10 BIOSECURITY MEASURES: RESPONSE TO A HIGHLY CONTAGIOUS FOREIGN ANIMAL DISEASE IN GAME BIRDS

4.10.1 Biosecurity Concepts for Game Birds

While many biosecurity measures are shared between commercial avian species, there are unique aspects in game bird production that need to be addressed in the event of a contagious foreign animal disease outbreak.

Game bird production facilities often incorporate breeding birds, hatcheries, growing birds, and sometimes hunting preserves all on the same premise. If exposure to a highly contagious foreign animal disease would occur, there is the possibility of significant economic loss to producers as the disease most likely could not be contained within one building or between various types of birds located on the same premises. If depopulation were necessary, not only would commercial flocks be affected, but next year's breeding stock replacements would also have to be destroyed.

For preventative biosecurity purposes, game bird producers can reduce disease risks by separating breeding facilities, hatcheries, commercial bird production and hunting preserves on different premises with separate personnel caring for them. In particular, the breeders and next years' breeders should be isolated from commercial birds since they are very expensive to replace.

Flight-ready game birds may be sold in a wide geographic area. To reduce time required, and to minimize transportation costs, multiple farm and premises deliveries are often arranged. A single large truck may visit multiple customers and premises at a time, unload a number of birds at each location, and then return with soiled crates and vehicle back to the farm. To minimize disease risk, growers should ideally unload bird deliveries off-site at mutually agreed locations, instead of driving onto each farm and potentially contaminating themselves by unloading birds for customers. All vehicles and crates should be cleaned and disinfected prior to returning to the home farm.

Mixing of mallard duck production and upland game bird production is a potentially risky practice. Waterfowl are commonly exposed to low-pathogenic strains of avian influenza but rarely suffer any noticeable ill effects. If there is enough direct or close indirect contact between upland game and waterfowl, cross-infection of diseases may occur. While Avian Influenza cross-infection is the primary concern, other diseases such as avian cholera might also occur.

Some producers that raise both mallards and other game birds have successfully controlled disease by keeping ducklings and upland game birds far apart physically and confining ducklings under netting. However, ideally, raised-for-release waterfowl and upland game birds should be kept separate. Furthermore, poultry, such as chickens and turkeys, should not be mixed with waterfowl and upland game birds.

4.10.2 Biosecurity for Hunting Preserves

Birds delivered to hunting preserves rarely survive beyond a few weeks and the risk of disease spreading from these preserves to commercial poultry is very low. Mixing of bird deliveries should be minimized for the sake of bird health and for the preserve owners. Only the number of game birds needed should be obtained to reduce the need for extended holding.

4.11 GUIDELINES ON HANDLING UPLAND GAME BIRDS AND WATERFOWL IN THE EVENT OF A SUSPECTED CASE OF NOTIFIABLE AVIAN INFLUENZA (NAI) OR ANY EXOTIC/NOTIFIABLE DISEASE EVENT

Mild forms of Avian Influenza (AI, North American strains) are considered endemic in waterfowl and shorebirds. Serotypes that affect these birds are variable, and most produce little to no clinical disease in their hosts. Low pathogenicity avian influenza infections in upland game birds are uncommon. Similar to poultry, low pathogenic strains of avian influenza may or may not result in positive antibodies in exposed birds with or without mild respiratory disease symptoms. Upland game bird infections with AI are usually the consequence of close contact with wild or domestic waterfowl. Preventing avian influenza in upland game birds is important. The National Poultry Improvement Plan has added avian influenza surveillance and testing for upland game bird and raised-for-release waterfowl. For more information, please contact the following website: *http://www.aphis.usda.gov/animal_health/animal_dis_spec/poultry/*

4.11.1 Response to a Highly Contagious Foreign Animal Disease in Game Birds

Depopulation methods are challenging in game bird facilities because breeders and flight birds are housed outdoors. Herding them together and moving them into an enclosed space would be necessary to achieve euthanasia via CO_2 gas or foam methods. Small groups of game birds could be euthanized by trained teams using cervical dislocation.

Disinfecting outdoor pens involves cleaning and disinfecting feeders, drinkers, and nest boxes. Netting material is best destroyed because it is very difficult to disinfect properly. Lastly, vegetation should be mowed down and the soil tilled and composted. Brooder houses can be cleaned and disinfected similar to commercial poultry buildings. Whatever methods are utilized, placement of sentinel birds on the premise should be used to verify that the virus has been effectively destroyed in the environment.

4.11.2 Guidelines for Routine Handling and Processing of Upland Game Birds and Water fowl to Prevent Disease Transmission by Avian Influenza (H5N1) or Other Zoonotic Diseases

Human infections with an avian influenza virus are extremely rare. The H5N1 virus, which has infected domestic poultry,game birds, and wild birds in Asia, primarily has resulted in illnesses and occasionally deaths in people exposed to droppings, blood, or discharges from sick or dead birds as well as from consumption of under-cooked meat. Fortunately, this AI virus strain is not known to exist in the Americas.

Several recommendations are suggested for hunters or those who process game bird meat to prevent AI infection. These guidelines are also helpful to prevent other zoonotic diseases from birds to people as well:

1. Do not butcher game birds that have been found sick or dead.
2. Do not eat, drink, or smoke while handling or butchering game birds.
3. Wear rubber gloves when cleaning game birds and wash hands thoroughly after cleaning is completed.
4. Wash tools and surfaces with soap and water followed by disinfecting the area with a 10% bleach solution.
5. Cook game birds to an inside temperature of 165°F.

For more information, visit the Alaska hunter safety website below: *http://www.adfg.state.ak.us/news/avian_bulletin_9-30-05.pdf*

Acknowledgements

Information for the Game Bird Industry chapter of the Poultry Industry Manual was obtained from the following sources:

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This FAD PReP Industry Manual was produced in collaboration with USDA-APHIS-VS National Center for Animal Health and Emergency Management by the Center for Food Security and Public Health, Iowa State University of Science and Technology, College of Veterinary Medicine through a cooperative agreement.

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Acknowledgements

- Ms. Lindsay Harlow
  Pennsylvania State University
- Dr. Darrell W. Trampel
  Iowa State University
- Dr. David Frame
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Photo and Illustration Credits

Page 132	***(Top)*** Examples of different species of game birds explained in this chapter. From right: Ring-necked Pheasant, Duck, Chukar Partridge, Bob-White Quail, and Hungarian (grey) partridge. *Photo sources: Dr. Eva Wallner-Pendleton (left and center), Lindsay Harlow (second from left), Linda White, freelance writer (fourth from left), and Mike Hulet (right)* ***(Center)*** This photo is of a Ring-Neck Pheasant. *Photo source: Eva Wallner-Pendleton, Pennsylvania State University* ***(Bottom)*** Ducks on a hunting preserve pond. *Photo source: Lindsay Harlow, Pennsylvania State University*
Page 133	Panoramic view of a netted outdoor pheasant pen. *Photo source: Eva Wallner-Pendleton, Pennsylvania State University*
Page 134	***(Top)*** Eggs in an incubator. *Photo source: Eva Wallner-Pendleton, Pennsylvania State University* ***(Bottom)*** Pheasant chicks ready for shipment in a typical live transport box (left). Vegetation in netting (right). *Photo source: Eva Wallner-Pendleton, Pennsylvania State University (all)*
Page 135	***(Top)*** Hunter hunting in a blind. *Photo source: Eva Wallner-Pendleton, Pennsylvania State University* ***(Second from top)*** Hunting lodge. *Photo source: Eva Wallner-Pendleton, Pennsylvania State University* ***(Third from top)*** Male and female pheasant. *Photo source: Eva Wallner-Pendleton, Pennsylvania State University* ***(Bottom)*** Feeder and a nest box in an outside pen. *Photo source: Eva Wallner-Pendleton, Pennsylvania State University*
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Page 142 ***(Top)*** Cardboard box used to ship or transport live game bird chicks (left). Truck with a trailer and yellow crates used to transport ducks. (center). Trucks and trailers used to transport game birds (right). *Photo sources: Michael Hulet, Pennsylvania State University (left), Lindsay Harlow, Pennsylvania State University (center), Eva Wallner-Pendleton, Pennsylvania State University (right)* ***(Bottom)*** Crates used to transport live game birds. *Photo source: Lindsay Harlow, Pennsylvania State University*

Glossary

Game Bird
Any bird that is used for hunting.

Upland Game Bird
Wild turkeys, partridges, pheasants, and quail (birds in the order of *Galliformes*). Excluded from this group are waterfowl and pigeons.

Started Bird
Birds ready to leave the brooder house, generally between five and eight weeks of age.

Mature Bird
Birds that have achieved adult weight and plumage and are ready for release onto a preserve or into the wild.

Commercial Production
Game birds raised to generate income for the grower.

Hobby Production
Birds raised for recreational purposes.

Hatching Eggs
Fertile eggs incubated for production of live chicks.

Flight-Ready
Birds ready for release or placement into the wild or on preserves.

Raised for Release
Game birds being raised for release onto a preserve or into the wild, as opposed to birds that are raised for meat production or breeding.

Straight – Run
Raising or selling birds of both sexes together. Chicks intended for straight-run production are not sexed after hatching.

Hoover
A wide, saucer shaped, propane-fueled heater for brooding baby chicks.

Tarsus
The shank or featherless area of the leg below the hock.

Vertical Integration
Multiple phases of production encompassed in one company. For instance, a verically integrated company may have breeders, hatchery, commercial production, and hunting preserves. They may also have a feed mill.

Chapter 5: Backyard Poultry Industry

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5.1 INTRODUCTION

Backyard poultry production is as varied and inclusive as are the myriads of backyards that house the birds. If enough backyards are visited,every conceivable poultry housing type and husbandry method will be observed. Backyard poultry, kept for all possible purposes, as well as pet birds of all types are maintained in various numbers and combinations (commonly included with a wide variety of non-avian species) in all types of neighborhoods and areas ranging from the most urban to the most rural -- even in isolated apparently inhospitable areas such as the remote desert. In many areas, the presence of backyard poultry is hardly noticeable; in other areas chickens as well as other poultry species roam and/or fly about freely. Some backyard poultry owners operate highly elaborate systems for breeding and/or raising birds and keep detailed records of their genetics and production. Others leave the birds to more or less fend for themselves among the vast array of untended objects and clutter on an enormous variety of premises.

Great differences in backyard facilities and husbandry practices present a widely variable series of challenges to taskforce personnel responding to an event of a highly contagious avian disease, such as avian influenza or exotic Newcastle disease. Surveillance, diagnostic, depopulation, and cleaning and disinfection teams will encounter every imaginable set of circumstances and all types of conditions in which they will have to conduct their activities. Great variation also will be encountered among backyard poultry owners. Some are highly cooperative, informed, sophisticated producers while others are the extreme opposite and difficult people with whom to deal. Some are openly belligerent to government employees. This latter category, although rare, sometimes makes it necessary to obtain judicial warrants and assistance from law enforcement in order to depopulate poultry during an exotic disease control event.

As will be seen throughout this chapter, the universal theme is that backyard poultry are ubiquitous, commonly found in all imaginable types of backyard facilities, and are kept under all possible husbandry circumstances by a wide spectrum of owners for as many purposes and reasons as there are owners.

5.2 SCOPE OF THE BACKYARD POULTRY INDUSTRY

5.2.1 Demographics

Keeping poultry in backyards is a widespread and very popular hobby that is practiced throughout society in every conceivable manner and place, in all circumstances including the most urban of neighborhoods. Likewise, production and husbandry practices are as many and varied as the number of places that keep poultry. Backyard poultry most commonly refers to chickens, however, the word poultry is defined in statutes and regulations in various ways in different states and countries to include numerous species even domestic rabbits (1). Certain species may be included as poultry in some states, but not in others. The World Organization for Animal Health (OIE), formerly known as the Office International des Epizooties, defines poultry as, “all domesticated birds, including backyard poultry, used for the production of meat or eggs for consumption, for the production of other commercial products, for restocking supplies of game, or for breeding these categories of birds, as well as fighting cocks used for any purpose" (2).

The term, "backyard poultry," however, has never been clearly defined. It would seem obvious that avian species defined as poultry and kept in a backyard would qualify as "backyard poultry." However, the dividing line between backyard flocks and small commercial flocks remains unclear and arbitrary, and difficult to precisely define. The United States Department of Agriculture (USDA), National Animal Health Monitoring System (NAHMS) Poultry '04 study (3) used the number of birds (other than, or in addition to pet birds) per residence as the dividing line between backyard (fewer than 1,000 birds) and commercial poultry operations (1,000 or more birds).

In the event of an exotic disease outbreak, such as avian influenza or exotic Newcastle disease, many if not all domestic and captive avian species may be targeted for disease control and eradication activities. These activities will bring responders, such as members of the National Animal Health Emergency Response Corp (NAHERC), into contact with a wide variety of backyard poultry facilities and circumstances. Pet birds continuously kept inside homes or in backyards may or may not be included in disease control protocols. In a disease control deployment, taskforce management will make these determinations and communicate that information to operations personnel. If there is any doubt about taskforce directives, responders should ask for complete clarification prior to taking any definitive action.

The USDA Poultry '04 study found an average of 29.4 residences that were located within a 1-mile radius of a commercial poultry operation. Of these, 1.9 had backyard poultry flocks (3,4). The primary reason cited for owning backyard birds was for pleasure or hobby (40.6%) while about 25% of owners cited food or family tradition (3,4). In backyard flocks, egg layer chickens were found in 63.2% of the premises and represented 37.5% of all birds. Pet birds made up only 0.3% of the total bird population of backyard flocks. The presence of guinea fowl varied from 4.3% in the East to 31.7% in the Midwest (3).

An average backyard flock consists of 35.1 birds (average numbers of birds per flock ranged from 26.1 in the Southeast to 49.2 in the East). Almost one third of backyard flocks consist of fewer than 10 birds (3). Backyard poultry owners may have only a single pet chicken or duck, maybe a few hens for egg production, perhaps a mixed group of exotic chickens for breeding and/or show purposes, possibly in conjunction with some ducks, geese, guineas, or countless other combinations. In other situations, backyards may contain substantial numbers of birds. Applicable zoning laws may preclude or limit the number of birds that can be kept. However, such restrictions and limitations are frequently ignored by owners and overlooked or poorly enforced by animal control agencies that consistently must operate with limited personnel and diminished budgets.

Gamefowl (fighting cocks) were reported in about 50% of backyard flocks in the southeastern U.S., but in only 4.1% of backyard flocks in the eastern region. In certain areas and ethnic neighborhoods, gamefowl are a consistent finding and may be present in highly variable numbers.

Pet birds are commonly kept and/or propagated in backyards. Small birds such as finches or quail, can be kept in extremely large numbers within a small space. As with most aspects of backyard poultry, there is great variability among pet birds regarding species, numbers, housing, purpose and use of the birds which are commonly found in urban, suburban, and rural neighborhoods. Owners belong to all ethnic and all age groups.

In certain areas, and particularly with gamefowl owners, it is common to find multiple owners that have rented small portions of a larger facility to house their poultry. Facilities originally designed and previously used as horse stables or stalls are frequently converted into chicken coops by urban and suburban gamefowl industry members. Concerns and considerations for disease spread and control are particularly high during the cockfighting season which begins on Thanksgiving Day and continues until the following August. Gamefowl may be transported and moved frequently and over long distances putting these birds at increased risk of contracting or spreading an exotic disease.

Hobby birds of many kinds are found in backyard as well. These birds may include racing pigeons, which technically are not poultry (unless they are raised for human consumption), but nevertheless are susceptible to many of the same diseases as poultry. Hobby birds, by their very nature, frequently travel and/or are transported over long distances at frequent intervals. Additionally, it is not uncommon to find ratites, such as ostriches and emus but rarely rheas, in backyards. As stated repeatedly, the only consistent component of keeping and rearing of backyard poultry (and other birds) is variability.

5.2.2 Business Structure

The highly variable nature of backyard poultry production means that, for most owners, there is no business structure or there may be a loosely defined business. This is because, in many cases, poultry keeping is more of a hobby than a business. Many hobby flock owners do not keep records of any kind or they may keep minimal records which may amount to a desk drawer full of feed store receipts. In these situations, birds are maintained only for the enjoyment of the birds per se, or to produce a few eggs for home use. In some cases, small flocks are maintained for the purpose of selling a few eggs in the neighborhood, possibly because they may have the appeal of being the source of local free-range or organic fresh eggs.

There are a few exceptions to this type of recordkeeping. Bird fanciers raising show birds usually maintain elaborate records of their birds detailing the genetics, breeding and production of birds and/or hatching eggs. An occasional gamefowl producer/breeder may keep elaborate computerized records of the genetics and production of each member of the entire flock and work for years to develop their “ideal” fighting cock. The fighting cock industry, which may range from a weekend hobby to a substantial commercial enterprise will, therefore, vary greatly among owners regarding the business structure and types of records they maintain.

5.2.3 Components

In the event of an exotic disease outbreak, responders to backyard poultry issues may encounter a wide spectrum of poultry as well as many other avian and non-avian species kept in the backyard setting. Many times, a hodgepodge of many species of birds will be encountered in the same backyard and frequently along with various other non-avian species. This collective group of backyard poultry and other types of birds are kept for a variety of reasons and purposes, such for pets, a hobby, egg and/or meat production, 4H or FFA projects, or cock fighting. The OIE definition of poultry appears to include pigeons that are raised for meat or egg production, but does not include racing pigeons unless one construes the meaning of “other commercial product” (see Section 1.1) to include the commercial aspects of racing as a product.

Clubs: Numerous and varied poultry fancier clubs exist, members of which raise their birds in backyards. Multiple exotic breeds may be present in the same backyard. These birds frequently are exhibited at breed shows or various other poultry shows. University Avian Sciences Extension and/or Veterinary Extension faculty frequently interact closely with such fancier clubs and, therefore, are an excellent source of further information and liaison contact with members.

Project poultry: Project poultry are poultry that are kept and raised by students for 4-H or FFA projects. Project poultry may be raised for many purposes, including egg laying and meat production. If they are of a recognized or exotic breed, project birds may be exhibited at local fairs or state fairs in competition for awards and prizes or to satisfy the need for a school project. Because these birds are transported into congregation points and then go out again to other events, there is an element of risk for disease transmission and spread. Many fairs and poultry exhibitions have established inspection points for all birds entering the premises. Poultry Health Inspectors (PHI’s) are usually trained by or associated with university extension services and examine birds before they are admitted to an event (5). Any bird showing signs of contagious disease may be excluded from admission onto the premises and is referred to a veterinarian for further evaluation.

Gamefowl: A substantial component of backyard poultry is made up by the gamefowl (cockfighting) industry. This industry is only beginning to be understood, primarily as a result of the 2002-03 exotic Newcastle disease epidemic in California, Nevada, Arizona, and Texas. Individual holdings within the gamefowl industry are highly variable with flocks ranging from a few birds in a backyard to thousands in large elaborate commercial enterprises. Estimates of total numbers of gamefowl range from 3-8 million birds in California alone, held by some 50,000-60,000 owners. California’s gamefowl industry represents an estimated 33-40% of the total national gamefowl flock which may consist of some 8-24 million birds. Gamefowl owners represent many racial and ethnic groups with the majority being Hispanic but also including Caucasian, Filipino, Vietnamese, Thai, Cuban, Hmong, and Chinese. Some are involved in the sport whereas others raise the birds simply because they are fanciers of the breeds. There are about 750 California members in the United Gamefowl Breeders Association, a national organization made up of about 15,000 gamefowl breeders and 150,000 gamefowl owners (5).

Doves and Pigeons: Doves and Pigeons: Although not considered poultry in United States federal regulations (7), or in California state regulations (9) unless they are to be used as human food, doves and pigeons are commonly found in backyard settings. Often these birds are kept purely for the pleasure of owning them or for production of squab meat. Fancy pigeons are frequently very expensive birds and may require a special appraisal if they have to be depopulated. Racing pigeons, or homing pigeons, are routinely transported long distances and then released to fly home. This activity presents some concerns about spreading disease, especially if an exotic disease outbreak or a quarantined area exists along their flight pathway. A policy for handling such species should be adopted and implemented by taskforce management in disease control activities.

Upland Game Birds: While upland game birds such as pheasants, quail, and chukars are usually raised in commercial facilities for sale to hunt clubs or to live bird markets, they also may be encountered in backyards where they may be raised for home consumption. These species, in addition to being raised for meat, are sometimes kept as purely ornamental birds, particularly the exotic types like Golden pheasants. Because of their very small size, quail may be raised in large numbers in very small spaces. It is entirely feasible that commercial quail production may be conducted in backyards or inside industrial buildings with no outward indication that any type of birds may be present. Raising game bird species may require a permit from the state's wildlife or fish and game department. In California, the Department of Fish & Game has regulatory authority over breeding these species in captivity (8). This regulatory agency may be contacted to assist emergency disease responders locate game bird breeders in an outbreak event.

Pet Birds: Pet birds include such species as parakeets, cockatiels, parrots, finches, canaries, and mynah birds, but also may include almost any species including chickens, ducks, and sometimes turkeys that have been hand raised from babies at Easter time. The author has observed a group of adult pet turkeys that were allowed to live and roost inside their owner's home.

Ratites: Ostriches and emus may be found in backyards, but rheas are less common. These species present their own unique challenges to taskforce personnel who may be assigned to disease surveillance testing, diagnostic teams, or to depopulation and disposal crews. Restraint and handling of these species can be difficult and dangerous, and is best left to the owner whenever possible. When taskforce personnel must handle these birds, chemical restraint in addition to the owner's assistance is essential, particularly if the flock is to be depopulated. Owners may be given the option to depopulate their own birds if they wish to do so. This activity should be monitored to ensure that all appropriate birds are depopulated. If the depopulation and disposal team is to handle ratites, it is most beneficial to ask the owner or a veterinarian familiar with ratites for assistance in capturing and restraining the birds. Use of chemical restraint, i.e. sedative and/or anesthetic drugs, makes depopulation much easier and safer for the disease control team.Various drugs are readily available for this purpose, although many of them are scheduled controlled substances that will require a Drug Enforcement Agency (DEA) license to purchase, possess and use. Inventory control records to account for these scheduled products are required to be kept.

Other Varieties: Backyards have been observed to contain virtually any and all kinds of other birds, including but not limited to: guinea fowl, peacocks, finches, mynah birds, parrots, love birds and many other species. Some of these birds may be kept in cages within the owner's home. In advance of an outbreak situation, protocols should be developed regarding the policies and contingencies for handling in-house cage birds in the event of a highly contagious disease outbreak requiring disease control action.

5.2.4 Economics

Most backyard poultry and hobby birds are kept solely for the owner's use and enjoyment and have little economic impact other than that resulting from purchases of feed, equipment and other supplies, or perhaps from sales of eggs or young birds that might be produced. However, gamefowl raised in backyards frequently do have significant financial importance to the owners. Income generated by gamefowl was estimated at $50 million annually in California in 2001 (5). Sales of gamefowl exported to other countries were estimated at about $125 million annually. In addition to sales of these birds, winnings from cockfighting events and "Derbies" are likewise substantial (5).

5.2.5 Allied Industries

For the backyard poultry producer or hobbyist, the local feed store serves as the central hub or meeting point where not only feeds and supplies are obtained, but husbandry questions, health issues of the birds, and virtually any other subject pertaining to backyard poultry are discussed and advice sought and/or given. Also, feed stores serve as a common location where all the biosecurity issues of all the customers' premises may come together. Foot traffic from each premises commonly ends up in the feed store on a regular basis and has the potential to bring with it disease organisms that can then be transported to other premises on the shoes of other customers of the store. The situation is somewhat similar to large commercial feed mills that have trucks going onto commercial poultry premises with the potential of carrying disease organisms on the vehicles and/or the driver's shoes and clothes. Because of this, there is a degree of risk of spreading diseases via the feed stores. Likewise, there is an opportunity for flock owners to practice good biosecurity between the backyard flock and the feed store, if owners are informed of the risks and how to avoid spreading disease and how to protect their own flocks. Biosecurity at such locations is especially critical during an outbreak situation, such as the 2002-03 exotic Newcastle disease outbreak in California. Feed stores represent a valuable opportunity to conduct training and outreach to the poultry-owning public to help them practice better biosecurity and thus reduce the risk of disease in their flocks.

Swap meets and auctions may have poultry and/or other birds for sale and, similar to feed stores, can serve as a central meeting or collection point for backyard poultry owners. The same potential for spreading disease organisms from backyards to the swap meet or auction and subsequently to other backyard flocks exists as with feed stores. Live birds may be bought and sold in these facilities and, therefore, the risk of spreading avian diseases through this mechanism is always present. Owners and vendors should be educated and made aware of this risk, and should be instructed in biosecurity methods to protect their flocks and their customers' flocks.

5.2.6 Diverse Workforce

Backyard poultry ownership is ubiquitous worldwide and widely prevalent within most, if not all, ethnic groups represented in the United States. This is especially true for the gamefowl culture which is thoroughly and irrevocably entrenched into the Hispanic population as well as many other cultures including Asian and Pacific Islander groups and a number of Caucasians. Larger gamefowl holdings frequently have employed caretakers, in addition to the owners, to look after the birds. Employed gamefowl caretakers are predominately Hispanic. The ability to converse in the Spanish language is especially beneficial when dealing with the cockfighting industry. For workers employed by the commercial poultry industry, ownership of other poultry or birds is strongly discouraged and usually forbidden. Likewise, bird ownership by employees of some larger backyard operations may be discouraged, but this stipulation is far more difficult or impossible to enforce. In any case, it is virtually impossible to preclude commercial poultry industry workers from having some degree of outside involvement in gamefowl activities. This connection to the gamefowl industry, therefore, represents an additional risk of disease introduction and/or spread from the gamefowl industry to commercial poultry facilities. Consequently, it is essential for poultry facility workers to consistently practice strict biosecurity methods. Many large commercial poultry firms require their employees to comply with a strict company biosecurity policy or face dismissal.

5.2.7 Business Continuity

Protocols have been developed that detail the steps and time intervals to be followed to repopulate a commercial poultry enterprise after a depopulation event for control of an exotic disease (10). These protocols are, thus far, not applicable to backyard poultry owners whose flocks have been depopulated as a disease control method. Similar protocols should be developed to guide backyard operations in repopulation methods following an outbreak situation.

5.2.8 Animal Disease Traceability

Producers should contact their state animal health agency and determine the state requirements for registering their premises. This information is helpful in the event of an animal disease outbreak to notify producers with susceptible species. Individual animal identification requirements vary by state and may depend on the event if the birds are taken to shows or exhibitions.

5.3 PRODUCTION CYCLES FOR BACKYARD POULTRY

5.3.1 Breeding Flocks and Hatcheries

Many chickens, ducks and other species raised by individuals in backyards are obtained from the local feed store, usually in the spring around Easter. Many feed stores have baby chicks or other baby poultry for sale at this time, but may not have them available during the remainder of the year. Similarly, there are various breeding flocks that offer baby poultry for sale during most, if not all, of the year. Some larger source flocks operate their own hatchery and will ship birds anywhere in the country by overnight courier. Feed stores may obtain their baby birds from any available source, including local breeder flocks, commercial hatcheries, or anywhere birds are available. Consultation with the store owner or manager should reveal the sources of birds, if it is necessary to trace or to conduct surveillance for disease control.

5.3.2 Breeding Seasons, Fighting Season, Show Schedules, Movements, Molting

As previously indicated, most baby poultry hatchlings are available in the spring, but larger firms make the birds available year round. For gamefowl chickens, the usual breeding season begins in January and lasts for about 3 months. Gamefowl chicks are raised for about a year before they become breeding stock. Fighting cocks (often called battle cocks) often are culled breeders that are available for sale through local dealers or directly at local swap meets. The fighting season, commonly referred to as “playing,” begins on Thanksgiving Day and continues until the following August. The usual molting time for gamefowl extends from July to November. During the molt, battle cocks are more difficult to handle and are not often moved during this time. Molting should be completed by November before the cockfighting season begins.

5.4 HUSBANDRY PRACTICES FOR BACKYARD POULTRY

5.4.1 Housing and Containment

A wide variation of housing and many methods for containment of poultry may be observed in the backyard setting. Traditional chicken houses of various designs and sizes are commonly used for backyard poultry. The housing type may also vary with the type of bird it serves. Chickens will often roost in trees, if accessible. Sometimes corral fences, haystacks, sheds, barns, junk piles, and most anything that will suit the birds may be used for roosting. Waterfowl may prefer to roost on the ground nearwater, or inside a building depending on options available to them. Gamefowl often are kept as “trios,” a breeding group of 1 rooster and 2 hens, that are maintained in a separate housing unit. Many of these units may be arranged in a “row house” type of layout. Gamefowl roosters must be kept individually or they may be separated by being tethered by a strong cord attached to one leg. Keeping gamefowl at a distance to prevent physical contact with one another is necessary to prevent fighting. Gamefowl cocks often are housed in used barrels or small A-frame structures tethered to a small stake driven into the ground. In other arrangements, gamefowl cocks may be maintained in individual cages most frequently with an opaque divider such as plywood or similar material separating the cages. Also, it is common to find poultry, and particularly gamefowl, housed in stables originally intended for horses which have been converted for use as chicken houses. Sometimes birds, and other types of livestock, may be housed inside industrial buildings in urban areas without any outward appearance that birds are present inside.

5.4.2 Feeding and Watering Systems

Depending on the numbers of birds and the type of housing in which birds are kept, feed and water may be dispensed in almost any type of container imaginable. Usually pans, bowls, or used containers of all sorts and sizes are used. Depending on the facility, this may also include any of the many commercially available feed or water dispensers or containers and even automated systems designed for chickens or other types of birds.

5.4.3 Feed Sources and Delivery

For the most part, feeds and other supplies are obtained at the local feed store and taken to the backyard facility in the owner's vehicle. Larger backyard facilities may have feed, usually in bags, delivered to the backyard by a feed store vehicle. Gamefowl breeders sometimes have feeds specially formulated at a feed mill or ordered through a local feed store and delivered to the facility by a store vehicle or their own vehicle. Once feed arrives at the backyard facility, it is commonly transported by wagon, wheelbarrow, by hand, or placed into self-feeders. Feeds utilized by gamefowl breeders include various supplements and other feed additives (including boiled eggs) in a quest to provide optimal growth rations and to produce the best possible gamefowl.

5.4.4 Health Care

Backyard flock owners rarely rely on a veterinarian for avian health issues. The Poultry '04 study found that only 2.9% of backyard flocks utilized veterinary services, but as flock size increased, the percentage of flocks using veterinary services also increased. Vaccination was practiced by only 2.8% of backyard flocks, but also increased with flock size (3,4). Cost of veterinary services is likely to be the greatest deterrent to flock owners, but low usage also may be partially explained by limited numbers of avian veterinarians and even fewer numbers of poultry veterinarians who are available to assist backyard poultry owners with health issues for their birds. As a result, many owners simply rely on their own judgment, product advertisements in trade journals or poultry magazines, the internet, and mostly advice from feed store operators, other breeders, farm advisors, their neighbors and any others whom they think may have the answers they need about avian health issues.

Another option for backyard poultry owners seeking avian health information and advice may be to take birds to a veterinary diagnostic laboratory, such as the California Animal Health and Food Safety Services Laboratory where a professional diagnosis can be obtained. In the California system, this diagnosis is free of charge to poultry "hobbyists," that is, those with flocks of fewer than one thousand birds. Some laboratories will accept shipments sent by bus but owners should be sure to telephone ahead for shipping instructions.

5.4.5 Marketing

Backyard producers may market their products such as eggs and live birds by "word of mouth" advertising in the local area. More commonly, marketing is done at the local swap meet, auction, or farmers market or by road signs in front of the residence. In other cases, advertising by internet website or in trade journals and newspapers is utilized.

5.4.6 Manure Disposal

Methods for disposal of poultry waste may vary depending on how many birds are kept and the amount of space available. In backyards with large spaces and few birds (pasture poultry system), it may be acceptable to let the manure dissipate into the soil. In many cases, the space and numbers of poultry necessitate collection and disposal of waste by other means. In some cases, it may be suitable to rake up the manure and dispose of it by placing it in the household trash container. Larger quantities of waste may necessitate disposal by other means. Composting and/or application to landscaping or gardens are generally acceptable manure disposal methods. Backyard poultry owners should check local ordinances for restrictions on methods for disposal of poultry waste in their area.

5.4.7 Disposal

Mortalities from backyard poultry operations also present a disposal issue in addition to manure disposal. Small holdings that only have the occasional dead bird may dispose of dead birds by placing them into household trash, provided that the waste collection authority is willing to accept this material. Composting dead poultry has become one of the preferred methods. If done properly, composting is a sanitary, odor-free, and efficient method to dispose of dead poultry and it produces a useful product at the end of the process. In some locations, laws may permit burial on site. Incineration is another acceptable method, but may not be practical or permitted in certain locations due to laws restricting burning. Rendering is an acceptable method for disposal of dead poultry, but rendering facilities are frequently reluctant to accept poultry carcasses. Over recent years, rendering companies have declined substantially in numbers and in the areas they service. This disposal method may be difficult to find and is unlikely to be an option for the majority of backyard poultry facilities.

5.4.8 Record Keeping

Record keeping methods for backyard poultry operations have been discussed previously in section 5.2.2 (Business structure) on page 154.

5.5 BACKYARD POULTRY AND PRODUCT MOVEMENTS, MARKETING

5.5.1 Transportation Methods

Transportation methods used vary according to the scope and needs of a particular operation. Out of necessity the owner of a few backyard chickens may simply place the birds into a small box, cage, other container, or even a paper grocery bag and transport them by car. Larger operations that transport birds or eggs to swap meets or farmers markets may utilize larger cages and trucks or vans dedicated to this purpose. Gamefowl roosters being transported to cock fight events must be held in individual cages to prevent fighting. For this purpose, various types of individual cages, or cages designed to carry multiple birds with each bird within its separate compartment are utilized. These cages fit into the trunk of a car or the back of a truck and can be easily disguised or hidden. Birds that are being smuggled across borders frequently are hidden by variety of means to avoid detection.

5.5.2 Breeding and Fighting Season

Movement of poultry for breeding or cock fighting purposes is commonly done in a variety of ways as described in section 5.5.1 above.

5.5.3 Quarantined Birds

Smuggling of various birds, particularly psittacine birds, is a big business particularly from Latin American origins. Gamefowl are commonly taken into and out of the United States, both legally and illegally, for breeding and/or cock fighting events by many different means.

During the exotic Newcastle disease quarantine in California in 2002-03, it was common for gamefowl to be moved around illegally in spite of restrictions imposed by state and federal quarantines against such movements. The purpose of this illegal movement was to avoid having the flock, or at least selected birds within the flock, depopulated due to infected or exposed birds being traced or epidemiologically connected to that flock. One of the favorite ingenious ways for gamefowl owners to move birds was to place them in rental pickups obtained from the same commercial firm that supplied vehicles to the Federal-State Taskforce. The taskforce had leased a substantial number of pickups and other box trucks and to identify those vehicles had finger painted an identifying number on the inside of the windshield. In order to avoid detection, many gamefowl owners leased the same types of pickups or trucks from the same rental company and painted similar looking numbers on the inside of the windshield. Using these “look-alike” vehicles, the birds would be moved in, out, or within the quarantined area without arousing any suspicion and with little chance of being detected. This scheme was not discovered until after the outbreak was over and the taskforce disbanded. After the fact, we learned that many movements of this type had taken place over a long time interval while quarantines were in place.

5.5.4 Marketing Methods and Practices

Backyard poultry may be marketed in any number of ways including direct sales on premises, taking birds to swap meets or auctions or even by internet sales. Approximately 17.8% of backyard flocks sold or gave away live birds in the year preceding the NAHMS survey (3). The NAHMS study found that backyard flocks that had introductions of new birds within the past year ranged from 28.3% to 51.7% with an average of about 36% (3). About 3.6% of backyard bird owners moved birds to congregation points where other birds are present. Most of these movements were within the same county or state of residence. As previously discussed, taking live birds into and out of congregation points introduces a risk that disease pathogens may be transported along with the birds. As a means of reducing this risk, it is important for disease control officials to maintain a liaison with market operators and to conduct regular training in biosecurity methods and to conduct regular surveillance testing of birds moving in these markets.

5.6 BIOSECURITY MEASURES FOR AVIAN INFLUENZA AND EXOTIC NEWCASTLE DISEASE

An incursion of a foreign animal disease, such as avian influenza or exotic Newcastle disease, necessitates an emergency response to contain and eradicate the outbreak as quickly as possible. This is vitally important to protect the production industry of the state(s) and the entire country, as well as to ensure continuity of a plentiful and wholesome food supply from the affected industry and protect the public health. In preparation for such an adverse event many government agencies have developed response plans and have stockpiled some of the common materials needed for the initial response to an outbreak. Part II of the current document is a summary of the organized response to an exotic disease introduction. Various reference documents are available that provide further guidance to disease control activities in response to a highly contagious disease event. (10, 11).

Backyard or hobby poultry producers will be affected by state and federal quarantines, if they are located within the area. Similarly, infected premises and contact premises that are backyards will be handled in the same way as any other premises where the highly contagious disease occurs. Movement restrictions may apply to poultry and birds in backyards within quarantined areas. Use of a permit system as part of the movement controls may allow uninfected entities to continue to operate (11.).

General principles of biosecurity share considerable similarity across all species and across different categories within a given species, for example the six types of poultry represented in this manual. Differences in biosecurity programs for various types of poultry operations come from variation in the type of premises involved, the magnitude of the operation, the amount of risk of disease at the specific premises, funding available, and the practicality of the intervention considering the risk-benefit to be achieved by including each component under consideration into the flock biosecurity plan.

Backyard poultry biosecurity is extremely variable due to a multitude of reasons including the design, construction, location, size, layout of the facility, and what's in the areas adjacent to the operation as well as the cost. To provide adequate biosecurity to protect the wide variety of backyard poultry operations, it may be necessary to apply non-standard approaches and innovative thinking to fit the specific premises at hand, while keeping in mind the objectives and intent of a biosecurity plan.

By definition, biosecurity is the application of any protective practice or intervention method that could decrease the risk of disease by preventing or diminishing the movement of pathogenic organisms into or out of a premises. Biosecurity reduces the probability of disease occurrence in a poultry flock to the lowest possible level. In the process of preparing a biosecurity plan, careful consideration must be given to the various options available, the practicality of each intervention method considered, the cost/benefit of the practice, and the feasibility of executing each component of the biosecurity protocol for the specific premises. Ideally, strictly-practiced, effective biosecurity is a critically important component of successful poultry production in all types of poultry operations from small backyard flocks to the largest commercial operations. An additional benefit of using good biosecurity practices is that they protect against all diseases and are not limited or applicable only to highly contagious diseases, such as avian influenza (AI) or exotic Newcastle Disease (END).

The three basic components of flock biosecurity include: isolation, traffic control, and sanitation (12). Isolation means the confinement of birds within an environment that can be controlled and protected, and refers to physical separation away from other poultry, people and equipment. Whenever possible, poultry facilities should be located well away from lakes or rivers that will attract wild waterfowl, roads on which poultry may be hauled, and other poultry production premises. In the case of backyard facilities, however, there is little or no control over what may be located in the adjacent environment, the backyard's location or what kinds of poultry may be kept on a nearby premises. Fencing around the facility and a buffer zone around poultry houses that is maintained free of vegetation to discourage rodent activity will be beneficial. Traffic control refers to all persons, vehicles, equipment and any other items that enter, move within the premises, or exit from the poultry facility. The fewer movements into or out of the facility, the less likely disease organisms will be brought onto or taken out of the premises. Sanitation is the cleaning and disinfection of equipment, vehicles, materials and other items, and the cleanliness of personnel on the premises. Sanitation is composed of about 90% cleaning and 10% disinfection. Because very few disinfectants are effective in the presence of organic matter, such as manure, mud or other debris, it is necessary to remove this material by thorough cleaning before a disinfectant is applied.

When doing cleaning and disinfection of backyard poultry facilities it is essential to remember:

1. It is impossible to disinfect soil, litter or manure, therefore, spraying disinfectant solutions on the ground (soil) has no beneficial effect.
2. Chemical disinfectants were not intended to be sprayed on live birds, either as a disease prevention or treatment method.
3. Chemical disinfectants (such as formaldehyde or Virkon-S and many others) are not to be sprayed on the skin (bodies) of workers as part of a shower-in/shower-out process.
4. Chemical disinfectants may be dangerous and must be used according to directions, e.g. formalin or formaldehyde is toxic and a known carcinogen and may be used only in certain applications.

Infectious disease agents may be introduced into, or escape from a poultry production facility in many ways including:

- Movements of diseased birds, or birds that have recovered from an illness, but have become carriers of the causative organism, or movements of healthy birds into a contaminated environment.
- Vehicles, shoes, and clothing of visitors, workers, delivery or service personnel that move between flocks or premises.
- Fomites including feeders, waterers, cages, coops, carts, or other equipment that may be moved or shared between different premises or even in multiple houses on the same premises
- Carcasses of dead birds following improper disposal
- Movement and disposal of manure or other waste materials
- Contaminated water, feed or feed bags, soil, or litter
- Rodents, wild animals, and free flying birds or insects
- Contaminated trucks or vehicles of any kind
- Eggs and egg handling equipment

Of the many ways that disease organisms may be introduced into a flock, the most critical methods involve movements of contaminated birds, people and equipment. Whenever possible, non-porous, impervious materials, such as metal or plastic cages, coops, and other equipment should be used because they are more easily cleaned and disinfected. Birds should be obtained from reliable sources and then should be isolated for 2-4 weeks before being introduced into the rest of the flock. People should be restricted from entering the premises unless it is essential for them to do so and then they should wear protective outer clothing and shoe covers. Similarly, vehicles and equipment should not be brought onto the premises unless necessary, and unless thoroughly cleaned (e.g. by high pressure power washing) and disinfected before entry and upon exiting the facility. Movements of persons and equipment within a given premises should be made beginning with the youngest birds first and progressing to the oldest, and from the resident birds first then moving toward the isolation area last. Another important component of backyard poultry biosecurity is the exclusion and control of rodents, wild birds, and insects from the premises.

These disease control principles should be applied and/or modified to suit the conditions of a particular premises and practiced accordingly at all times. However, practicality should be continuously kept in mind and strict biosecurity methods should be even more strenuously applied during times when outbreaks of diseases such as AI or END are known to be occurring.

5.7 POULTRY HUSBANDRY NEEDS

(See Part I, Section 1.2) Husbandry needs for a backyard poultry flock will be the same in the face of an outbreak as they would be in normal circumstances unless the flock is selected for depopulation.

5.8 PRODUCT HANDLING

Backyard poultry producers seldom have any product other than young or adult birds, or eggs either for consumption or for hatching, or that are in the process off being hatched by the hens. Baby or juvenile birds could be considered product, but for purposes of depopulation and disposal, all live birds on a premises should be handled in the same way. On occasion, nests full of eggs, usually goose, duck, or gamefowl eggs, are encountered and appraised with assistance from the owner. The eggs are then disposed of by including them with the depopulated birds.

5.9 SURVEILLANCE

Surveillance includes two types of disease control activities. First, is the search component or looking for the presence of susceptible species, that is, finding out where the birds are and where they are not located. Door-to-door surveys, and completion of a questionnaire when birds are found, are frequently used to document which premises have poultry. In an outbreak situation, this activity is most often done in quarantined areas around infected premises to define the extent of the outbreak. It is especially critical to conduct surveillance around commercial poultry production facilities when an outbreak exists in the general area. The purpose of this activity is to monitor poultry near commercial facilities as a means of protecting the commercial industry. From the data obtained, maps may be generated that show the location of poultry and bird-owning premises and show spatial relationships between the various types of facilities.

The second surveillance component, is the continued monitoring and testing of flocks located in or near quarantined areas and of suspect or high risk premises through repeated surveillance visits to observe birds for signs of illness and to collect samples for disease testing. OIE Guidelines specify minimum surveillance to obtain adequate data to ensure freedom from disease. Those guidelines should be consulted when establishing a surveillance program after an outbreak has been controlled.

After the outbreak, continued surveillance is conducted to demonstrate disease free status. Once disease free status is established, surveillance may be conducted as a means of early detection in case disease returns. In the interim, door-to-door surveys provide very little benefit considering the cost and time involved in conducting the activity. A better method for early detection of a new incursion of disease is to use surveillance testing at poultry concentration points. This includes random testing of birds in market channels, such as swap meets, auctions, live bird markets, and other concentration points, such as fairs, shows and other expositions. It is of utmost importance to keep and maintain good records of surveillance activities in a database that can be readily and easily accessed.

5.9.1 People

Personnel assigned to surveillance activities must first be given adequate training in the protocols for biosecurity, sampling methods, and sampling quantities (how many birds to sample in the various situations and what types of samples to collect and how to prepare the samples and accompanying paperwork for submission to the laboratory). Some types of surveillance may be limited to canvassing neighborhoods looking for poultry and gathering data pertaining to the flocks when found.

5.9.2 Vehicle Traffic

Surveillance crews should park their vehicle on the street outside the premises whenever possible. If suitable parking is not available outside the premises, or outside the farm gate, vehicles should be parked as far away from the area containing the birds as practical. The intent of this is to reduce the risk of bringing disease organisms into a premises, or out of the premises on the vehicle. In addition, tires and wheel wells should be sprayed with disinfectant on arrival and again before departing the premises. It is good practice to take the vehicle through a commercial car wash that includes a high pressure power wash with soap and hot water, if possible, at the end of each day's operations.

5.9.3 Disease Monitoring

This is another application of surveillance, usually applied to premises outside the infected zone or buffer zone, within the free area, part of the control area that have demonstrated that they should not be classified as infected premises, contact premises, suspect premises or at-risk premises. Also please refer to Section 5, above.

5.9.4 Sample Collection

Taskforce personnel conducting surveillance sampling and diagnostic crews that respond to sick calls will be collecting samples for laboratory testing to determine disease status of the flock of interest. It is critically important that these crews practice very strict biosecurity while visiting premises and obtaining samples. The following section gives a generic example of a protocol followed by diagnostic and surveillance crews for visiting a backyard poultry facility. However, both surveillance and diagnostics crews should follow protocols established for the taskforce event at hand. (10)

1. DO NOT enter premises with dead or sick birds. If you observe dead or sick birds, leave the premises and call your supervisor or the Administrative Assistant in Epidemiology and report your findings.
2. A biosecurity line must be established between the premises and the vehicle. Use the biosecurity procedures and personal protection equipment (such as Tyvek suits, double boots, double rubber gloves, hairnet, face mask, and goggles). Refer to the Standard Operating Procedure Manual for instructions, or in the absence of such a manual, contact the operations supervisor for direction.

3. Two members of the three-person surveillance team will enter the premises. One crew member will hold and handle the bird(s). The other crew member will collect oropharyngeal and cloacal swabs and handle media tubes.
4. Oropharyngeal and/or cloacal swabs must be collected and handled according to prescribed procedures. Refer to the standards for the area in which you are operating, i.e., the surveillance zone, or the quarantine zone.
5. The third crew member is the clean person who remains at the biosecurity line established between the premises and the vehicle. This crew member calls for the premises identification information and takes decontaminated samples at the biosecurity line and stores them in an ice chest that will be used to transport them. This crew member also processes the trash when the other two crewmembers return to decontaminate at the biosecurity line prior to returning to the vehicle at the end of the collection.
6. The two crew members who collect the samples should complete the paperwork and prepare sample tubes for submission to the laboratory before crossing the biosecurity line.

5.9.5 Sample Submission

Taskforce management should provide protocols for collecting samples. Similarly, diagnostic laboratories should provide specific guidelines for collecting samples and preparing them for submission to the laboratory. Continuous interaction of taskforce and laboratory management will be necessary throughout the disease control program.

5.10 EUTHANASIA AND MASS DISPOSAL (SEE FAD PREP/NAHEMS GUIDELINES AND SOP)

In the event of a disease control taskforce to contain and eliminate an exotic disease outbreak, such as AI or END, backyard poultry facilities present a wide array of challenges to the euthanasia and disposal crews. As previously explained, backyards are as varied and different in size, design, and content from each other as there numbers of such places. Some backyards are highly organized, very neat and orderly, well-cleaned, and maintained. Also, there is the opposite extreme and every conceivable arrangement in between the two. Each backyard, as it is designated for depopulation, must be assessed and a strategy devised for catching, euthanizing, and disposing of the birds. Backyards frequently contain a wide range of other items, such as inoperative cars (sometimes with trees growing up through them), used or inoperative equipment, and materials of all types, sizes and amounts, refuse that has been disposed of by placing it in “storage” in the backyard, and myriads of any and all other things collectively referred to as junk, trash, or clutter. This, combined with the fact that chickens and other birds frequently are allowed to roam freely about the premises, presents various challenges for capturing loose birds for euthanasia and preventing their escape to other premises. At the same time, such conditions potentially may present additional hazards to the depopulation and disposal crew. During the pre-depopulation assessment, these potential hazards can be noted and any additional equipment for safety and/or capturing the birds (such as fishing dip nets or chicken leg snaring rods) that may be needed can be obtained. In some places, it may be impossible to catch large numbers of loose birds. In that case, the option of doing the depopulation after dark when the birds are roosting in trees, or elsewhere among the items present in that backyard and could more easily be caught could be considered. Sometimes, owners may have a dog(s) that usually will ignore loose chickens in the facility, but if given the signal by the owner, these same dog(s) will be thoroughly delighted to catch and retrieve the loose chickens. That system is routinely used by owners where loose chickens regularly are free to move about the facility. Each backyard premises will present its own set of circumstances and challenges that will have to be evaluated and accommodations made to fit the conditions.

Once birds are caught, they are carried to the euthanasia station located as near as feasible to where the birds are housed. The euthanasia station consists of cylinders of compressed CO_2 mounted onto carts, and some of the heavyweight plastic or cardboard barrels with plastic trash bag liners. CO_2 is administered into this chamber via a hose introduced through a hole the same size as the hose through one of the barrel lids that has been specially modified, such that the hose from the CO_2 tank can be introduced inside the barrel. As the barrel is filled with poultry carcasses, the bag is closed and the modified barrel lid is replaced by a regular lid that is secured onto the barrel with the special locking metal band. The barrels are then disposed of in a landfill or as determined by taskforce management. Other similar systems and methods of applying CO_2 and disposal of the carcasses may be used.

There are five basic methods for disposal of backyard poultry carcasses: bury, burn, render, landfill, or compost. For commercial premises, strong consideration should be given to disposal by composting, either on-site in the same houses the poultry were in at the time of euthanasia, or at another acceptable site. Disposal of poultry euthanized by a disease control taskforce has been, as was the case in the 2002-03 California END Taskforce, by using a landfill that will accept dead poultry. At the onset of the taskforce, the Planning Section should make determinations as to what disposal method(s) will be used and determine protocols to follow. In the California taskforce (2002-03), carcasses were initially placed in heavy weight trash bags and "double bagged" to prevent bags leaking or tearing open. Later on, this method was revised to include placing carcasses in double plastic bags inside of heavyweight cardboard barrels with metal lids and a special type metal ring and latch device to seal the barrels. Filled barrels were placed in a roll-off dumpster container which was later loaded onto semi-trucks for transfer to landfills. Barrels were then buried in the landfill. As trucks left the landfill, drivers sprayed the wheels and wheel wells with a disinfectant solution.

5.11 APPRAISAL AND COMPENSATION FOR DEPOPULATED ANIMALS

At the time a backyard premises is designated for depopulation, this assignment will be given to the depopulation crew. Sometimes the depopulation crew includes a person designated as the appraiser. In this case, when the crew arrives at the premises, the designated appraiser will consult with the owner to determine a count of each type of bird on the premises and then establish an appraisal value. When the appraisal was completed and the owner had signed the forms, depopulation began. Owners received payment for their birds at some later date, generally 1-2 months after the paperwork was processed. An alternate method was to send the appraiser to the premises in advance of the depopulation team. During the 2002-03 California END Taskforce, this latter method was rarely used due to limitations in the numbers of trained personnel available to do appraisals and the large number of depopulation and disposal teams operating in the field. In that case, depopulation team leaders usually were quickly trained and tasked with the appraisal process. Guidelines were provided by taskforce management about the value and limits of appraised value of various types of poultry and other birds.

5.12 CLEANING AND DISINFECTION (SEE FAD PREP/NAHEMS GUIDELINES AND SOP)

As soon as possible following depopulation and disposal of the birds, a team should be assigned to visit the backyard premises to clean and disinfect and to remove and dispose of contaminated materials that cannot be cleaned. The objective of backyard cleaning and disinfection is to reduce the potential for virus spread from an infected or dangerous contact premises. Cleaning and disinfecting activities on such premises should be limited to areas inhabited by, or exposed to, poultry. Task Force on-site supervisors should evaluate each premises with this objective in mind and make a reasonable determination as to whether materials can be effectively cleaned and disinfected or should be discarded. In general, cleaning and disinfection crews will follow guidelines established by taskforce management. The following general guidelines (10) may be helpful, especially in the initial phases of the outbreak:

Materials commonly found in backyards generally fall into three categories:
- Structures: Rooms and pens/cages;
- Clutter: Items that are not structures for housing birds and require judgment as to whether they can be cleaned and disinfected effectively or must be discarded; and
- Trash: Items that impede the cleaning process and should be discarded.

The following items should be considered for disposal instead of disinfection:
- Rotten, unglued, splintered, broken, insect- (termites) infested, or otherwise unsound wood that cannot be cleaned and disinfected;
- Deteriorating chipboard or particleboard;
- Plastics and other materials that are damaged with grooves, deep gouges, cracks, split, slits, or that are broken or otherwise structurally unsound;
- Tarps that are torn, shredded, contaminated with feces, or have exposed fibers;
- Metal items that cannot be easily cleaned and disinfected. Some large metal items (e.g. appliances, car bodies, and lawn mowers), should be cleaned and disinfected as thoroughly as possible and left on-site.
- Porous materials that will require excessive effort to clean and disinfect;
- Other materials with surfaces that are likely to harbor contamination;
- Clutter that may be perfectly sound but cannot be effectively disinfected. These items may include carpet, cardboard, feed, and bedding material;
- Open feed bags or containers (closed impermeable bags of feed may be sprayed with disinfectant and removed from the contaminated area,
- Trash (anything of no value that cannot be cleaned). Examples of trash include empty bottles, milk cartons, aluminum cans, and paper.

5.13 WILDLIFE MANAGEMENT

The role that wildlife and wild birds, including waterfowl, other migratory birds, pigeons, and other non-migratory birds, may play regarding disease in backyard poultry remains controversial. Potential roles for these species should be considered early in an outbreak by disease control management authorities and appropriate protocols for managing wildlife should be adopted.

Acknowledgements

Information for the Backyard Poultry Industry chapter of the Poultry Industry Manual was obtained from the following sources:

- California Code of Regulations, Title 3 (Food and Agriculture), Division 2 (Animal Industry), Chapter 5 (Poultry Inspection), Subchapter 1 (General Provisions), Article 1, Section 1200 (a) (24). [defines rabbits as poultry]
- World Organization for Animal Health (OIE). 2008 Terrestrial Animal Health Code, Article 10.4.1, General provisions, #2). [definition of poultry]
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This FAD PReP Industry Manual was produced in collaboration with USDA-APHIS-VS National Center for Animal Health and Emergency Management by the Center for Food Security and Public Health, Iowa State University of Science and Technology, College of Veterinary Medicine through a cooperative agreement.

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Photo and Illustration Credits

Page 152 ***(Top)*** Free range chickens in a backyard. *Photo source: Dr. Everardo Mendes, California Department of Food & Agriculture, Meat, Poultry and Egg Safety Branch.*
(Second from top) Chickens housed with other avian species (pigeons). *Photo source: Dr. Everardo Mendes, California Department of Food & Agriculture, Meat, Poultry and Egg Safety Branch.*
(Third from top) Exotic breeds of chickens frequently are found in backyard facilities. *Photo source: Dr. Everardo Mendes, California Department of Food & Agriculture, Meat, Poultry and Egg Safety Branch.*
(Bottom) Example of an unkempt, make-shift backyard facility. *Photo source: Dr. Larry J. Allen, California Department of Food & Agriculture, Animal Health Branch*

Page 153 ***(Top)*** Example of an unkempt, make-shift backyard facility. *Photo source: Dr. Everardo Mendes, California Department of Food & Agriculture, Meat, Poultry and Egg Safety Branch.*
(Center) Gamefowl kept in any available housing. *Photo source: Dr. Everardo Mendes, California Department of Food & Agriculture, Meat, Poultry and Egg Safety Branch.*
(Bottom) Gamefowl breeding pair. *Photo source: Dr. Larry J. Allen, California Department of Food & Agriculture, Animal Health Branch*

Page 154 ***(Top)*** Gamefowl roosters housed individually. *Photo source: Dr. Larry J. Allen, California Department of Food & Agriculture, Animal Health Branch*
(Bottom) Unkempt, make-shift backyard facility (top left). Unkempt, make-shift backyard facility (top right). Gamefowl facility at a remote location in the desert (bottom left). Interior view of a gamefowl facility (bottom right). *Photo source: Dr. Larry J. Allen, California Department of Food & Agriculture, Animal Health Branch (all)*

Page 155 ***(Top)*** Backyard poultry housed with a variety of other avian and non-avian species. *Photo source: Dr. Everardo Mendes, California Department of Food & Agriculture, Meat, Poultry and Egg Safety Branch*
(Second from top) Multiple species of poultry housed together in a backyard (ducks, turkeys, chickens) *Photo source: Dr. Everardo Mendes, California Department of Food & Agriculture, Meat, Poultry and Egg Safety Branch*
(Third from top) Poultry and livestock (sheep) maintained in the same backyard. *Photo source: Dr. Everardo Mendes, California Department of Food & Agriculture, Meat, Poultry and Egg Safe Branch*
(Fourth from top) Broiler chickens and egg layer chickens maintained separately but in the same room of a backyard facility. *Photo source: Dr. Everardo Mendes, California Department of Food & Agriculture, Meat, Poultry and Egg Safety Branch*
(Bottom) Goose co-located in a gamefowl housing facility. *Photo source: Dr. Larry J. Allen, California Department of Food & Agriculture, Animal Health Branch*

Page 158 Backyard poultry kept in a wide variety of housing (top left). Gamefowl trio (top right). Rooster in make-shift individual housing (bottom left). Make-shift multiple-unit housing for gamefowl (bottom right). *Photo sources: Dr. Everardo Mendes, California Department of Food & Agriculture, Meat, Poultry and Egg Safety Branch (top left), Dr. Larry J. Allen, California Department of Food & Agriculture, Animal Health Branch (top right, bottom left, and bottom right)*

Page 159 Variation in methods to provide water and feed. *Photo source: Dr. Everardo Mendes, California Department of Food & Agriculture, Meat, Poultry and Egg Safety Branch*

Acronyms

AI	Avian Influenza
CAHFS	California Animal Health and Food Safety Services Laboratory
DEA	Drug Enforcement Agency
END	Exotic Newcastle disease
FAD	Foreign Animal Disease
FAD PReP	Foreign Animal Disease Preparedness and Response Plan
HCD	Highly Contagious Disease, e.g. avian influenza, exotic Newcastle disease
NAHEMS	National Animal Health Emergency Management System
NAHERC	National Animal Health Emergency Response Corp
NAHMS	National Animal Health Monitoring System
OIE	Office International des Epizooties, currently referred to as the World Organization for Animal Health
PHI	Poultry Health Inspector
SOP	Standard Operating Procedure
USDA	United States Department of Agriculture

Glossary

Biosecurity
Any management practice that may help reduce the risk of transmission of disease, i.e., anything that can be done to prevent or reduce the risk of disease entering into or escaping from a defined area such as a poultry production premises.

CO_2
Carbon dioxide gas

Derby (or Derbies)
Multiple cockfighting events, tournaments

Gamefowl
Cockfighting birds, also referred to as show birds, exhibition birds, avian athletes, gallos de pelir, gallos para combate

Ratites
Ostriches, emus, rheas

Trio (gamefowl trio)
One rooster and two hens maintained as a breeding unit

Upland Game Birds
Game birds that commonly inhabit areas located away from wetlands or bodies of water, e.g. pheasants, quail, and chukar partridge

INTERNATIONAL TRADE

The United States is the world's largest poultry producer and the second-largest egg producer and exporter of poultry meat. U.S. poultry meat production totals over 43 billion pounds annually: over four-fifths is broiler meat; most of the remainder is turkey meat; and a small fraction is other chicken meat. In 2012, total export value of broilers, turkeys, and eggs and egg products reached $5.7 billion. International exports of broilers totaled nearly 7,280 million pounds valued at over $4.6 billion USD. Approximately 797 million pounds of turkeys sold to other countries had a total value of $678 million. Exports of shell eggs (155 million dozen) and egg products (equivalent to 146 million dozen shell eggs) had a total value of $263 million.

BROILERS

The United States is the world's second-largest exporter of broiler meat behind Brazil. In 2012, approximately 21.4% of broiler meat produced in the U.S. was exported. Demand for U.S. broiler products has fluctuated over the last several years because of changing economic conditions and currency exchange rates in major importing countries. The largest importers of U.S. broiler products are Russia, China (including Hong Kong), and Mexico. Together, these markets accounted for over half of U.S. broiler product exports, on a quantity basis.

TURKEYS

The United States is the world's largest exporter of turkey products. In 2012, 13.5% of total U.S. turkey production was purchased by other countries. Less than 1 percent of turkey exports are whole birds; the majority of shipments are lower-valued turkey parts or ground or mechanically deboned meat (MDM). Many importing countries mix the ground or MDM turkey meat with other meats in sausage production. Mexico is by far the largest importer of U.S. turkey meat, accounting for over half of turkey exports.

EGGS AND EGG PRODUCTS

The United States is the third largest egg producer in the world, behind China and the European Union. Approximately 4.1% of eggs produced in this country were exported in 2012. Whole shell eggs for consumption are exported primarily to Hong Kong, Canada, and Mexico. Egg products (dried and nondried albumin; dried and nondried yolk) are used mainly in restaurants and in the baking and prepared-foods industries. Major destinations for U.S. exports of dried albumin are Japan, Spain, and Israel, while Canada is the largest importer of nondried albumin. Japan, Mexico, and Canada are the top destinations for dried yolk, while Japan, Canada, and South Korea are the top importers of nondried yolk.

INTERNATIONAL MARKETS

These markets are vital to the poultry industry. In the event of a highly contagious FAD outbreak affecting poultry, international trade of broilers, turkeys, eggs and egg products will be halted. Compartmentalization may potentially play a role in an effort to retain markets during recovery from a highly contagious FAD, once zoning efforts have been exhausted or proven inadequate.

Source:

- *USDA Economic Research Service. Accessed April 2013 at http://www.ers.usda.gov/topics/animal-products/poultry-eggs/trade.aspx*

Regionalization, also known as zoning, separates animal subpopulations to maintain disease-free status in one or more zones. Regionalization defines animal subpopulations primarily on a geographical basis. As an FAD response tool, regionalization can facilitate international trade, as well as FAD eradication.

For more information on regionalization, please see the FAD PReP SOP: Overview of Regionalization for International Trade, as well as 9 CFR 92.2, which lists 11 factors that should be evaluated in establishing a region.

Compartmentalization, which distinguishes between animal subpopulations by "management and husbandry practices related to biosecurity," has not yet been implemented within the United States with any trading partners (OIE, Chapter 4.4). Disease-free compartments must be recognized by trading partners prior to an outbreak for product movement. For further information on compartmentalization, please see the OIE Terrestrial Animal Health Code (2012), Chapter 4.4, as well as sections on compartmentalization in disease-specific chapters (for example, see Chapter 10.4 on infection with viruses of notifiable avian influenza).

DESIGNATION OF ZONES, AREAS, AND PREMISES

A critical component for FAD response is the designation of zones, areas, and premises. Epidemiological investigation and tracing will be used to classify premises. It is the responsibility of the Incident Management Team to designate zones and premises in an FAD outbreak. These zones, areas, and premises designations will be used in quarantine and movement control efforts.

Table 1 summarizes the premises designations that would be employed in an FAD outbreak response. Table 2 summarizes the zone and area designations that would be used in an FAD outbreak response.

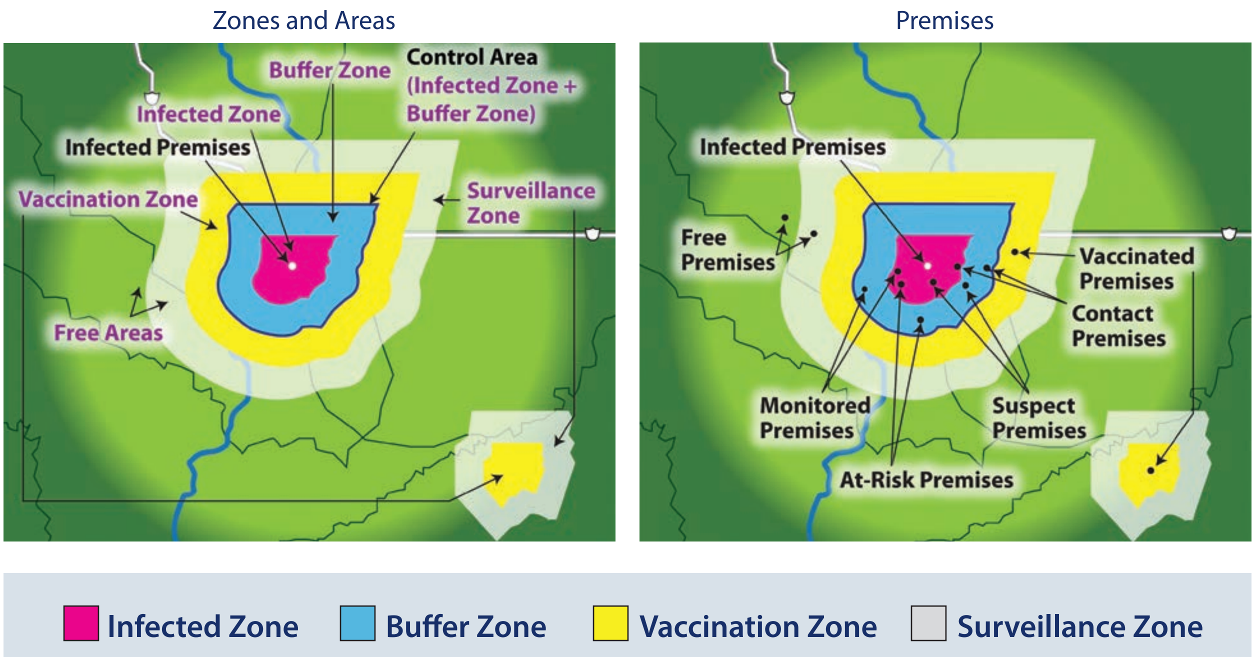
Table 1. Summary of Premises Designations

Premises Category	*Definitions*	*Zone*
Infected Premises (IP)	Premises where a presumptive positive case or confirmed positive case exists based on laboratory results, compatible clinical signs, case definition, and international standards.	Infected Zone
Contact Premises (CP)	Premises with susceptible animals that may have been exposed to the FAD agent, either directly or indirectly, including but not limited to exposure to animals, animal products, fomites, or people from Infected Premises.	Infected Zone, Buffer Zone
Suspect Premises (SP)	Premises under investigation due to the presence of susceptible animals reported to have clinical signs compatible with the FAD. This is intended to be a short-term premises designation.	Infected Zone, Buffer Zone, Surveillance Zone, Vaccination Zone
At-Risk Premises (ARP)	Premises with susceptible animals, but none have clinical signs compatible with the FAD. Premises objectively demonstrates that it is not an Infected Premises, Contact Premises, or Suspect Premises. At-Risk Premises seek to move susceptible animals or products within the Control Area by permit. Only At-Risk Premises are eligible to become Monitored Premises.	Infected Zone, Buffer Zone
Monitored Premises (MP)	Premises objectively demonstrates that it is not an Infected Premises, Contact Premises, or Suspect Premises. Only At-Risk Premises are eligible to become Monitored Premises. Monitored Premises meet a set of defined criteria in seeking to move susceptible animals or products out of the Control Area by permit.	Infected Zone, Buffer Zone
Free Premises (FP)	Premises outside of a Control Area and not a Contact or Suspect Premises.	Surveillance Zone, Free Area
Vaccinated Premises (VP)	Premises where emergency vaccination has been performed. This may be a secondary premises designation.	Containment Vaccination Zone, Protection Vaccination Zone

Table 2. Summary of Zone and Area Designations	
Zone	***Definition***
Infected Zone (IZ)	Zone that immediately surrounds an Infected Premises.
Buffer Zone (BZ)	Zone that immediately surrounds an Infected Zone or a Contact Premises.
Control Area (CA)	Consists of an Infected Zone and a Buffer Zone.
Surveillance Zone (SZ)	Zone outside and along the border of a Control Area.
Free Area (FA)	Area not included in any Control Area.
Vaccination Zone (VZ)	Emergency Vaccination Zone classified as either a Containment Vaccination Zone (typically inside a Control Area) or Protection Vaccination Zone (typically outside a Control Area). This may be a secondary zone designation.

Figure 1 illustrates all the zones and premises. Note: Figures are not to scale. The Vaccination Zone can be either a Protection Vaccination Zone or Containment Vaccination Zone

Figure 1. Example Zones and Premises



For details on the zones, areas, and premises, please see the *APHIS Foreign Animal Disease Framework: Response Strategies*. For additional information integrating the zones, areas, and premises designations with specific FAD response strategies, please see the disease specific response plans, such as the *HPAI Response Plan: The Red Book*.

These documents are available on the USDA-APHIS National Center for Animal Health Emergency Management website at *http://www.aphis.usda.gov/animal_health/*