POULTRY PRODUCTION, MANAGEMENT, AND SCIENCE

Topic Titles & Calendar Years for Written Examination

ALL YEARS (2012, 2013, 2014, 2015)

- Production Segments of the Poultry Industry
- Careers in the Poultry Industry
- Anatomy and Physiology of the Fowl
- Poultry Embryology
- Poultry Health Management
- Poultry Waste Management

ODD-NUMBERED YEARS (2013 and 2015)

- Poultry Environmental Control Management
- Poultry Genetics
- Poultry Nutrition
- Processing Poultry Products
- Marketing Poultry Products

EVEN-NUMBERED YEARS (2012 and 2014)

- Poultry Hatchery Management
- Market Broiler Management
- Market Turkey Management
- Egg-Strain Pullet and Hen Management
- Additional Poultry Enterprises and Products

PRODUCTION SEGMENTS OF THE POULTRY INDUSTRY

INTRODUCTION

The commercial poultry industry in the United States has two overall objectives: (1) production of table eggs, and (2) production of meat, primarily consisting of chicken and turkey products. In both systems, contract arrangements are usually made between the integrated company and the independent producers to coordinate the production of the final product (meat or eggs).

THE TABLE EGG INDUSTRY

The commercial egg industry is responsible for producing infertile eggs (table eggs) for human consumption. Throughout most of the United States, these operations use Leghorn-strain hens to produce white-shell eggs.

Egg Breeder Operations

The table egg production system must first include breeder farms on which parent birds (breeder males and females) are raised to produce fertile hatching eggs. From the hatching eggs come production-level males (cockerels) and females (pullets). However, because the goal is to produce infertile table eggs for consumption, production-level cockerels are not needed in egg pullet and egg laying operations.

Egg Pullet Operations

Production-level pullets are sent to pullet-growing farms responsible for growing pullets to replace older flocks of hens, which eventually reach the point where they can no longer efficiently produce infertile table eggs. Pullet growers employ management systems designed to maximize future egg production by producing healthy, vigorous pullets that can reach their genetic production potential.

On Leghorn-strain pullet farms, bird are raised from hatchlings to approximately 16 to 17 weeks of age, so pullet growers must provide facilities capable of brooding and growing the pullets. In most cases, the egg company pays pullet growers based on the number of birds produced or for returns per square foot, and efficiency bonuses may be available.

** Adapted from "The Poultry Industry" by Dennis Epperly, AST, Washburn, MO, and edited by Dr. Jason Emmert, Assistant Dean, ACES, University of Illinois, Urbana, IL.*

Egg Laying Operations

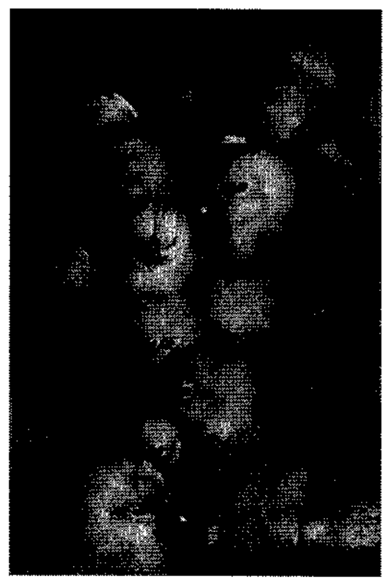
When Leghorn-strain pullets reach sufficient age and body weight and are ready to begin egg production, they are moved to another farm responsible for managing the hens during the egg production phase. Ninety percent of all table eggs are commercially produced by caged hens in large houses. Feeding and egg gathering are usually done mechanically. Initial investment is high, but this type of operation has steady cash flow.

For a typical egg laying operation, the production goals are to produce an average of oen dozen table eggs for every 3.0 to 3.5 pounds of feed provided, and to gather 240 to 350 eggs per hen housed during the 52 to 80-week laying period. In most cases, the egg company pays the grower based on the number of eggs produced, and efficiency bonuses may be available.

Egg Processing Operations

Table eggs are processed at facilities that wash, grade, and sort eggs. Many eggs are sold as shell eggs, but further processing of eggs into various products (hard-cooked eggs, frozen scrambled eggs, dried or liquid whole eggs, dried or liquid egg whites, etc.) also occurs.

THE BROILER MEAT INDUSTRY



The goal of broiler producers is to provide meat products for human consumption. Throughout most of the United States, the commercial broiler meat industry uses a white-feathered bird that is a cross between Cornish and White Plymouth Rock chickens. Similar to the egg laying industry, the broiler meat industry first includes breeder operations, which are responsible for raising parent birds (males and females) to produce fertile hatching eggs.

Broiler Breeder Operations

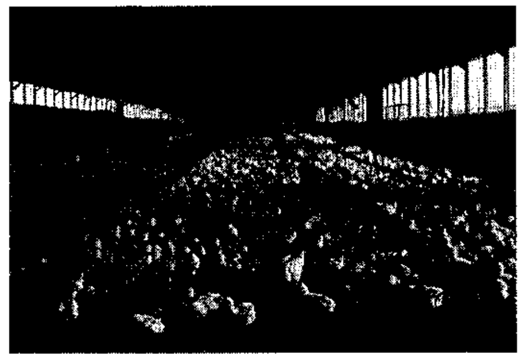
Broiler breeder operations include pullet and cockerel farms responsible for growing broiler breeder females and males to replace older breeder flocks, which eventually become unable to produce fertile hatching eggs efficiently.

On broiler breeder pullet and cockerel farms, birds are raised from hatchlings to approximately 20 weeks of age, so brooding and growing-out facilities must be provided. Broiler breeder pullet and cockerel growers are usually paid based on the number of birds produced or for returns per square foot, and efficiency bonuses may be available.

Broiler breeder operations also include a breeder farm to house broiler breeder cockerels and pullets that have reached sexual maturity. Breeder hens and roosters are managed to maximize production of fertile hatching eggs. Most houses have raised and slatted floors that include nest boxes to facilitate egg collection. Because of frequent egg gathering, breeder operations are more labor intensive than are grow-out operations. However, returns on investments are higher for breeder operations.

Growers are typically paid based on the number of hatching eggs produced. Companies may provide houses for efficiencies in hatchability, feed conversions, and settable eggs (those without double yolks or cracked and deformed shells). Efficiency standards toward which broiler breeder strive are one dozen settable eggs on seven or fewer pounds of feed and with 85% hatchability.

Broiler Grow-out Operations



After the hatching of fertile broiler breeder eggs at a company-owned hatchery, male and female broilers are taken to a grow-out farm, which is responsible for efficiently raising the birds to market weight. Broilers are young chickens of either sex grown as fryers or roasters to produce tender meat. Broilers are typically raised in large confinement house (for example, a 40' X 200' area may house 10,000 or more broilers at one time). Each broiler farm usually consists of one to six houses in which five to seven flocks are raised annually.

Nearly all (99%) of broiler production occurs under a contract system, and growers are typically paid based on the number of pounds of birds produced. Efficiency bonuses are usually available.

A broiler should reach 3.5 to 4.5 pounds of live weight in 6 to 7 weeks, and require two or fewer pounds of feed per pound of body weight. A broiler dresses into a 2 to 3-pound ready-to-cook carcass to be marketed whole, by parts, or further-processed.

Broiler Processing and Marketing Operations

Enormous competitions exist for different products (especially meats) in the poultry industry. Broiler processing plants and marketing operations must continuously evolve to support production of an ever-changing variety of products. These value-added items included ready-to-eat nuggets, tenders, and patties, and processed meats such as hams, frankfurters, and bologna, and various wing products. This is in addition to the raw meat products that include everything from whole birds to boneless, skinless thighs.

Operations are designed to maximize distribution of products to appropriate markets. White meat is primarily marketed to domestic customers. Dark meat products are mainly exported to countries that can more easily afford dark meat, or where consumer preferences are for dark meat products.

THE TURKEY MEAT INDUSTRY

The goal of turkey production operations is to produce turkey meat products for human consumption. Throughout most of the Untied States, the commercial turkey industry raises and uses Broad Breasted White birds. Similar to the egg laying and broiler industries, the turkey industry first includes breeder operations, which have the responsibility of raising parent birds (males and females) to produce fertile hatching eggs.

Turkey Breeder Operations

Turkey breeder operations include breeder poult farms responsible for growing turkey breeder males and females to replace older breeder flocks, which are no longer able to efficiently produce fertile hatching eggs. On turkey breeder poult farms, birds are raised sex-separately from hatchlings to approximately 25 to 30 weeks of age, so brooding and grow-out facilities must be provided.

Turkey breeder operations are similar to broiler breeder operations, except for the toms (males) being housed separately from the hens (females). Hens are artificially inseminated because selection for a market turkey with a large breast area makes natural mating inefficient. Turkey breeders require more labor than do broiler breeders, but payments are higher.

Turkey Grow-out Operations

After the hatching of fertile turkey breeder eggs at a company-owned hatchery, male and female turkeys are taken to separate grow-out farms responsible for efficiently raising the birds to market weight. Market turkeys are usually grown in large confinement operations, although a few are still raised on open ranges. Confinement operations vary in facilities, but most have separate housing for brooding and rearing. A typical turkey operation has a grow-out capacity of 16,000 to 18,000 birds.

Most (95%) turkey production occurs under a contract system, and growers are typically paid based on the number of birds produced. Efficiency bonuses are usually available.

Growers produce young turkeys that require approximately 2.5 pounds of feed per pound of body weight gain during the growing period. A hen marketed at 16 weeks of age usually weighs approximately 20 pounds. A tom marketed at 21 weeks of age weighs usually more than 40 pounds.

Turkey Processing and Marketing Operations

Most turkeys are marketed as whole carcasses, and seasonal variations (corresponding to increased consumption during the holidays) still exist but further processing does occur to produce value-added products. In particular, a demand exists for low-fat turkey products such as smoked turkey hams and turkey luncheon meats.

SUMMARY

The poultry production industry in the United States serves to produce table eggs and chicken or turkey meat products for human consumption. The industry is highly integrated, with egg and poultry meat operations combining breeding, hatching, growing out, and processing functions. Increased efficiencies of operation favor large operations and production of value-added products.

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TAMU Poultry Science – pg. 3

USDA – ARS – pg. 4

USDA – pg. 4, pg. 6

Tyson Foods, Inc. – pg. 5

CAREERS IN THE POULTRY INDUSTRY

Is there a future for you in poultry science? YES! Several job opportunities are available for individuals in today's highly advanced poultry industry that are trained and have initiative to get the job done. Phase of the industry with a demand for professional-level openings include:

Scientists	Mechanical and sales engineers
Businesspersons	Technology specialists.

GENETICS

Highly skilled geneticists have replaced the individual producer in the reproduction of today's commercial egg, broiler, and turkey production industries. Staff geneticists are employed by large primary breeding farms to assist in and direct the further development of their breeding programs, which include bird selection through advanced blood typing methods, as well as computerized compilation and analysis of production records.

Hatchery operations employ the following professionals to insure continued production of top quality chicks with integrated hatchery programs:
Numerous geneticists
Managers
Sales representatives
Service technicians

Time and research have proven that the biology and principles of incubation are as important as the functional mechanics of an incubator.

The thrill of new discoveries awaits individuals with an interest in the life sciences. Amazing progress has been made in past years, but more is yet to come in the reproduction of chickens and turkeys.

Training should include a background in basic poultry science with specialization in genetics. Opportunities await those who combine these talents with hatchery management.

PHARMACEUTICALS

Disease control is vitally important in the poultry industry. Rapid growth and intensified production demand that production losses associated with disease be held to a minimum.

While significant improvements have been made in disease management and biosecurity programs, continued improvement in disease management is needed to continue to reduce the risk of commercial poultry flocks to disease challenges. This type of research allows college graduates a wide latitude of personal choice and broad opportunities to express personal talents in specialized research laboratories.

**Dr. Jason Lee, Assistant Professor of Poultry Production, College of Agriculture and Life Sciences, Texas A&M University, reviewed and edited this topic's information.*

Large pharmaceutical companies have bacteriologists, pathologists, serologists, and other professions to continue to develop effective vaccines, medications, and feed additives (probiotic and prebiotic products) to solve complex disease problems.

Pharmaceutical firms need trained young people in sales, service, and communications. The efforts of scientists would be wasted without this vital link in the industry's chain.

Training for the pharmaceutical field generally requires undergraduate study and, in some cases, graduate work leading toward a degree in veterinary medicine or other specifically related fields.

NUTRITION

Experts predict that the well-fed hen, turkey, or broiler receives a more scientifically balanced diet throughout life than do most humans. As the industry becomes more advanced and deals with challenges including rising dietary costs, nutritionists are challenged to discover new combinations of feed ingredients and feed additives to meet the producer's needs.

A nutritionist's job does not end with merely finding new scientific nutritional facts, however. They must also help discover the most economical source of ingredients and assist in combining these ingredients into skillfully balanced feed formulas to meet the ever changing nutrient requirements of commercial poultry. A nutritionist's training generally requires advanced degree work.

There are also opportunities for young people in sales, service, and management among the highly competitive feed companies. These large concerns must also give the producer service and provide information on management techniques in addition to providing a high quality feed.

The sales and service field requires knowledge of technological subjects in addition to business training.

ENGINEERING

The efforts of agriculturally oriented engineers in the poultry industry have advanced toward complete automation as compared to any other livestock enterprise. Although, more innovation is still needed to continue to increase automation and reduce potential production costs.

Individuals are needed to design and build the automated poultry equipment of tomorrow that will be used in production and processing facilities; other engineers are needed to supervise the actual construction of new automated equipment. Although these people are primarily engineers, they must have a basic knowledge of the product and production cycle and its ultimate use.

Opportunities exist in the sales and service fields. Large manufacturers of poultry equipment seek young persons with a combined knowledge of poultry technology, sales ability, and mechanical aptitude to sell and service their line of products.

Training for these areas should include mechanics, electricity, design, and general agricultural engineering, and some background in poultry science and business.

PRODUCTION

To be successful, young persons should obtain a college education to properly prepare themselves for coping with the complexity of modern poultry production.

Such success requires that a producer have a firm foundation in technological husbandry — including genetics, nutrition, disease control, business principles, equipment, and the many other aspects of commercial enterprises. Knowledge of the marketing chain and the economics associated with marketing are necessary.

A very large investment is required for starting the operational ownership of a chicken or turkey enterprise to provide economic stability. This is a major problem for young people to overcome, but it is being done!

The industry trend to specialization and integrated units has increased the demand for trained managers who can solve production problems, direct employees, and supervise business operations. These managers often acquire ownership, thus providing young people with another avenue to eventual self-employment.

FOOD SCIENCE AND PROCESSING

The future growth of the poultry industry is closely associated with advancements in food manufacturing technology combined with food safety. There is a large demand for well-trained poultry food scientists with these capabilities. Managerial skills are a major asset because of the interrelationships and management of individuals in the processing and further-processing plants.

A food science career offers the potential for rapid advancement for the poultry science graduate. It requires a strong science background, which provides ample opportunities for advanced graduate study and career enhancement. Individuals that decide to move forward with graduate opportunities can also enjoy a career in the research and development of new poultry food products.

AGRIBUSINESS

Agribusiness is the supplying of producers with the services and materials necessary for production, including the processing and marketing of products to meet the consumer's needs.

Commercial banks, finance institutions, and accounting firms need agricultural representatives in major poultry areas to assist producers with management problems.

Increased emphasis is being placed upon packaging and merchandising poultry products by private business, cooperatives, industry organizations, and governmental agencies, thus providing young people with many promising careers.

Likewise, the fields of mass communications and public relations offer many positions for college graduates with journalistic abilities and poultry knowledge — young people who know the "language of agriculture" and can explain it in simple terms to the general public.

Specialized training is necessary for these various fields as well as a solid background in both business and poultry science.

Poultry production operations are increasing in volume to meet the demand of an exploding population. Such technological advancement has increased the demand in all segments of the industry and allied fields for more trained individuals, and thus has created a serious problem for the industry in the shortage of qualified individuals to fill these needed positions.

CHALLENGES

Challenges go with the problems, and imaginative young people who select careers in poultry science will solve many of the current problems including managing increasing diet cost, continually providing a safe product through integrated food safety programs, and continued management of disease and biosecurity programs. Those who can meet these challenges creatively and productively will find excellent opportunities for professional growth.

ATTRACTIVE POSITIONS

Careers in the poultry industry include:

- Research and development
- Management
- Production and food science technology
- Merchandising
- Sales and service
- Engineering
- Business
- Public relations

Salaries are equally attractive. The average graduate entering the commercial job market will find salaries to be better than those available in other fields of agriculture.

Fringe benefits included in employee incentives:

- paid vacations
- profit sharing
- bonus plans
- company credit unions
- stock purchases
- housing
- health services
- medical & life insurance
- holidays
- retirement benefits

GET READY FOR A POULTRY CAREER

Selected Poultry Industry Occupations related to Research and Engineering

- Automated Systems Engineer
- Biochemist
- Biomedical Engineer
- Biophysicist
- Equipment Designer
- Parasitologist
- Physiologist
- Quality Control Technician
- Safety Engineer
- Toxicologist

- Food Product Engineer
- Food Scientist
- Geneticist
- Microbiologist
- Nutritionist
- Veterinarian
- Veterinary Anatomist
- Veterinary Laboratory Technician
- Waste Systems Engineer

Selected Poultry Industry Occupations related to Product Marketing and Sales

- Buyer
- Commodity Broker
- Customs Inspector
- Equipment Sales Representative
- Feed Sales Representative
- Grader
- Marketing Analyst
- Marketing Manager
- Marketing Inspector
- Merchandiser
- Packaging Supervisor
- Sales Promotion Director

Selected Poultry Industry Occupations related to Management and Finance

- Appraiser
- Business Manager
- Credit Analyst
- Economist
- Egg Processing Supervisor
- Enterprise Management Analyst
- Feed Mill Supervisor
- Financial Accountant
- Food Processing Manager
- Hatchery Supervisor
- Industry Analyst
- Information Systems Programmer
- Laboratory Supervisor
- Meat Processing Supervisor
- Product Manager
- Production Supervisor
- Research Director
- Vehicle Assets Manager

Selected Poultry Industry Occupations related to Production

- Confinement Systems Worker
- Domestic Bird Breeder
- Domestic Bird Producer
- Egg Candling Worker
- Egg Packaging Worker
- Egg Producer
- Egg Production Worker
- Equipment Installer
- Equipment Servicer
- Exotic Bird Breeder
- Exotic Bird Producer
- Facilities Builder
- Feed Producer
- Flock Service Technician
- Game Bird Breeder
- Game Bird Producer
- Hatchery Manager
- Maintenance Worker
- Meat Producer
- Production Foreman
- Ration Formulator
- Wholesale Producer

Selected Poultry Industry Occupations related to Education and Communications

- Advertising Specialist
- Agricultural Sciences Teacher
- Broadcaster
- College Faculty Member
- Computerized Information Specialist
- Cooperative Extension Agent
- Information Systems Analyst
- Instructional Media Specialist
- Mass Communications Specialist
- Poultry Extension Specialist

Selected Poultry Industry Occupations related to Social Services

- Disease Control Agent
- Environmentalist
- Field Service Technician
- Industry Planner
- Industry Representative
- Quality Control Agent
- Veterinary Inspector
- Waste Products Consultant

More information about poultry science careers can be obtained from the school counselor, agriscience teacher, the Cooperative Extension Service, an agricultural college or university in the state, or write/call the following:

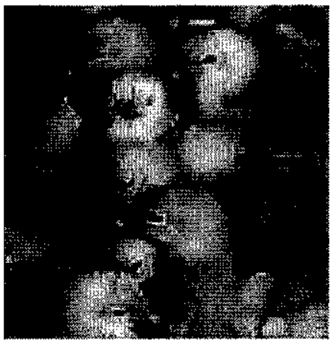
National Chicken Council, 1015 Fifteenth Street, NW, Suite 930, Washington, DC 20005-2605, Phone 202-296-2622, Fax 202-293-4005, http://www.eatchicken.com/

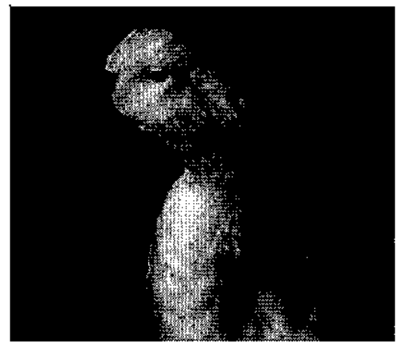
Poultry Science Association, 1111 North Dunlap Avenue, Savoy, Illinois 61874, Phone 217-356-3182, Fax 217-398-4119, http://www.psa.uiuc.edu/, psa@assochq.org

U. S. Poultry and Egg Association, 1530 Cooledge Road, Tucker, Georgia 30084-7303, Phone 770-493-9401, Fax 770-493-9257, http://www.poultryegg.org/

ANATOMY AND PHYSIOLOGY OF THE FOWL *

INTRODUCTION





A bird's body is made up of biological systems consisting of groups of tissues, which collectively contribute to one or more complex and vital functions of the organism. Part of the success of any poultry business depends upon a thorough knowledge of how these systems function as a unit when they are subjected to varying changes in the bird's environment. Discussed in this topic is each biological system from the standpoint of its major functions, how it compares anatomically and physiologically to other domesticated animals, and how these features affect the total management of poultry.

The various species of poultry belong to the animal kingdom and to the class Aves. They are feathered, biped, warm-blooded vertebrates with a four-chambered heart. The chicken (*Gallus gallus*), guinea fowl (*Numida meleagris*), turkey (*Meleagris gallapavo*), and pheasant (*Phasianus colchicus*) belong to the order Galliformes. They are large-bodied birds of terrestrial habits, have comparatively short wings that are poorly adapted for long flight, possess short beaks, and have legs and toes adapted for running and scratching. Ducks (*Anas platyrhynochos*) and geese (*Anser anser*) belong to the order Anseriformes.

Other familiar fowl include the peafowl (*Pavo cristatus*), pigeon (*Columba livia*), and bobwhite quail (*Colinus virginianus*).

Poultry, when compared to other livestock, have unique anatomical and physiological characteristics.

- high body temperature (105°F to 107°F; 40.6°C to 41.7°C)
- high pulse rate (300 beats per minute while at rest)
- high respiration rate (14 to 22 exchanges per minute while at rest)
- high rate of food passage (example: 2.5 hours for a laying hen; 8-12 hours for a nonlayer)
- lightweight skeleton (hollow long bones) and fusion of certain bones (provide rigidity for flight)
- modification of forelimbs into wings

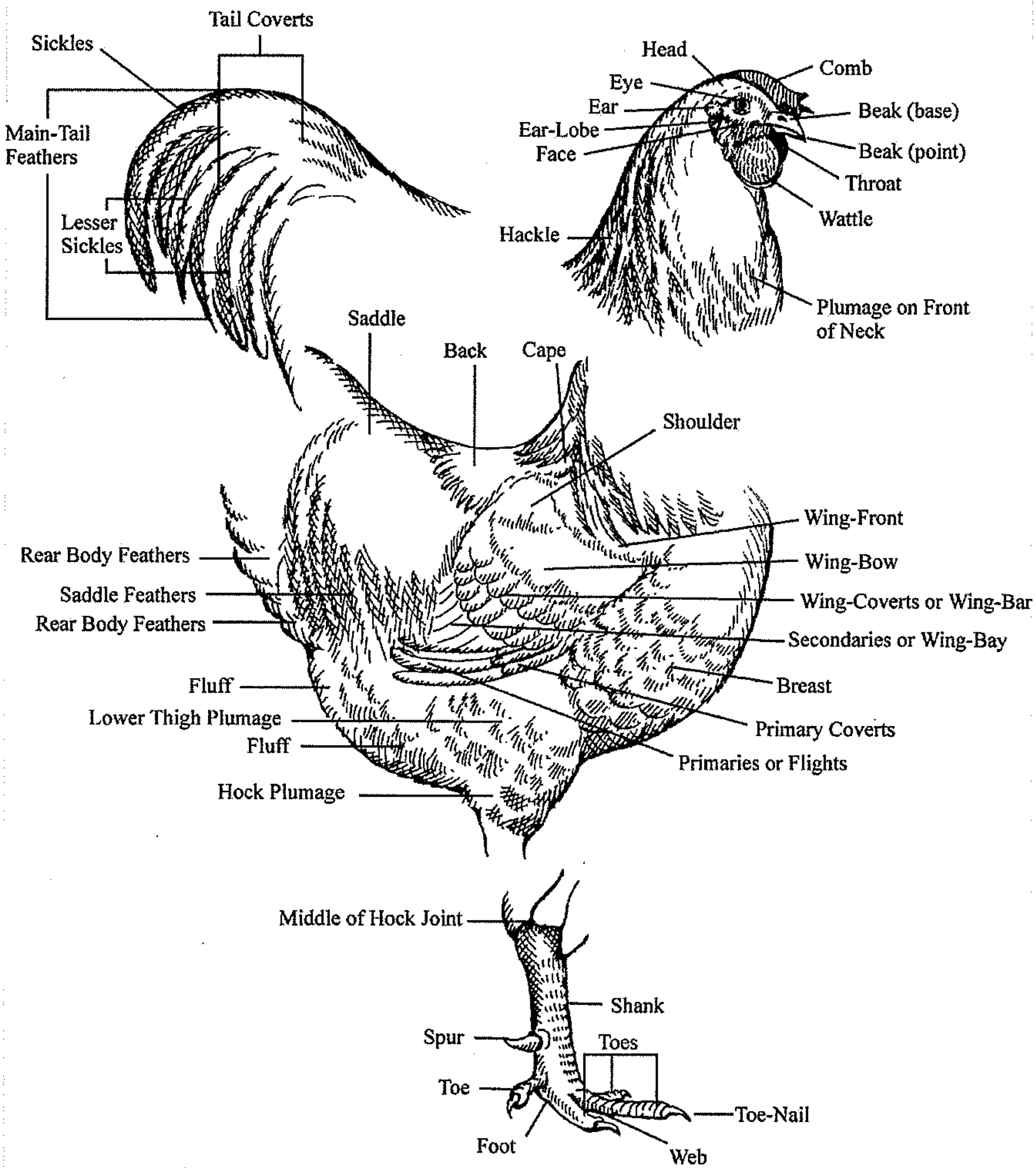
** Adapted from information by Albert W. Adams and Ken Anderson, Poultry Extension Specialists, Kansas State University and North Carolina State University, respectively. Reviewed and revised by Dr. Lyndon Irwin.*

Table 1. Taxonomic Classification of Important Poultry Species

Kingdom	Phylum	Class	Order	Family	Genus	Species	Common Name
Animalia	*Chordata (subphylum Vertebrata*	*Aves*	*Galliformes*	*Phasianidae*	*Gallus*	*Gallus gallus*	*Chicken (domestic)*[1]
					Meleagris	*Meleagris gallipavo*	*Turkey (wild & domestic)*
					Phasianus	*Phasianus colchicus*	*Pheasant (ring-necked)*
					Pavo	*Pavo cristatus*	*Peafowl (Indian, or blue)*
					Coturnix	*Coturnix coturnix*	*Quail (common)*
				Odontophoridae	*Colinus*	*Colinus virginanus*	*Quail (northern bobwhite)*
				Numididae	*Numida*	*Numida meleagris*	*Guinea fowl (helmeted)*
			Anderiformes	*Anatidae*	*Anas*	*Anas platyrhynchos*	*Duck (mallard)*
					Anser	*Anser anser*	*Goose (domestic)*
					Cygnus	*Cygnus cygnus*	*Swan (common whooper)*
			Columbiformes	*Columbidae*	*Columba*	*Columba livia*	*Pigeon (domestic)*
					Streptopelia	*Streptopela decipiens*	*Dove (mourning)*

[1] The term Gallus domesticus, often used for domestic chickens, is a misnomer.

External Parts of a Chicken



INTEGUMENTARY SYSTEM

Functions of the integumentary system (skin and its appendages) are protection, regulation of body temperature, flight, and development of secondary sex characteristics.

Skin

The fowl's skin is comparatively thin and consists of an outer layer (epidermis) and an inner layer (dermis). Various skin colors found on fowl, particularly on the shanks and beaks, result from different combinations of pigments (carotenoids such as xanthophyll from feed and melanic from the bird) in the upper and lower layers of skin. Common shank colors are yellow, white, blue, green, and black. Skin color influences consumer acceptability of poultry meat, with yellow preferred in the United States.

Special features of a bird's skin are the comb, wattles, earlobes, oil gland, and feathers. The comb and wattles serve as secondary sex characteristics. They are important for regulating the bird's body temperature. Their development is closely related to the gonadal activity of the bird.

Surgical removal of the comb and wattles is called "dubbing" and "dewattling," respectively. The earlobes are usually either red or white patches of skin on both sides of the bird's head. Both earlobe color and comb type are genetically controlled.

Feathers

Feathers originate from distinct feather tracts called pterylae. Feathers are appendages of the skin. Feather color is a genetic trait. Most economically important species of chickens and turkeys in the nation are predominantly white feathered, because carcasses of white feathered birds look cleaner after processing than do carcasses of dark feathered birds. Feather appearance differs between the sexes in the neck, back, saddle, and tail sections.

Molting (shedding of old feathers) is not compatible with egg production. Growing new feathers is a severe physiological drain on the bird. Therefore, when hens molt, they generally go out of egg production. Molting rate and molting pattern of the large wing feathers are estimates of the length of time a laying hen has not been producing eggs.

Muscle System

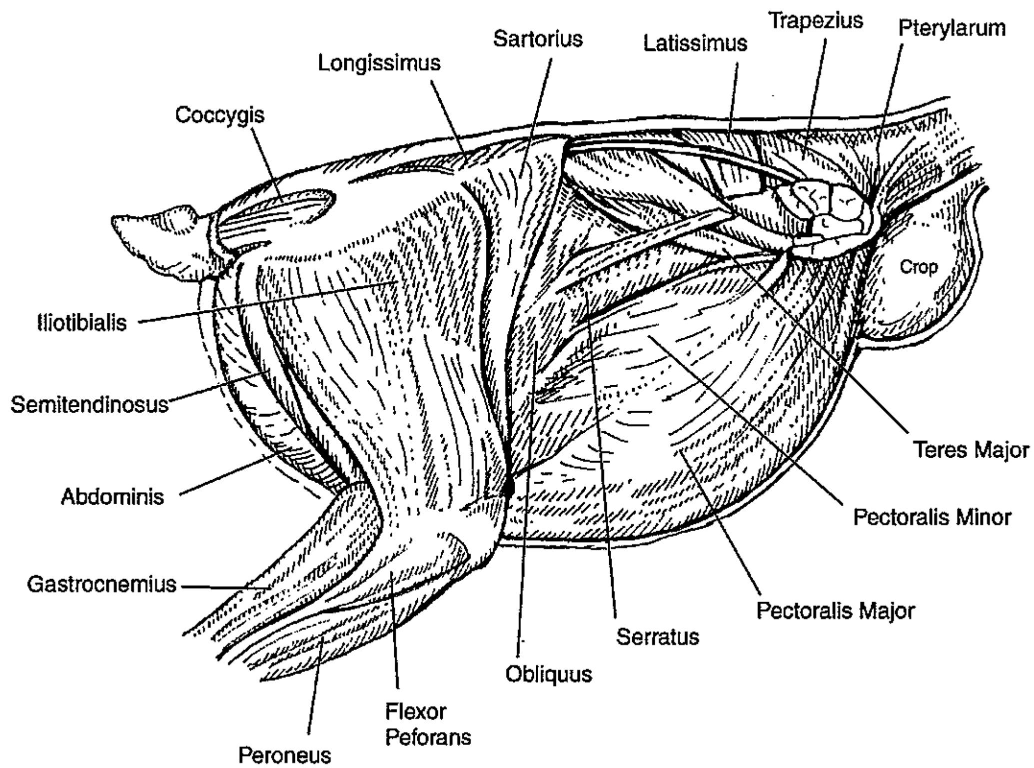
The fowl's muscle system is a powerful one designed for flight. Major functions are movement, body form, protection, and heat generation.

A unique feature of the avian muscle system is the extensive development of pectoral muscles in the wing and breast regions. The greater proportion of these muscles appears to be on the body proper because of the extensive attachment to the sternum. Muscles in this region weigh nearly as much as all the other muscles. Pectoral muscles account for 15% to 20% of the bird's total weight; this compares to less than one percent for a human's total weight.

Although flight is not a primary consideration in domesticated birds, the ratio of breast meat weight to total body weight is important because most American consumers prefer breast meat.

Breast muscles of chickens and turkeys are very light in color because of a low level of myoglobin pigment. The amount of myoglobin depends on the type of flight pattern of the bird, particularly as it relates to level and duration of muscle activity. Less muscle activity causes a lower level of myoglobin and thus the reason for the white meat in chickens and turkeys.

Muscle	Body Action
Abdominis	Supports the abdomen
Coccygis	Elevates and depresses the tail
Flexor perforans	Flexes the toes
Gastrocnemius	Extends the toes downward
Iliotibialis	Flexes and extends the hip
Latissiumus	Draws the humerus inward
Longissimus	Maintains bird posture
Obliquus	Flexes the abdomen
Pectoralis major	Depresses the wing
Pectoralis minor	Elevates the wing
Peroneus	Extends the tarsometatarsus (foot) outward
Pterylarum	Moves the feathers
Sartorius	Flexes the knee and rotates the leg outward
Semitendinosus`	Flexes the knee joint and extends the thigh
Teres major	Rotates the humerus
Trapezius	Moves the scapula & draws the head left or right



Muscles of a Chicken (head, wing, and shank removed)

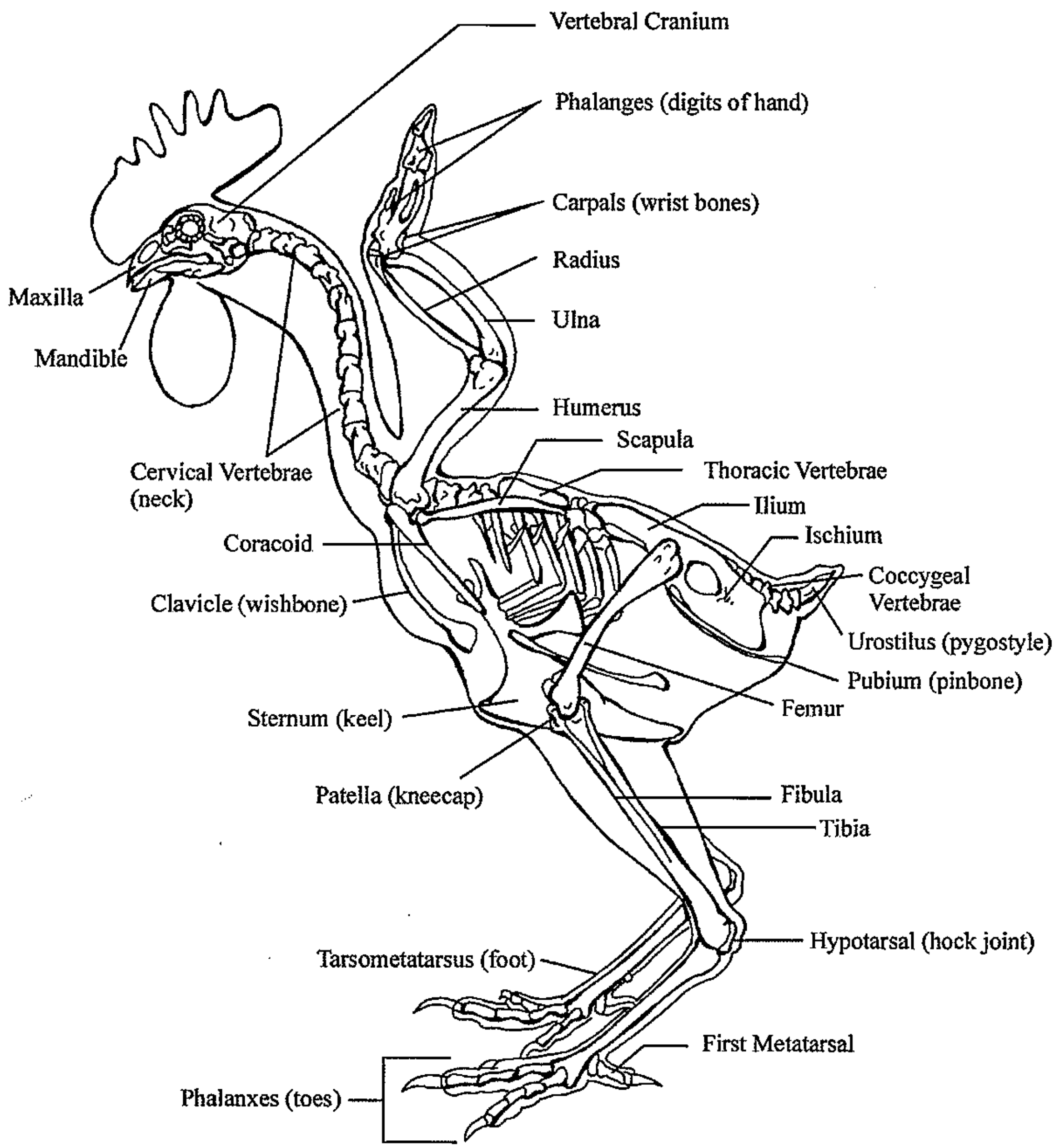
Skeletal System

Major functions of the skeletal system are locomotion, support of the muscles, protection of internal organs, formation of red blood cells, and assistance in respiration and flight.

The skeletal system of birds is built for flight. It is light in weight because many of the long bones are hollow and are penetrated by extensions of the air sacs. It is rigid because of a marked tendency for bones to fuse in certain areas, such as in the vertebral column and pectoral and pelvic girdles. The sternum or breastbone is highly developed to provide attachment for the pectoral muscles. Deformed breastbones (resulting from improper management, nutrition, or disease) reduce the market value of poultry, because they distract from the appearance of the dressed carcass.

Another skeletal feature is modification of the forelimbs into wings.

Skeleton of a Chicken



Special Senses

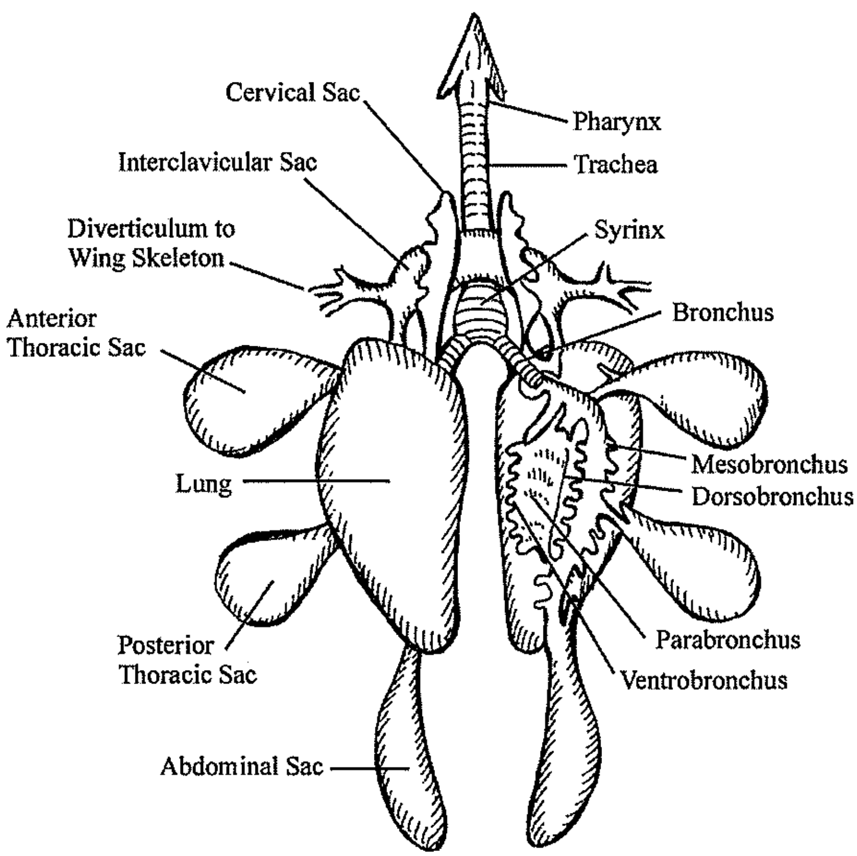
The degree of development of the senses of sight, hearing, smell, and taste varies among species. In the fowl, the senses of sight and hearing are highly developed, and the senses of taste and smell are poorly developed.

Chickens and turkeys are more sensitive to the red portion of the light spectrum than to the blue portion. This has practical applications in bird production. Red light controls cannibalism, and blue light calms birds for handling.

Respiratory System

Respiratory system functions are gas exchange, temperature regulation, and communication.

LARYNX - Birds have an upper and lower larynx. The lower larynx (syrinx) is the voice box. It is located where the trachea divides into the two primary bronchi.
TRACHEA - This tube consists of cartilaginous rings that connect the upper and lower larynxes.
BRONCHI - The main bronchi pierce the ventral end of each lung, pass through the whole length, and communicate finally with the abdominal air sacs. Within the lung, these primary bronchi branch into secondary bronchi of various sizes, which communicate directly or indirectly with air sacs. Tertiary bronchi radiate toward the surface of the lung where they end blindly.
LUNGS - The avian lung differs from the mammalian lung in that it is non-expandable, non-lobed, and is partially imbedded in the ribs. Lungs serve as the site for gaseous exchange.
AIR SACS - Along with the parts normally found in mammals, birds possess eight to nine air sacs in the body cavity and a complex system of bronchi that move air in and out of the lungs. Air sacs are unique to birds and certain reptiles.



The membranes composing the walls of the air sacs are extremely thin, transparent, and mostly devoid of blood vessels. The lack of blood vessels prevents gaseous exchange and makes the fowl's air sacs very susceptible to respiratory infections when exposed to high concentrations of dust.

Functions of the air sacs are related to the ability of birds to fly.

- aid in efficient circulation of air through the lungs
- reduce specific gravity of flying birds
- help regulate body temperature
- provide a reserve supply of air for flying birds
- used in the courting ceremony by the males of certain species of birds (such as the turkey and the prairie chicken)

CIRCULATORY SYSTEM

Circulatory system functions in the fowl are transportation of food, gases, wastes, and hormones to and from cells; body temperature regulation; and disease protection. The fowl's circulatory system differs slightly from mammals in that avian red blood cells are nucleated. Like mammals, birds have four chambers in the heart (2 atria & 2 ventricles), that separate oxygenated and de-oxygenated blood. The extremely fast heart beat is unique to the bird.

DIGESTIVE SYSTEM

Functions of the digestive system are prehension, storage, mastication, digestion, absorption, and elimination of waste. The structure and length of the alimentary tract largely determines the type of food that is nutritionally useful for a particular species. Meat and grain eaters such as birds, dogs, and cats have shorter digestive tracts than do livestock. For example, the ratio of body length to digestive tract length is 1:4 for chickens and 1:27 for sheep. Among birds, the ratio varies with meat-eaters having a narrower ratio than grain-eaters.

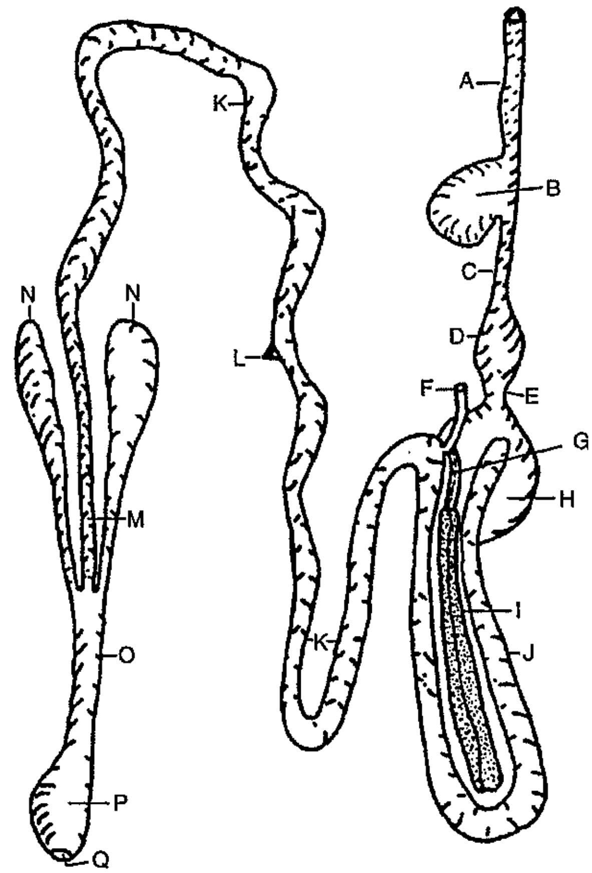
MOUTH - Prehension of food by birds differs from mammals because birds do not have teeth, lips, or cheeks. The pointed tongue (with barb-like projections on the back) and the horny papillae on the roof of the mouth serve the purpose of forcing food toward the gullet. A relationship exists between the shape of a bird's beak and the type of food it normally eats. Chickens and turkeys have pointed beaks because they are grain eaters.

ESOPHAGUS - This flexible tube, next to the trachea, connects the mouth to the crop.

CROP (INGULVIES) - The crop stores and moistens food. The length of time that food remains in the crop depends on the nature of the food. Whole grains remain in the crop longer than do ground grains. Research indicates that the crop's fullness is involved in regulating feeding activity.

"BIRD'S EYE" VIEW OF THE FOWL'S ALIMENTARY CANAL (Mouth & Pharynx excluded)

A. Cervical Esophagus
B. Crop (Ingulvies)
C. Thoracic Esophagus
D. Glandular Stomach (Proventriculus)
E. Isthmus
F. Hepatic Duct
G. Pancreatic Duct
H. Muscular Stomach (Ventriculus or Gizzard)
I. Pancreas
J. Duodenum
K. Jejunum
L. Remnant of Yolk Stalk
M. Cecum
N. Ileum
O. Colon
P. Cloaca
Q. Cloacal Orifice



GLANDULAR STOMACH (PROVENTRICULUS) - This segment contains cells that secrete gastric juices, which contain hydrochloric acid and the enzyme pepsin.

MUSCULAR STOMACH (VENTRICULUS OR GIZZARD) - The gizzard serves as the bird's "teeth." It consists of a thick, powerful muscle and has a thick, tough lining. The chief function of the gizzard is to grind coarse food. Grit is sometimes added to the feed to aid this process. Birds that are fed finely ground feedstuffs generally do not benefit from grit. The muscular development of the gizzard depends on the type of feed. Gizzards of birds fed finely ground mash are less developed than are gizzards of birds fed whole grains.

SMALL INTESTINE - The first section is the duodenum. This folded loop encloses the pancreas. Termination of the duodenum is marked by the pancreatic and bile ducts, which empty their secretions into the small intestine. Main functions of the small intestine are secretion of digestive enzymes and absorption of nutrients. The pancreas is a narrow strip of tissue lying in the duodenal loop. It secretes digestive enzymes (into the small intestine) and the hormone insulin.

CECUM - This paired segment marks the junction of the small and large intestines. The ceca help with the breakdown of the more resistant cell wall materials in the presence of anaerobic bacteria.

LARGE INTESTINE - The large intestine is very short in the fowl. Its main functions are resorption of water and storage of fecal wastes.

CLOACA - The cloaca is a cavity for the entrance of the genital, urinary, and digestive tracts.

LIVER - The liver is an accessory organ to the digestive tract. It synthesizes lipids and proteins (for eggs), secretes bile (for absorption of fat), and stores excess carbohydrates (as glycogen).

GALL BLADDER - The green-colored gall bladder attaches to the liver, and it stores bile.

REPRODUCTIVE SYSTEM

The Female System

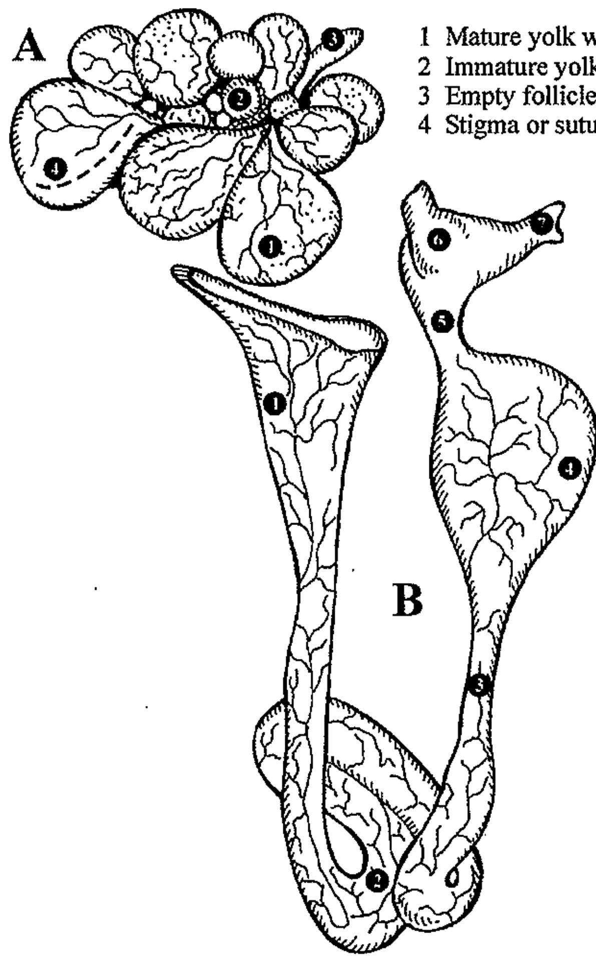
Important structural features of the fowl are associated with the reproductive organs. During her life, a hen lays many eggs, which are produced by her one functional ovary (left side) and its associated oviduct. The egg is large because it contains enough food material to support the developing embryo until hatching. The female reproductive system's functions are reproduction (egg laying) and sex hormone secretion. It is divided into two distinct sections — ovary and oviduct.

The ovary consists of a large ovarian mass of loosely connected, follicular tissue. Each spherical body in the ovary is a follicle, containing an ovum (undeveloped yolk) surrounded by a vascular follicle membrane. A nonvascular stigma (suture line) is on each mature follicle. During normal ovulation, the follicular membrane ruptures along the stigma to prevent hemorrhaging and blood spots in the egg.

The chicken's oviduct is nearly 78 cm (30 in) in length. It contains the infundibulum, magnum, isthmus, uterus, and vagina. Refer to the table and illustration on the next page.

Malfunction of the hen's reproductive system may result in abnormalities such as double-yolk eggs, yolkless eggs, shell-less eggs, and an egg within an egg.

REPRODUCTIVE TRACT OF FEMALE



A Ovary

1 Mature yolk within yolk sac or follicle
2 Immature yolk (Dudoplasm)
3 Empty follicle
4 Stigma or suture line (*represented by broken line*)

B Oviduct

1 Infundibulum
2 Magnum
3 Isthmus
4 Uterus
5 Vagina
6 Cloaca
7 Vent

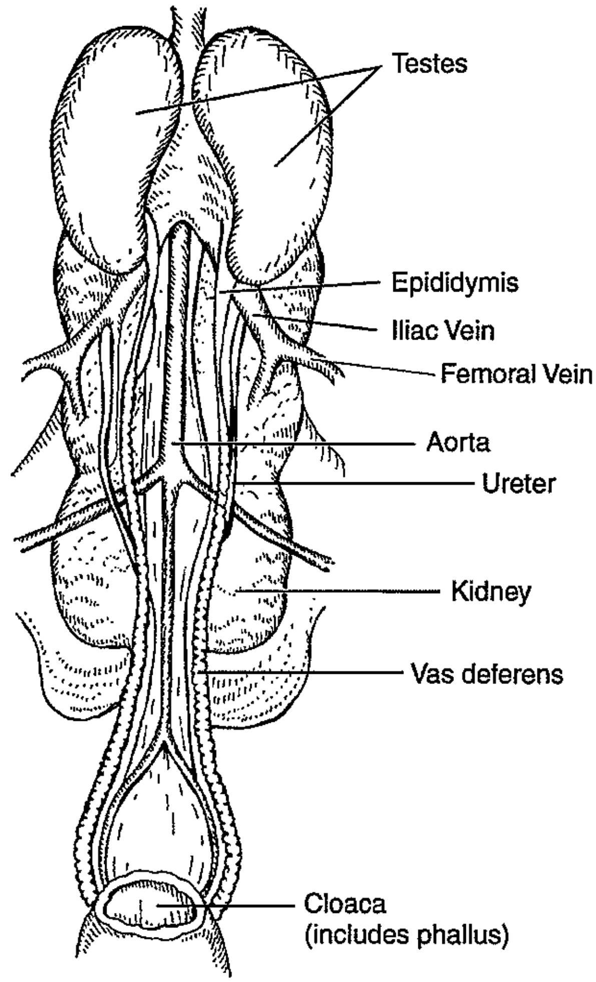
Section	Length of Time Egg Spends in Each Section	Function(s)
Infundibulum	15 minutes	Engulfing of the yolk, site of fertilization
Magnum	3 hours	Secretion of thick white (albumen)
Isthmus	1.25 hours	Formation of the two shell membranes
Uterus	20 to 21 hours	Formation of thin white (albumen) consisting mainly of water Addition of salts, hard shell, and shell pigment
Vagina		Passage of the egg (oviposition)

The Male System

The reproductive system of the male fowl differs from mammals. Spermatogenesis occurs at a higher temperature for the fowl than for mammals because the testes of male fowl are located in the body cavity rather than in a scrotum.

Males lack an external penis. The male's small papilla becomes erect and deposits semen on the everted vagina of the female during mating. The papilla is more developed in ducks and geese than in chickens and turkeys. Day-old chicks and poults can be sexed by examining their everted rudimentary sex organs.

Sperm survive in the avian female's body for several weeks but only a few hours in the mammalian female.



Urogenital System of the Male

Urinary System

The main feature of the fowl's urinary system is the lack of a bladder and the excretion of nitrogen waste products (as uric acid) with the feces. The uric acid is the white material seen in bird droppings. The dark red kidneys are located on either side of the vertebral column. Excretory ducts (ureters) are visible on the surface of the kidneys. Main functions of the urinary system are filtration, absorption, and excretion.

Endocrine System

The endocrine system consists of a number of glands that produce secretions called hormones. These hormones, along with the nervous system, regulate most body functions. The action of each hormone is very specific. Many malfunctions that occur in birds are the result of improper functioning of one or more endocrine glands.

HYPOTHALAMUS - This is a gland at the base of the brain, which when stimulated by neural stimuli, secretes releasing factors that regulate the release of hormones from the pituitary gland.

PITUITARY - This is a bi-lobed gland located at the base of the brain that is called the "master gland" because it releases hormones (such as the following) that regulate activities of other endocrine glands.

Follicle Stimulating Hormone (FSH) - FSH is responsible for growth and maturation of ovarian follicles (egg yolks) in the ovary. Secretion of this hormone is under the influence of a gradual increase or decrease in duration of the diurnal photoperiod.

Luteinizing Hormone (LH) - LH causes release (ovulation) of the ovum from the follicle. Secretion is influenced by the dark-light cycle of the diurnal sequence.

Oxytocin - This hormone stimulates oviposition (laying of eggs).

Prolactin - This hormone stimulates the female to become broody (maternal tendency of birds to nest and hatch eggs).

Thyrotropin - This hormone regulates activity of the thyroid gland.

THYROID - The thyroid secretes thyroxin, which regulates rate of metabolism and is involved in pigmentation, structure, and molting of feathers.

PARATHYROID - The parathyroid secretes a hormone that regulates calcium levels of the blood. This is very important in egg shell formation.

OVARY - The ovary secretes the hormone, estrogen, which stimulates development of the secondary sex characteristics (such as hen feathering), and the hormone, progesterone, which prepares the ovary and oviduct for egg formation. Synthetic estrogenic compounds are used to pseudo caponize cockerels.

TESTES - Testes secrete the hormone, testosterone, which stimulates development of secondary sex characteristics (male feathering, crowing, and spur development), comb growth, and spermatogenesis.

PANCREAS - The pancreas secretes insulin, which regulates sugar metabolism.

ADRENALS - Adrenals secrete hormones that regulate utilization of minerals.

SUMMARY

A bird's body is made up of several biological systems, which collectively contribute to one or more complex and vital functions of the organism. The success of any poultry business depends not only on a thorough knowledge of the integumentary, muscular, skeletal, endocrine, respiratory, digestive, reproductive, urinary, and circulatory systems, but also on the effects of management and environment.

POULTRY EMBRYOLOGY *

INTRODUCTION

To provide an idea of how complex the development of an embryo is, we can compare embryology to playing music. A symphony, an orchestra having 100 or more players, is one of the most complex forms of musical organizations. Many of the members play string instruments, such as violin and cello, usually with several different parts for each instrument. There are also woodwind, brass, and percussion sections. When playing music, there is a time for each member to play and a time to rest. There is a time to be featured in the music and a time to remain in the background. When each member plays correctly, various sounds, tempos, and volumes make music that we recognize and enjoy.

The development of an embryo, and later a mature animal, is more complex than performing music. Scientists are mapping genomes; discovering the sequences of information that are in chromosomes. It is expected that more than 20,000 sequences will be discovered in the chicken genome, each sequence resulting in a body protein (Cogburn et al., 2003). Producing the right amount of each protein at the right time is what regulates development and life. Considering all the factors that must be coordinated, it is amazing that only a few mistakes occur.

EARLY EMBRYONIC DEVELOPMENT

An egg starts development in the ovary (refer to "Anatomy and Physiology of the Fowl" unit). In about a week's time, an ovum develops to the size of a yolk by collecting lipid particles from the blood that was made in the hen's liver. When the yolk is the correct size, it is released from the ovary into the hen's abdomen. The infundibulum catches the yolk, which then starts its journey through the oviduct to add the albumen and shell.

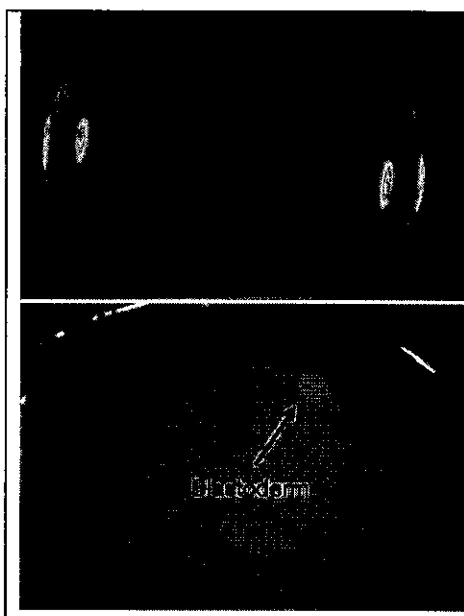


Figure 1 - An infertile egg (top) has a blastodisc; a fertile egg (bottom) has a blastoderm. The blastoderm is larger because cell division proceeded after fertilization until the egg was laid.

The particles in the yolk are an important source of nutrition for the developing embryo. The yolk particles contain fat as the major energy source, as well as some of the protein and other nutrients needed by the developing embryo. Yolk contents are retained by the vitelline membrane. A small white dot, the blastodisc, is attached to the vitelline membrane (Figure 1).

The blastodisc contains the genetic information that is supplied by the female. If the female has mated within the last few weeks, sperm should be present in the infundibulum. They will locate the blastodisc and penetrate it in the process of fertilization.

Many sperm will attempt fertilization (Figure 2), but only one actually causes fertilization. That single sperm provided by the male will provide one-half of the genetic material of the new embryo.

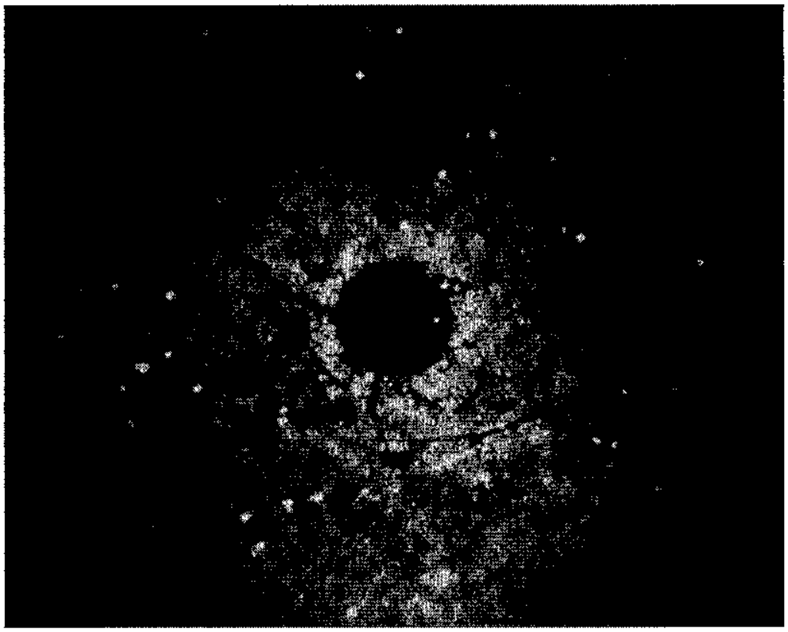


Figure 2 - The white spots are "bullet holes' caused by the sperm that penetrated the egg's vitelline membrane.

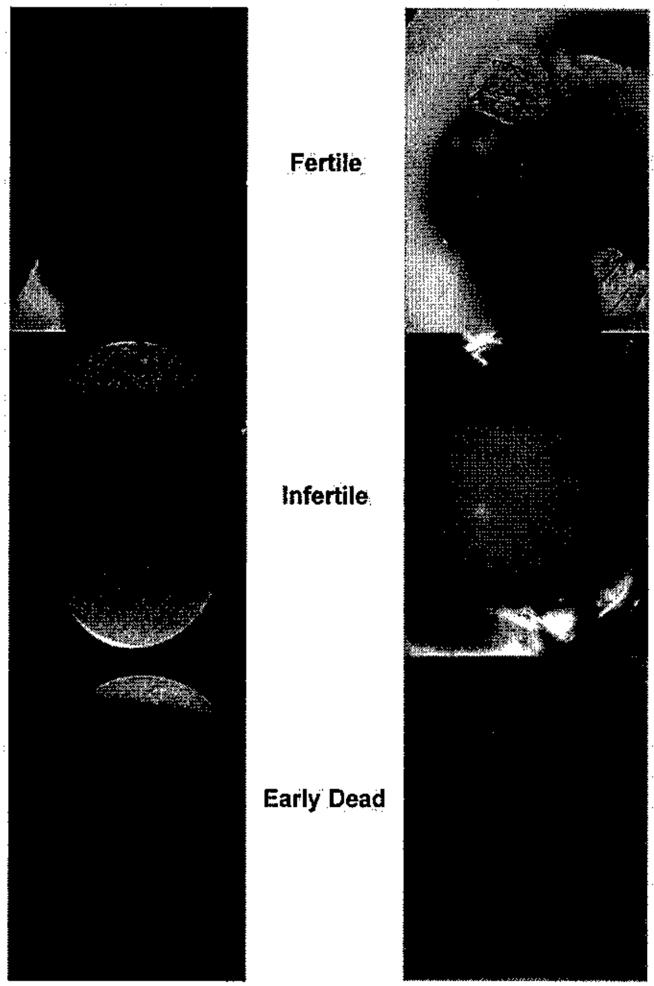
When fertilization occurs, embryonic development begins and continues for the 24 or more hours that it takes to form an egg in the hen. One cell divides into two, which divide into four, and cell division continues. By the time the hen lays the egg, enough embryonic cells have formed to be visibly changed. The structure is now a blastoderm rather than a blastodisc, as shown in Figure 1

Those who study embryology do not agree on the number of cells present at this point, but the estimates range from about 15,000 to 60,000 cells. Some of the difference is due to different lengths of time that the egg remains in the hen. When the egg is laid and the temperature drops below 85° F, cell division stops until the egg is brought to incubation temperature.

SUPPORTING STRUCTURES FOR THE DEVELOPING EMBRYO

When the egg is laid, the blastoderm can be compared to a doughnut. The outer part is the area opaca, meaning that not much light passes through it. The inner part, rather than being a hole, is hollowed out (similar to a saucer for a cup). It is the area pellucida, indicating that light can pass through it to give an almost transparent appearance.

Supporting structures called extraembryonic membranes develop mostly from the area opaca (Bellairs and Osmond, 1998). As the name indicates, the extraembryonic membranes are outside of the embryo and never become a part of it. However, they have vital functions for the developing embryo. Early in the development of the embryo, nutrition comes from stores in the blastoderm. Soon after incubation, the embryo begins to develop again, and the area opaca attaches to the surface of the vitelline membrane. At about 48 hours of incubation, blood vessels coming from the embryo join with those coming from the area opaca. When this happens, the term "area opaca" is no longer used; it is replaced by "yolk sac." The yolk sac continues to grow until it surrounds the yolk.



Blood vessels from the yolk sac are inside the shell but are visible by candling (Figure 3), which provides the first visible evidence that an egg is fertile. The developing yolk sac produces enzymes that digest yolk material to the point where it can be absorbed into the blood and become available to the embryo. When that occurs, the yolk becomes the main source of nutrition for the embryo. At about day 19 of incubation, the embryo has used much of the yolk.

This image (Figure 3) presents examples of some of incubated eggs. A healthy embryo causes the egg to have a red appearance; blood vessels from the yolk sac are visible when candled. An infertile egg has a dark middle caused by the yolk. An embryo that died early in incubation is not as dark as a living embryo, and no blood vessels are visible. At the right side of the illustration, each egg's contents are shown in a Petri dish.

What remains is drawn into the chick's abdomen, and the abdomen closes to leave only the navel as evidence of this process. Ways of supplementing the food supply near the time of hatching are being investigated (Uni and Ferket, 2004).

Soon after incubation, other membranes begin to form. One will eventually extend around the embryo and lie next to the shell; it is the chorion. Another membrane, the amnion, forms under the embryo and collects water from the albumen. After four to six days of incubation, the embryo appears to be floating in a bed of water, which helps prevent physical injury to the embryo and keeps the embryo bathed in fluid.

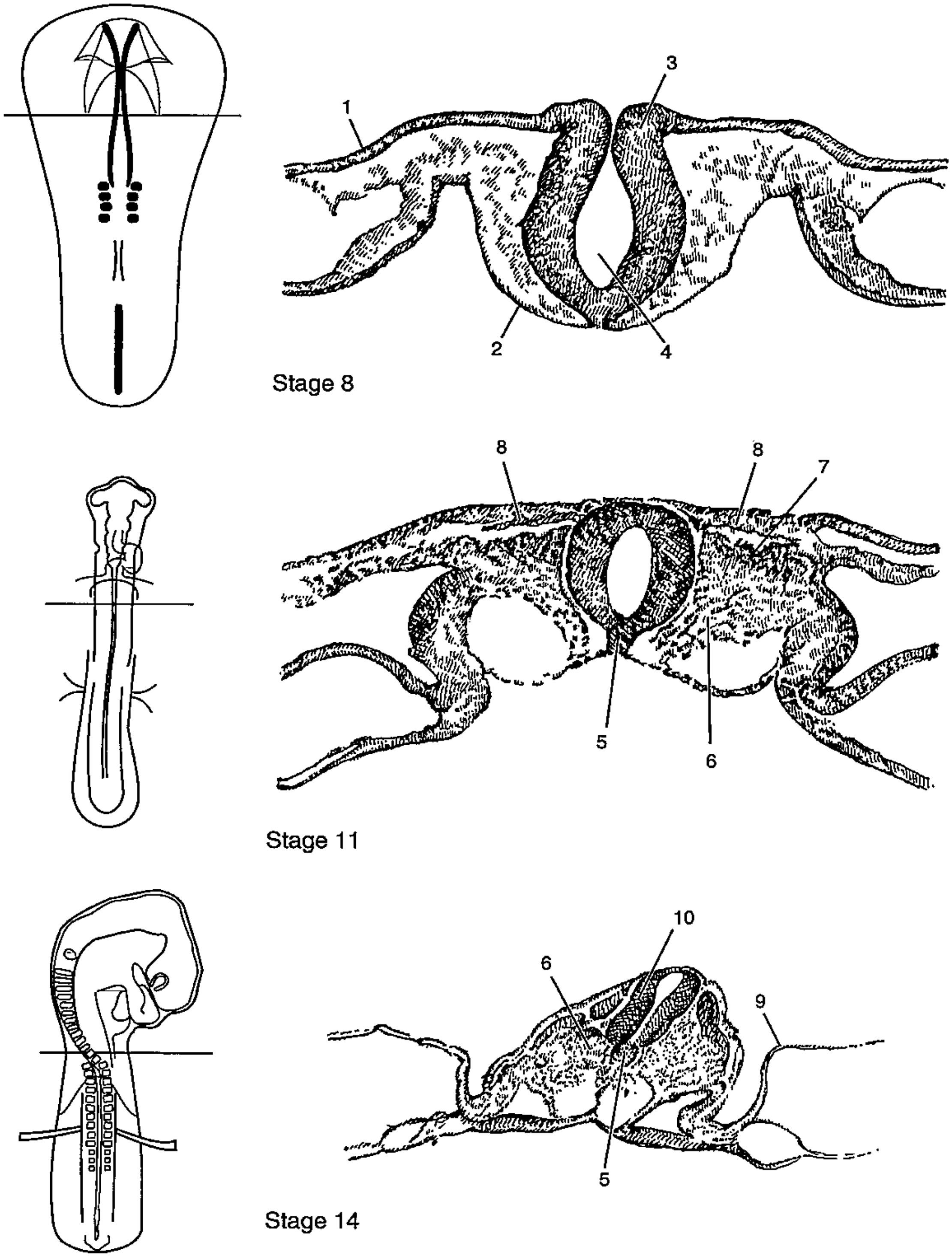
The last membrane, the allantois, begins to form at about the same time as the others. It appears as a sac on the outside of the embryo at four to six days of incubation. A little later it fuses with the chorion to form the chorioallantoic membrane, which lies next to the shell. When a chick first hatches, the chorioallantoic membrane is visible on the inside of the shell, crisscrossed by small blood vessels. This membrane has three functions. It is attached to the inside of the shell and helps exchange oxygen and carbon dioxide between the outside of the shell and the embryo. It also acts as a reservoir to collect solid wastes that the embryo produces. After a chick hatches, these wastes remain in one spot on the inside of the shell, appearing as white, chalky material. The third function of the chorioallantoic membrane is to remove calcium from the shell so that it can be used by the embryo to form bones. This process results in thinning of the shell, which becomes more brittle and easier for the chick to pip at the time of hatching.

DEVELOPMENT OF THE EMBRYO

The developing chicken embryo has been studied for many years (Romanoff, 1960), but much about it is still unknown. To make it possible for different people to compare what they are studying, the development of the embryo is described in stages. The most common standard is that prepared by Hamburger and Hamilton (1951 and 1992) who divided the development prior to hatch into 45 stages that are described in a Normal Table (http://embryology.med.unsw.edu.au/OtherEmb/chick1.htm).

Changes occur rapidly in an embryo. As soon as fertilization occurs, cell division begins. The area pellucida is the part of the blastoderm from which the embryo develops. Cell division starts from the posterior (back) of the pellucida and creates a thin layer of cells as it moves in an anterior (forward) direction, creating a triangular wedge. The cells of the wedge then move toward the middle, a process called gastrulation. When the cells bunch toward the middle, they form a concentration of cells called the primitive streak. As they bunch, they cause the cells in the middle to buckle downward, resulting in a primitive groove. Another result is that the primitive streak gets longer, mostly toward the posterior, causing the appearance to be pear-shaped.

As part of this process, cells form into three layers — ectoderm, mesoderm, and endoderm. Ecto- refers to outside, meso- to the middle, and endo- to the inside. All of this is visible in the egg at Stage 4 after 18 to 19 hours of incubation.



Identification: 1, ectoderm; 2, endoderm; 3, neural fold; 4, lumen of neural tube; 5, notochord; 6, sclerotome; 7, derma-myotome; 8, neural crest; 9, left amniotic fold; 10, neural tube.

Figure 4. Diagrams of chick embryos at three stages of development. A magnified transverse section of the embryo is drawn on the right. Adapted from Bellairs and Osmond (1998).

At fertilization, there is only one cell and it has only one feature. As development continues and the number of cells increases, cells move toward specialization. During Stage 4 and several stages that follow, cells form the primitive streak and then may move to different locations in the primitive streak. At this time, cells are not committed, which means that they could become part of the brain or muscle or any other tissue in the body. Surrounding cells influence what the noncommitted cells eventually become.

A few days later, the cells will be committed, which means they can no longer be influenced to be different kinds of tissue. Their fate has been determined. Fate maps are used to indicate the part of the embryo that will eventually become each kind of tissue (Garcia-Martinez et al., 1993).

Formation of the central nervous system is dependent on the neural tube (Figure 4). The neural plate is a region that folds inward to form a neural tube. Under the neural tube is the notochord, which is important for forming the neural tube. After the neural tube is formed, the notochord disappears. The neural tube differentiates or matures into the spinal cord and brain. Cells from the primitive streak begin to organize, which causes the primitive streak to disappear. The most noticeable features are somites that originate from the mesoderm and appear on both sides of the primitive groove. The first pair of these dots appears at about 24 hours of incubation. They first appear in an anterior position, and then move to a posterior position. Stages 7 to 14 are based mostly on the quantity of somites present. Eventually, the embryo will have 22 pairs of somites after 55 hours of incubation (Figure 5).

Each somite differentiates into three distinct kinds of cells: the dermatome will form skin; the myotome will form muscle; and the sclerotome will form skeletal structures. For example, sclerotome in the somites forms vertebrae and ligaments. There are more than 40 vertebrae in the newly hatched chick, and some of the vertebrae attach to the ribs. All of this structure is present as cartilage after eight days of incubation.

The somites exist for only a few days, but they direct the development of a nearby part of the body while they are present. The myotome in each somite causes the formation of muscles that are close to it. Most of this occurs between days 5 and 9 of incubation. By day 10, all of the muscle groups present in an adult are established. For example, myotome from somites 27 through 32 forms the leg muscles. Cells from these somites move to create leg buds between days 6 and 8. Normal development then results in legs.

All of the parts of a chick are in place by day 10. From then until the chick hatches, most development involves enlarging the parts already in existence, resulting in the form that we recognize as a chick (Figure 6).

The last few days of incubation are a critical time for the embryo. It must absorb the yolk sac with any remaining nutrients into its body. The embryo must also begin to breathe. For this to happen, the humidity in the incubator must be correct so that the air cell is large enough to provide space above the area surrounded by the shell membrane.

Following that, the chick must pick a hole in the shell and eventually emerge. Most of the time, an embryo is able to complete all of these steps properly and enter the world outside of its previous home.

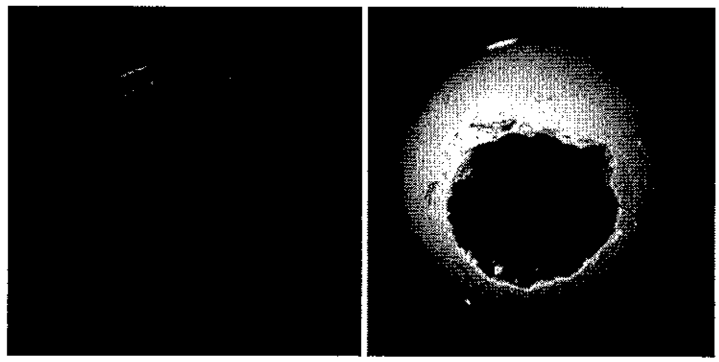


Figure 5. Embryos at early stages of development. The embryo on the left was incubated for 2.5 days, and the embryo on the right was incubated for 5 days. [Candling made it possible to mark the edges of the air cell. A small drill was used to cut the shell inside the marks, and a small part of the shell was removed with tweezers.]

EMBRYONIC MORTALITY

Most embryos that develop will complete the process and become healthy chicks, but there are always some\that do not fully develop. If serious problems occur with the developmental process, the embryo dies. If the defect is less serious, the chick may hatch but have an abnormal appearance.

An embryo must be positioned correctly in the egg for it to hatch successfully (Romanoff, 1972). The embryo's head should be tucked under the right wing and located toward the round (large) end of the egg, which puts the embryo in position to pip the egg at the normal place. If the embryo is not oriented correctly, the condition is known as malposition.

Several frequent malpositions have been identified. Having the head on the outside of the wing is one malposition, and it is not too serious. A very serious malposition is having the head toward the pointed (small) end of the egg. Less than half of the chicks with this malposition hatch.

Another category of defects is malformation, which indicates that the embryo is not formed properly. Malformations are "birth defects" in humans. More than 40 specific kinds of defects have been identified, which commonly affect the skeleton, parts of the head, wings, and legs. In commercial poultry, the combination of malpositions and malformations decreases the overall hatchability by about five percent.

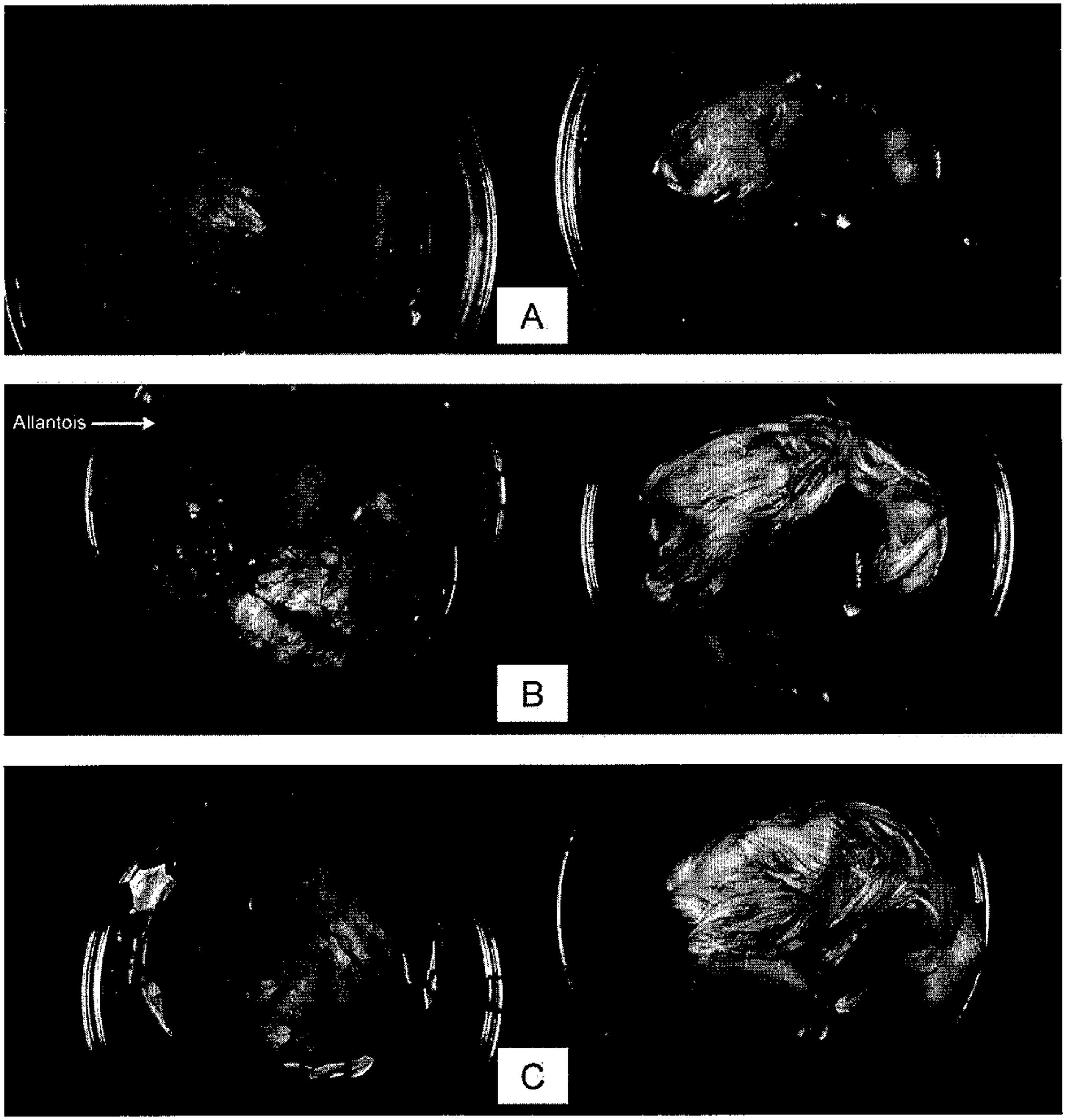


Figure 6. Chick embryos after 14 (A), 16 (B), and 18 (C) days of incubation. The total contents of the egg are shown at the left, while the embryo is at the right. The allantois is visible as a green area (refer to the top left of B).

A number of conditions increase embryonic mortality. One factor is genetics. Mutations occur in chromosomes that change biological instructions on building a certain part of the body. Sometimes the changes do not have any negative effect on the body, but other times they do. Sometimes the mutation is recessive, which means that the chromosome from one parent has a mutation, but the normal chromosome from the other parent prevents any effect. But if both parents have the same mutation, and if the effect is negative, the chick will be affected. An important reason for not mating closely related birds is to decrease the chance of getting the same mutation from both parents. A number of lethal recessive conditions have been identified, which result in increased embryonic mortality and decreased hatchability. Nutrition also is important for embryonic development. The egg must have the proper amounts of about 40 different nutrients for the embryo to develop (Wilson, 1997). Some nutrient deficiencies affect the hen so dramatically that egg formation cannot occur. For example, if the hen does not receive enough calcium and phosphorus in the feed, she will not make an egg. Other deficiencies in the hen's diet (such as vitamins and trace minerals) are not severe enough to prevent egg formation, but are severe enough to affect embryonic development. Looking at the time an embryo dies is often helpful in diagnosing a hatchability problem related to nutrition.

A certain percentage of embryos will die throughout the incubation period, but there are times when mortality is normally increased (Figure 7). Around day 4, an increased number of embryos die, with an even larger percentage at day 18. These are the times when many important changes occur, and problems at these times are likely to cause the embryo to die.

In contrast, when a nutrient is in short supply in the egg, the embryo will develop until the nutrient is depleted, with the embryo often showing signs of defects before dying. A nutrient problem can therefore increase the overall mortality, and much of the mortality will occur earlier than at day 18.

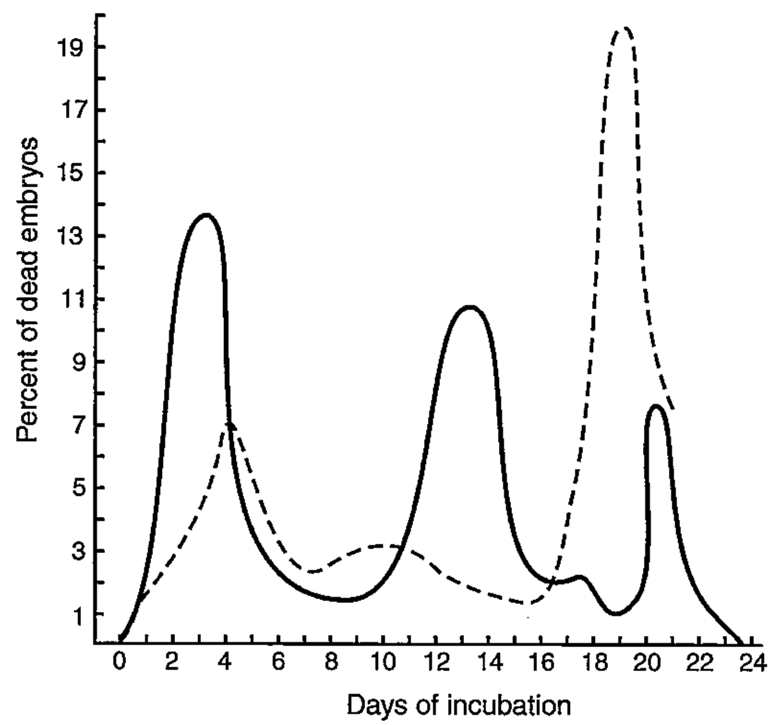


Figure 7. Incubation age of embryonic death from normal fertile eggs (- - - -) or from eggs that had a nutrient deficiency (——). Normal eggs had 7.9% embryonic mortality, and riboflavin-deficient eggs had 87.5% embryonic mortality. Data were adapted from Riddle (1930) and Romanoff and Bauernfeind (1942).

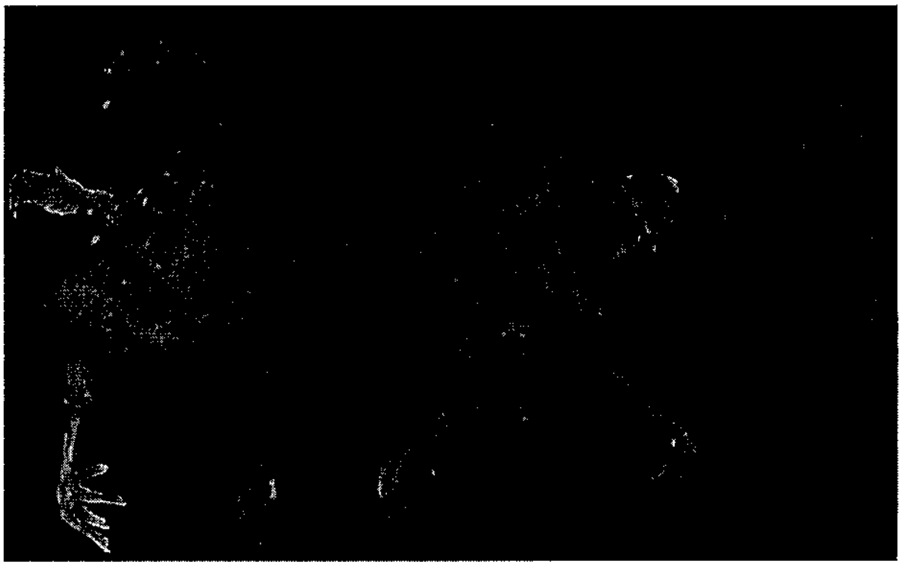


Figure 8. The "creeper" results from a lethal mutation that was identified in chickens. (Reprinted from Landauer, 1965, with permission of Oxford University Press).

If present, toxic compounds may also enter the egg, either from the hen's feed or from the environment surrounding the egg. These compounds can cause the death of a developing embryo or may cause malformations

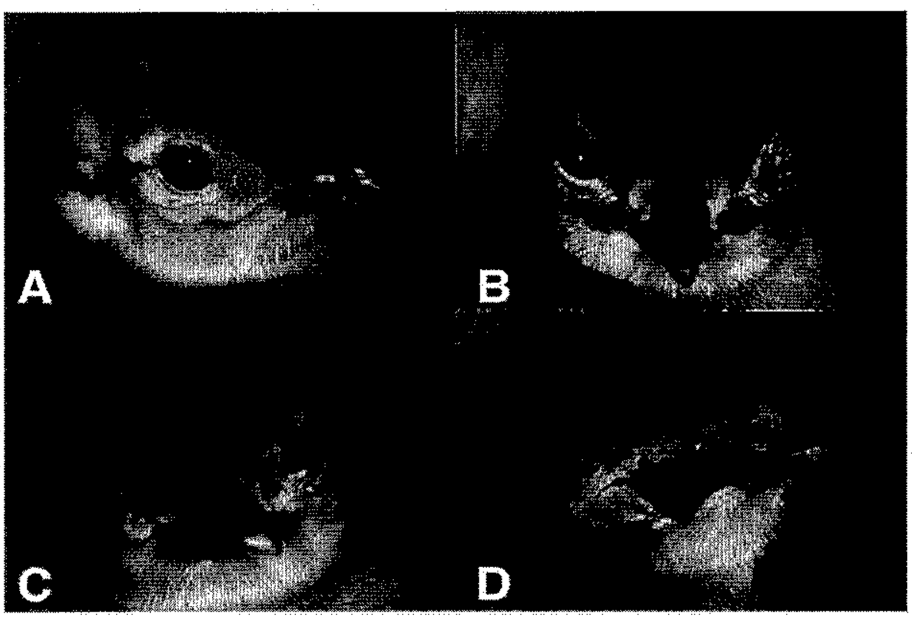


Figure 9. Beak and head deformities – A, B, C, and D – were produced in hatchlings from eggs laid by pheasants that were fed toxic amounts of selenium. (Reprinted from Latshaw et al, 2004, with permission of American Association of Avian Pathologists.)

SUMMARY

One of the greatest miracles of nature is the transformation of a fertile avian egg into a live bird after a few weeks of egg incubation. The complexity of the development of the embryo during that relatively short interval of time is only understood with a knowledge of and training in embryology. As stated in this topic, the developing avian embryo has been studied for many years, but much about it is still unknown. Those involved with market and breeding poultry, incubation principles and practices, and hatchery equipment and management have good reason to stay informed of current and future studies of the avian embryo.

** This topic is a reprint from "Development of Avian Embryos" (2004) by Dr. David Latshaw, Professor, Department of Animal Sciences, The Ohio State University, Columbus, Ohio. Reviewed by Dr. Jason Emmert, Assistant Dean, College of Agricultural, Consumer, and Environmental Sciences, University of Illinois, Urbana, IL.*

REFERENCES

Bellairs, R., and M. Osmond. 1998. *Atlas of Chick Development.* Academic Press. San Diego, CA.

Cogburn, L. A., X. Wang, W. Carre, L. Rejto, T. E. Porter, S. E. Aggrey and J. Simon. 2003. Systems-wide chicken DNA microarrays, gene expression profiling, and discovery of functional genes. *Poultry Science*. 82: 939-951.

Garcia-Martinez, V., I. S. Alvarez, and G. C. Schoenwolf. 1993. Locations of the ectodermal and neuroectodermal subdivisions of the epiblast at stages 3 and 4 of avian gastrulation and neurulation. *Journal of Experimental Zoology*. 267: 431-446.

Hamburger, V., and H. L. Hamilton. 1951. A series of normal stages of development of the chick embryo. *Journal of Morphology*. 88: 49-92. Reprinted in 1992 in *Developmental Dynamics*. 195: 231-272.

Landauer, W. 1965. Nanomelia, a lethal mutation of the fowl. *Journal of Heredity*. 56: 131-138.

Latshaw, J. D., T. Y. Morishita, C. F. Sarver, and J. Thilsted. 2004. Selenium toxicity in breeding ring-necked pheasants (Phasianus colchicus). *Avian Diseases*. 48:935-939.

Riddle, O. 1930. Studies on the physiology of reproduction in birds. XXVII. The age distribution Of mortality in bird embryos and its probable significance. *American Journal of Physiology*. 94: 535-547.

Romanoff, A. L. 1960. *The Avian Embryo.* The Macmillan Company. New York, NY.

Romanoff, A. L. 1972. *Pathogenesis of the Avian Embryo.* Wiley-Interscience. New York, NY.

Romanoff, A. L., and J.C. Bauernfeind. 1942. Influence of riboflavin deficiency in eggs on Embryonic development (Gallus Domesticus). *Anatomical Record.* 82: 11-23.

Uni, Z., and P. R. Ferket. 2004. Methods for early nutrition and their potential. *World's Poultry Science Journal.* 60: 101-111.

Wilson, H. R. 1997. Effects of maternal nutrition on hatchability. *Poultry Science.* 76: 134-143.

POULTRY HEALTH MANAGEMENT *

Disease is any departure from health, a particular destructive process in an organ or organism with a specific cause and signs. **Disease Agents** are physical, chemical, or biological factors that cause disease. Factors that interfere with the normal process are commonly termed stresses. Stress factors may include viruses, bacteria, fungi, nematodes, arthropods, other birds, or environmental conditions. Since a disease is the condition in which the functioning of the body or a part of the body is interfered with or damaged, the type of abnormal functioning that occurs, not the causal agent, is the disease. **Injury** is usually limited to an abnormal physical condition of the animal caused by a short-term interaction of the bird with a stress factor, usually non-living. A response by the animal due to a somewhat longer interaction with a stress factor more often is considered to be a disease condition. Usually an organism will show some signs of the problems it is having with functioning. A **disease sign** is defined as "any change that can indicate an underlying disease" and may be the first clue to the presence of a problem. The chicken in this picture is infected with avian influenza.

Disease should not be confused with infection. An **infection** is the entry and development of an infectious agent in the body of a person or animal. In an apparent "manifest" infection, the infected animal outwardly appears to be sick. In an "inapparent" infection, there is no outward sign that an infectious agent has entered that individual. A **microorganism** is a form of life that can be seen only with a microscope and includes bacteria, viruses, yeast, and single-celled animals. Not all microorganisms cause disease. In fact, many are neutral or non-harmful, and some are actually beneficial to the host they populate. A **pathogen** is a harmful microorganism (bacteria, parasites, viruses, or fungi) that is infectious and causes disease. A **vector** is a carrier that transmits an infective agent from one host to another. A **host** is the individual with the disease; however, in flock management, such as production poultry operations, host commonly is considered to be the flock. Consider the flock to be a population, and we concentrate our attention on the health of the population of birds and not necessarily on the care or survival of individual patients. A **zoonotic disease or infection** denotes a disease that may be transmitted from vertebrate animals (such as a rodent or poultry) to humans.

Pathogenicity or **virulence** refers to the ability of an organism to produce disease in poultry. Some less pathogenic organism will only cause disease in stressed or compromised hosts, while other, more virulent, organisms may attack even very robust individuals and spread rapidly throughout the flock. Some pathogens are specific to a certain host or closely related hosts, and others may be able to invade a variety of unrelated hosts. Some pathogens such as Marek's disease virus is seemingly ubiquitous (nearly everywhere) in the chicken population.

Bacteria are single-cell organisms. Bacteria can be carried by water, wind, insects, plants, animals, and people. They may be able to survive well on skin, clothes, and in human hair. They also thrive in scabs, scars, the mouth, nose, throat, intestines, and room-temperature foods. Even though bacteria are often maligned as the causes of human and animal disease, there are certain types that are beneficial.

Mycoplasma refers to a group of very small bacteria that lack a cell wall. Without a cell wall, they are unaffected by many common antibiotics such as penicillin or other antibiotics that target bacterial cell wall synthesis. Mycoplasmas are unusual among bacteria in that most require sterols (waxy insoluble substances) for the stability of their cytoplasmic membrane (a membrane enclosing the cytoplasm or cell contents). Sterols are acquired from the environment, usually as cholesterol from the animal host.

Viruses are non-cellular biological entities that can reproduce only within a host cell. Viruses consist of nucleic acid covered by protein; some animal viruses are also surrounded by a membrane. Inside the infected cell, the virus uses the synthetic capability of the host to produce progeny viruses.

Protozoa are microscopic, single-celled organisms that can be free-living or parasitic in nature. They are able to multiply in birds and other animals, which contributes to their survival and also permits serious infections to develop from just a single organism. Transmission of protozoa that live in poultry intestines to another animal typically occurs through a fecal-oral route (for example, contaminated food or water or bird to bird contact). Protozoa that live in the blood or tissue of animals are transmitted to other animals by an arthropod vector (for example, through the bite of a mosquito or sand fly).

A **parasite** is an organism that lives on or in a host organism and gets its food from or at the expense of its host. A **parasite host** is an organism in which a parasite lives and by which it is nourished. Parasites may be anything from a virus to a fowl mite, although fowl mites more commonly fit our understanding of parasites as organisms that derive nourishment and protection from other living organisms or their hosts. Parasites may be transmitted from animals to humans, from humans to humans, or from humans to animals. Several parasites have emerged as significant causes of foodborne and waterborne diseases. These organisms live and reproduce within the tissues and organs of infected human and animal hosts, and are often excreted in feces.

Although the term ectoparasites (outside the body) can broadly include blood-sucking arthropods such as mosquitoes (because they are dependent on a blood meal from a host for their survival), this term is generally used more narrowly to refer to organisms such as ticks, fleas, lice, and mites that attach or burrow into the skin and remain there for relatively long periods of time (e.g., weeks to months). Arthropods are important in causing diseases in their own right, but are even more important as vectors, or transmitters, of many different pathogens that in turn cause tremendous morbidity and mortality from the diseases they cause.

In many cases of disease, there are may be more than one single disease agent involved. Multiple causes of disease might include factors such as environment, social, or nutritional stress; immune suppression, and even secondary pathogenic organisms that attack the animal because it is in a weakened or stress condition due to other disease conditions.

TRANSMISSION OF INFECTIOUS AGENTS

Transmission of infectious agents may occur by any mechanism through which an infectious agent, such as a virus, is spread from a reservoir host (or source) to another host. Usually each type of infectious agent is spread by only one or a few of the different mechanisms. A **carrier** may be animal that harbors a specific infectious agent without visible symptoms of the disease. A carrier acts as a potential source of infection. Recovered or asymptomatic or individuals with inapparent infections (signs not observed) may harbor residual pathogens in their bodies or shed the microorganisms from time to time leading to transmission of that disease in other individuals within the flock.

There are several types of transmission mechanisms:

a. Direct transmission: With direct transmission, the transfer of the infectious agent is from one infected host to a susceptible uninfected host. Different infectious agents may enter the body using different routes. Direct routes include direct contact, such as touching, pecking or mating. In these cases the agent enters the body through the skin, mouth, an open cut or lesion or sore, or sexual organs. Infectious agents may spread by tiny droplets of spray directly into the conjunctiva (the mucus membranes of the eye), or the nose or mouth during sneezing, coughing (although usually this type of spread is limited to around one meter of distance.) This is called droplet spread.

b. Indirect transmission: Indirect transmission may happen in any of several ways:

Vehicle-borne transmission:
In this situation, a vehicle—that is, an inanimate object or material called in a **fomite**—becomes contaminated with the infectious agent. The agent, such as a virus, may or may not have multiplied or developed in or on the vehicle. The vehicle contacts the new host's body. It may be ingested (eaten or drunk), touch the skin, or be introduced internally during cuts or body penetration. Examples of vehicles that can transmit diseases include feeders and drinkers.

Vector-borne transmission:
When researchers talk about vectors, often they are talking about insects. A vector can also be any living creature that carries and transmits an infectious agent to another animal. Vectors may mechanically spread the infectious agent, such as a virus or parasite. The agent is transmitted from the vector when it bites or touches a person. In the case of an insect, the infectious agent may be injected with the insect's salivary fluid when it bites. Or the insect may regurgitate material or deposit feces on the skin, which then enter the host's body, typically through a bite wound or skin that has been broken by scratching or rubbing. In the case of some infectious agents, vectors are only capable of transmitting the disease during a certain time period. In these situations, vectors play host to the agent. The agent needs the host to develop and mature or to reproduce (multiply) or both. Once the agent is within the vector animal, an incubation period follows during which the agent grows or reproduces, or

both, depending on the type of agent. Only after this phase is over does the vector become infective.

c. Airborne transmission: In this type of transmission, infective agents are spread as aerosols, and usually enter an animal through the respiratory tract. Aerosols are composed of tiny particles, consisting in part or completely of the infectious agent itself, which become suspended in the air. These particles may remain suspended in the air for long periods of time, and some retain their ability to cause disease, while others degenerate due to the effects of sunlight, dryness or other environmental conditions. Small particles of many different sizes contaminated with the infective agent may rise up from soil, bedding, or floors when these are moved, cleaned, or blown by wind. These dust particles may contain fungal spores—infective agents themselves—tiny bits of infected feces, or tiny particles of dirt that have been contaminated with the agent.

Another form of airborne transition is by droplet nuclei. These droplet nuclei, like aerosols may remain in the air for a long time. Droplet nuclei are usually the small residues that appear when fluid emitted from an infected host evaporates. Spray washing or cleaning of the poultry facilities or equipment may contact these dried residuals and break them loose from the surfaces being washed and then form aerosols.

Preventing Poultry Disease

In working directly with animals as part of our daily activities, we have a responsibility to protect ourselves, others, and the animals from potential disease transmission risks. The following guidelines are recommended for minimizing disease risk in performing required tasks. Considering the investment in a large poultry complex, security precautions are a small price to pay to keep disease away from a flock.

It is suggested to visit only one farm per day and never go from a known disease-positive farm to a known negative farm. Many operations require individuals who travel from one farm to another to allow 48 to 72 hours between visits to another farm. When touring multiple locations and units within a poultry production complex, visitors are usually directed to visit the components of the operation in the following order: first visit the breeder farms, then the hatchery, then possibly the grow-out or production farms, and then proceed to the processing plant.

What is biosecurity?

Biosecurity generally refers to precautions taken to minimize the risk of introducing an infectious disease into an animal population. "Bio" refers to life, and "security" indicates protection. Biosecurity is the key to keeping poultry flocks healthy. Biosecurity involves taking actions to reduce the chances of an infectious disease being carried to a farm, a backyard, an aviary, or to pet birds, by people, animals, equipment, or vehicles, either accidentally or on purpose.

Biosecurity has three major components:

1. Isolation
2. Traffic Control
3. Sanitation

Isolation refers to the confinement of animals within a controlled environment. A fence keeps the birds in and it also keeps other animals out. Isolation also applies to the practice of separating birds by age group. In large poultry operations, all-in/all-out management styles allow complete depopulation of facilities between flocks and allow time for periodic clean-up and disinfection to break the cycle of disease.

Traffic Control includes both the traffic onto a farm and the traffic patterns within the farm. Sanitation addresses the disinfection of materials, people, and equipment entering the farm and the cleanliness of the personnel on the farm.

Biosecurity concepts during poultry farm visits: First of all it is very helpful to understand which areas are to be considered clean and to be kept clean and which areas to which one should not be responsible for the introduction of a disease organism.

Always consider the farm you're going to as clean and you and the farm where you have been to be dirty.

On arrival at the farm, the poultry building is "clean". Areas around a building are "dirtier than the building," but "cleaner than you the visitor." You are "dirty."

When preparing to leave the farm, the poultry building is "dirty" so the visitor (you) is still the "dirty" item.

Area around the building is now considered to be "cleaner than the poultry building". The visitor should strive to leave "dirtiness" behind. Take care not to contaminate clean equipment areas of your vehicle. If you must take soiled items such as booties, coveralls, and gloves with you as you leave from the farm, place them in bio-secure storage containers and do not allow contamination of your vehicle with these items.

Who are visitors? A visitor is considered to be anyone who doesn't work on the farm on a daily basis and plans to go into a poultry building where birds are present or past bio-secure perimeters.

Since farm visitors might be a source of disease introduction, the farm operation protocol normally encourages managers to reduce the number of visits to what's absolutely necessary. Visit by appointment only. If a disease-positive farm must be visited, it should be done at the end of the day and the end of the week.

Infectious diseases can be spread from farm to farm by:

- Introduction of diseased birds
- Introduction of healthy birds who have recovered from disease but are now carriers
- Shoes and clothing of visitors or caretakers who move from flock to flock
- Contact with inanimate objects (fomites) that are contaminated with disease organisms
- Carcasses of dead birds that have not been disposed of properly
- Impure water, such as surface drainage water
- Rodents, wild animals and free-flying birds
- Insects
- Contaminated feed and feed bags
- Contaminated delivery trucks, rendering trucks, live hauling trucks
- Contaminated premises through soil or old litter
- Air-borne fomites
- Egg transmission

Of all the possible breakdowns in biosecurity, the introduction of new birds and traffic pose the greatest risk to bird health. Properly managing these two factors should be a top farm priority.

Biosecurity Steps

Consistent biosecurity practices are the best way to prevent diseases. The following steps help keep your birds healthy. A summary of USDA guidelines follows:

Keep Your Distance. Isolate your birds from visitors and other birds.

- Restrict access to your property and your birds. Consider fencing off the area where you keep your birds and make a barrier area if possible.
- Allow only people who take care of your birds to come into contact with them. If visitors have birds of their own, do not let them near your birds.
- Game birds and migratory waterfowl should not have contact with your flock because they can carry germs and diseases.

Keep it clean. Prevent germs from spreading by cleaning shoes, tools and equipment.

- Wear clean clothes, scrub your shoes with disinfectant, and wash your hands thoroughly before entering your bird area.
- Clean cages and change food and water daily.
- Clean and disinfect equipment that comes in contact with your birds or their droppings, including cages and tools. Remove manure before disinfecting.
- Properly dispose of dead birds.

Don't haul disease home. Also, clean vehicles and cages.

- If you have been near other birds or bird owners, such as at a feed store, clean and disinfect car and truck tires, poultry cages, and equipment before going home.
- Have your birds been to a fair or exhibition? Keep them separated from the rest of your flock for at least 2 weeks after the event.
- New birds should be kept separate from your flock for at least 30 days.

Don't borrow disease from your neighbor Avoid sharing tools and equipment with neighbors.

- Do not share lawn and garden equipment, tools, or poultry supplies with your neighbors or other bird owners.
- If you bring these items home, clean and disinfect them before they reach your property.

Know the warning signs of infectious bird diseases Watch for early signs to prevent the spread of disease

- Sudden increase in bird deaths in your flock
- Sneezing, gasping for air, coughing, and nasal discharge
- Watery and green diarrhea
- Lack of energy and poor appetite
- Drop in egg production or soft- or thin-shelled misshapen eggs
- Swelling around the eyes, neck, and head
- Purple discoloration of the wattles, combs, and legs (AI)
- Tremors, drooping wings, circling, twisting of head and neck, lack of movement (END)
- Early detection is important

Report sick birds Report unusual signs of disease or unexpected deaths.

- Don't wait. If your birds are sick or dying, call your local cooperative extension office, local veterinarian, the State Veterinarian, or U.S. Department of Agriculture (USDA) Veterinary Services office to find out why.
- The USDA operates a toll-free hotline (**1 866 536-7593**) with veterinarians to help you. There is no charge for this service.

Anyone working on or associated with a poultry farm should understand that the farm's performance is directly linked to good biosecurity measures. Poultry quality depends on disease-free birds. Disease-causing microorganisms and pathogens, including bacteria and viruses, are carried through vectors (living organisms that transmit pathogens). Frequently these vectors are the people who work on and visit a poultry farm. Remember, biosecurity doesn't cost, it pays off in disease-free poultry products.

If biosecurity measures are implemented only in certain areas of a poultry farm and neglected in others, they won't be effective. An effective biosecurity plan:

- Defines objectives and responsibilities.
- Assigns the responsibilities to individuals.
- Provides for the supervision of individuals assigned with those responsibilities.
- Isolates a farm so that infectious diseases can be prevented from entering or leaving it.
- Modifies if needed as local conditions change and as disease threats change regionally.

Vaccination and Disease

Disease control emphasizes encouraging and developing disease resistance through sanitation and stress management and proper treatment of disease condition. Treatment is the last resort to reduce losses. Select treatments based on diagnosis of problem rather than using "shotgun" treatments. Practice "Bio-Security" and control potential disease organism movements. Most diseases can be controlled by hygiene or cleanliness. It is almost impossible to disinfect filth.

Proper cleaning removes over 95% of disease organisms, even without disinfectants.

There are numerous diseases associated with poultry. This section will discuss diseases for which vaccination or feed additive programs are available.

Commercial poultry are vaccinated to protect them against a several diseases. New techniques are allowing commercial operations to administer certain vaccines to the chick while still in the egg. Vaccination is seldom practiced by small flock owners. Unfortunately, small poultry flocks do suffer from many diseases which could be controlled through appropriate vaccination. Getting a proper diagnosis of the cause of disease for a small flock is a problem. The value of the flock may not justify obtaining the specialized assistance to diagnose the diseases and even in cases when the disease is diagnosed the loss may have already advanced to the point that the flock should be eliminated. Vaccinating the flock is also a challenge. The owner may not know where to purchase the vaccines and these may be too expensive because poultry vaccines usually come in 500 to 10,000 dose vials.

For the small flock owner, vaccination should be considered if the flock owner has experienced one or more of the following:

Takes birds to poultry shows
Buys birds from hatcheries, bird auctions, or other sources and adds them his flock
Had disease problems in the past

The goal of a vaccination program is to produce high "blood titers" or the measurement of blood antibody levels, especially in breeder hens, yet not severely stress the birds causing susceptibility to other disease challenges. Immunization helps prevent disease outbreaks. It is no substitute for poor management or poor sanitation. All immunity is separated into active or passive. Immunity to vaccines is isolated to the individual disease or closely related antigens contained in the vaccine. Immunization does not relieve the producer from practicing good husbandry or Bio-Security

POULTRY VACCINES

The most successful poultry vaccines are against viral diseases. The viruses in live vaccines multiply in the host. A killed-virus product is dependent upon antigenic units present in the vaccine dose to stimulate antibody production. Low-virulence live viruses are present in live vaccines. They are administered to chickens and turkeys by a variety of routes including drinking water, intraocular (eye drops), intranasal (nose drops), and spray. Vaccination through the water is the most common vaccination method used in the poultry house. Killed-virus oil emulsion vaccines are commonly administered to pullets by intramuscular or subcutaneous injection. The killed vaccines are administered after a series of live-virus vaccinations and prior to the onset of egg production.

It is usually recommended to only vaccinate healthy birds, however, there are exceptions. Flocks can be given fowl pox vaccination during an outbreak to reduce the severity. Administration of Infectious Laryngotracheitis vaccine is very useful to help control an outbreak.

Vaccines need protection from heat and direct sunlight. Most vaccines are living, disease-producing agents. When using the drinking-water method of vaccination, be sure the water is free of sanitizers and chlorine. Live-virus vaccines are readily destroyed by these chemicals. Most vaccine instructions recommend that after vaccinating, burn or disinfect all opened containers to prevent accidental spread to other poultry or possibly other avian species.

OVERVIEW OF MAJOR POULTRY DISESES AND VACCINES

Marek's disease

Marek's disease is a disease of chickens that is caused by a herpesvirus. The clinical signs include grey eye, enlarged feather follicles, limb or neck paralysis, and formation of visceral tumors. For Marek's vaccine to be effective, it is necessary for newly hatched chicks to be vaccinated at the hatchery. The vaccine is administered subcutaneously at the back of the neck. Chickens 2 to 16 weeks of age (prior to sexual maturity) are the most susceptible to Marek's disease. Other poultry species do not receive Marek's disease vaccinations.

Newcastle disease

Newcastle disease (ND) is an acute, rapidly-spreading, contagious viral disease of birds of all ages characterized by lesions in the respiratory tract, visceral organs, and brain, and causing minor to severe mortality in susceptible flocks. The clinical signs observed will vary with the age and immune status of the birds, strain of ND virus, and the environmental conditions. In young birds that have little or no maternal antibodies or that haven't been vaccinated, the symptoms can be severe. Birds under stressful conditions also are more susceptible to severe clinical signs. Three are 3 forms of Newcastle disease. The velogenic and mesogenic forms are not commonly present in the United States and are reportable diseases. The lentogenic form causes mild respiratory disease and drops in egg production. The live vaccines are derived from the lentogenic form.

The velogenic form spreads rapidly through a susceptible flock. Birds may be found dead without any signs. Initially, birds are depressed with increased respiration. There is progressive weakness and prostration. The birds develop a watery greenish diarrhea. A marked cough and gasping respiration, nasal and eye discharge are often present. Comb and wattles may turn dark and bluish, and birds may develop swollen heads. Birds that survive the initial acute phase show involvement of the nervous system. Egg production drops sharply and deformed eggs are present. Mortality is usually over 90% in a susceptible flock.

The clinical signs of the mesogenic form are similar to the velogenic form, but less severe. Mortality may vary from 5-50%, depending on the age of birds and environmental conditions. Nervous signs may occur.

The lentogenic form is characterized by mild respiratory symptoms and by a sudden drop in egg production. The egg production returns to normal within a few weeks and birds completely recover from the disease. In young susceptible birds, serious respiratory disease problems can be seen.

Both live and killed vaccines are available for prevention of Newcastle disease. A combination Newcastle-Infectious Bronchitis live vaccine can be given at 10-35 days. Low-virulence live-virus vaccines are administered to chickens and turkeys by a variety of routes such as drinking water, intraocular (eye drops), intranasal (nose drops), spray. In vaccination programs for breeder flocks, repeated vaccinations are given to assure transmittance of parental immunity to offspring. LaSota Newcastle disease vaccine causes a more severe reaction than the B-1 type and is given to replacement pullets prior to egg laying.

Infectious bronchitis

Infectious bronchitis (IB) is a highly acute and contagious viral disease of chickens which primarily affects the respiratory system. It is caused by a coronavirus. The disease is characterized by rales, coughing and sneezing. In susceptible laying flocks, there is a drop in egg production and an adverse effect on egg quality. Some IB strains may affect the kidneys. There are a number of serotypes of the virus in this group. Infection from one serotype confers little protection against others. The virus spreads rapidly within a flock of chickens by means of inhalation. The virus may also be spread by means of contaminated equipment and personnel. It is not egg transmitted.

Susceptible birds will start to show clinical signs approximately 2-3 days following exposure to the IB virus. Initially, there are mild respiratory symptoms, such as sneezing, snicking, gasping and moist rales. In addition, a nasal discharge may be observed. Young chicks appear depressed and huddle under a heat source. In affected birds, feed consumption and weight gains are significantly reduced. In older birds, the disease may spread through the flock with only a mild cough observed. Birds affected with nephropathogenic (affects the kidney) strains of IB appear depressed, dehydrated, and have ruffled feathers. There is usually a watery diarrhea with an excess amount of urates in the droppings. In laying flocks, there is a decline in egg production with or without respiratory signs. There is a tendency for many of the eggs laid to be thin-shelled, rough-shelled, and misshapen. Mortality will vary depending on the virulence of the IB serotype, age and immunity status of the flock, and the presence of stress.

IB is controlled through biosecurity and vaccination. Strict isolation of the farm and thorough cleaning and disinfection of the poultry house can prevent the introduction new strains of IBV. Because of the different types of IB viruses found in the field, most poultrymen use an IB vaccine containing more than one strain. Vaccination programs vary between poultry farms and different regions of the country and are based on the incidence of the disease, IB strains common to the area, density of chicken population, purpose of the birds raised, and general management practices. When the inactivated vaccine is used, it is routinely given at approximately 18 weeks of age. Live vaccines are often given every 50-60 days during production. Frequently, IB vaccine is administered in combination with Newcastle disease vaccine.

Infectious laryngotracheitis

Infectious Laryngotracheitis (ILT or LT) affects chickens, peafowl, and pheasants. It is caused by a herpesvirus and is characterized by rapid spread, sneezing, and gasping. There may be expectoration of blood-stained mucus, which may be observed on the wing and breast feathers as a result of the bird shaking its head to clear its trachea. Mortality may be high due to the development of a bloody or a cheesy plug in the windpipe (trachea). The disease is controlled by vaccination. State approval is required prior to vaccination. The vaccine is administered by the eye- or nose-drop method. Birds should be at least 4 weeks old. All chickens on the premises must be vaccinated, including any new additions and a yearly booster is needed. If birds are vaccinated at less than 10 weeks of age, they should be revaccinated at 10 to 18 weeks of age. Two types of LT vaccines are available: tissue culture, which must be administered by eyedrop, and chick embryo origin vaccine, which may be administered by eye drop or mass application methods (water or spray).

Fowl pox

Fowl pox virus is spread from bird to bird through the bites of blood-sucking insects (especially mosquitoes), through wounds and scratches, or by inhalation. There are two forms of fowl pox:
The dry form causing yellow wart lesions on the fleshy head regions of the bird (face, comb and wattles) and the wet form in which yellow cheesy lesions form in the mouth and windpipe (trachea). Most pox strains can be prevented in chickens, turkeys and pigeons by vaccination, but there is no effective commercial vaccine against canary pox. There is also no cross protection between quail pox and fowl pox. Chickens usually vaccinated by the wing web stick method, while turkeys are vaccinated by a thigh-stick method. Chicks and poults can be vaccinated at 1 day of age, pullets at 10 to 12 weeks, and turkeys at 8 to 14 weeks or when moved to range. In areas of pox problems, flocks should be revaccinated after reaching 8 weeks of age or older to assure lasting immunity.

Fowl cholera

Fowl cholera affects most birds including domestic fowl (primarily chickens and turkeys), game birds (especially pheasants), ducks, cage birds, wild birds, and birds in zoological collections and aviaries. Fowl cholera is caused by a bacterium, *Pasteurella multocida*. In acute infections, birds may die without any visible signs. Usually birds have ruffled feathers, nasal discharge, diarrhea, reluctance to walk and anorexia. Cyanosis (bluish discoloration of the head, comb and wattles) may be observed prior to death. When diarrhea is present it is usually watery and white to greenish in color and contains mucus. Birds that survive acute infections may become chronically infected or may recover. In chronic infections, clinical signs are associated with localized infections. Often there is swelling of the wattles, leg or wing joints, sinuses, or sternal bursae.

Conjunctivitis with cheesy plugs and respiratory distress may be observed. Torticollis (twisting of neck) is seen in birds suffering from middle ear infections. In hens, there is usually a drop in egg production.

There are two types of fowl cholera vaccines -- live attenuated and inactivated bacterins. The oral vaccine is a live attenuated culture that is administered in the drinking water. Oil-emulsion bacterins require a series of two injections given at 4 week intervals. Vaccination is not recommended unless an outbreak occurs in the area. Various antibacterials have been used to treat fowl cholera. It is recommended that sensitivity testing be done since strains of *P. multocida* vary in susceptibility to antibacterials and resistance to treatment may develop, especially during prolonged use of these agents. The most commonly used antibiotic is oxytetracycline. Sulfa drugs cannot be used in flocks producing eggs for human consumption.

Avian encephalomyelitis

Avian encephalomyelitis (AE) is a viral infection of poultry, primarily chickens, turkeys, pheasants, and coturnix quail. Young birds may be infected through the egg. The signs of the disease include deterioration of muscle coordination primarily affecting the legs and the bird's ability to stand and walk. Lifetime immunity is acquired through vaccination or recovery from a natural outbreak. Breeder chickens are vaccinated at 10-16 weeks of age. The vaccine is administered in the drinking water or by wing-web stick.

Avian influenza

Avian influenza (AI) viruses can infect chickens, turkeys, pheasants, quail, ducks, geese, and guinea fowl, as well as a wide variety of other birds. Avian influenza is caused by a type A influenza virus and is a reportable disease. AI viruses are subtyped according to their hemagglutinin and neuraminidase. There are numerous subtypes of the virus that can affect poultry. Influenza virus is released in respiratory secretions and excretions and droppings of infected birds where it is protected by organic material. The virus is labile in warm dry conditions but survives for long periods of time under cool and moist environmental conditions. It is inactivated by heat and drying and is also very sensitive to most disinfectants and detergents. AI viruses are classified into lowly pathogenic (low path or LPAI) and highly pathogenic (high path or HPAI) forms. LPAI is by far the most common.

LPAI, or "low path" avian influenza, naturally occurs in wild birds and can spread to domestic birds. The clinical signs of LPAI are extremely variable and depend on the species affected, age, gender, concurrent infections, subtype of the virus, and environmental factors. Silent infections are possible. In LPAI listlessness, coughing, sneezing, rales, swollen sinuses and diarrhea may be observed. Death is usually due to secondary infections. In egg laying birds, egg production drops sharply and hatchability may be affected. Eggs from turkey breeders or brown egg laying chickens may be white and chalky. These strains of the virus pose little threat to human health.

LPAI H5 and H7 strains have the potential to mutate into HPAI and are, therefore, closely monitored. Most AI occurrences are of the low pathogenic avian influenza and are spread primarily by direct contact between healthy and infected birds, and by contact with contaminated equipment and materials. Serological testing is used for detecting all AI viruses. If it is determined that an AI virus is present, the virus is cultured to determine its subtype and pathogenicity. A report and samples goes directly from the state veterinarian to the National Veterinary Services Laboratory in Ames, Iowa.

HPAI, or "high path" avian influenza, is often fatal in chickens and turkeys. HPAI develops from mutation of H5 or H7 AI subtypes. HPAI spreads more rapidly than LPAI and has a higher death rate in birds. HPAI H5N1 is the type rapidly spreading in some parts of the world. The clinical signs of HPAI are severe listlessness, sudden high mortality, swollen dark combs and wattles, and subcutaneous hemorrhage of the shanks.

There is no treatment for avian influenza virus infections. Antibiotic treatment has been used to reduce the effects of concurrent bacterial infections. There are two recognized reservoirs of avian influenza: live bird markets and wild shorebirds and waterfowl. Prevention of avian influenza requires preventing the introduction from these reservoirs. Since the disease is spread by direct and indirect contact, strict biosecurity and a good sanitation program are imperative. In outbreaks involving highly pathogenic virus, eradication programs are used.

Infectious Bursal Disease

Infectious bursal disease (IBD), often referred to as Gumboro Disease, is a highly contagious viral disease of young chickens characterized by high mortality, anorexia, diarrhea, and depression. It is caused by a virus that has a preference for lymphoid tissue, primarily the bursa of Fabricius. The subclinical form of the disease may cause prolonged immunosuppression of chickens infected at less than 3 weeks of age. Immunosuppression induced in birds over 3 weeks of age is temporary. Chicks with IBD may fail to develop immunity to other diseases when vaccinated. Maternal antibodies help protect the chick. The bursa may become enlarge and develop a yellowish color. The IBD virus is very stable and persists for long periods of time in poultry houses, even when houses have been thoroughly cleaned and disinfected. The virus spreads within a flock by direct contact, by inhalation, or contaminated feed and water. It has also been demonstrated that the darkling beetle can be a reservoir of the virus. There is no evidence that IBD virus is transmitted through the egg, or that a true carrier state exists in recovered birds. In affected flocks, morbidity may reach 100% and mortality may vary from none to 30% or higher with some more virulent strains. There are vaccines available for IBD which are given depending on challenge and maternal antibody status.

Infectious coryza

Infectious coryza is an acute bacterial respiratory disease of chickens characterized by facial edema, inflammation of infraorbital sinuses, and occasionally conjunctivitis. It usually occurs in mature birds in densely populated areas. The disease is caused by the bacterium *Haemophilus paragallinarum.* The organism is delicate and is inactivated rapidly outside the host. Chronically infected chickens (commercial poultry or backyard chickens that have recovered from the disease) may serve as carriers and act as the main reservoir of infection. The bacterium spreads in a flock through water contamination by nasal discharges from infected chickens or by inhalation. The bacterium is maintained on multiple age farms. In susceptible birds exposed to the organism, the initial signs usually appear in 1-3 days. Typical symptoms include swelling of the face and infraorbital sinuses. There is marked conjunctivitis with purulent exudate seeping from the eyes. Frequently, the eyes become matted with this exudate making it difficult for the birds to consume feed and water. In layers, there is a drop in egg production. A foul odor may be detected in flocks where the disease has become chronic and complicated with other bacteria. Since the disease spreads slowly through a flock, the course of the disease may be prolonged. Mortality is usually low, but morbidity may reach 100%. Various antibacterial agents are used to treat infectious coryza. Relapses may occur after treatment is discontinued. Good management practices are essential in controlling this disease. Since carrier birds are a major source of infection, avoid placing started birds from an outside source on the farm without knowing the flock history of the source. Isolation of younger birds from old stock is also helpful. Eliminating the disease from an infected farm requires depopulation and complete cleanout and disinfecting of the house(s). This is not always economical or practiced on multiple-age layer operations. There are killed vaccines (bacterins) available which reduce the adverse effects of this disease. Birds are usually injected twice with the bacterin prior to the onset of egg production.

Coccidiosis

A disease affecting birds as well as many other animals, coccidiosis is caused by the multiplication of single celled animals (protozoa) primarily in the digestive tract. The protozoa belong to the genus *Eimeria.* The many species of coccidia are very host specific and even though the signs of the disease are very similar in various animals, the species of coccidia are usually not the same. There are nine species of coccidia that affect chickens, and there are three species that are considered pathogenic to turkeys. The life cycle of coccidia takes 4 to 7 days for completion. The disease is characterized by varying degrees of inflammation in the intestine (enteritis), decreased production performance (body weight and feed efficiency), and mortality. Depending on the level of infection and coccidial species involved, signs may include paleness, ruffled feathers, unthriftiness, and the passing of blood in the droppings. Mortality may be high in some cases. Feed consumption is usually reduced. Infected birds may carry and possibly discharge coccidia oocysts for months following recovery from the disease. Control is normally maintained in chickens by use of a feed additive such as amprolium until immunity or resistance has been established. Raising pullets in cages off the floor ordinarily breaks the life cycle of coccidia by preventing access to the droppings. Cage-reared pullets are highly susceptible to coccidiosis if they are exposed to oocysts. Vaccines have now been developed and are being used for coccidiosis control.

Leg Disorders in Broilers and Turkeys

Small and commercial flocks of rapidly growing strains of broilers and turkeys may develop leg disorders. Various factors cause leg disorders. Causative factors are classified as nutritional, genetic, and infectious.

Rickets, perosis, and tibial dyschondraplasia (TD) are three nutrition-related conditions.

Rickets is caused by a lack of mineralization of the bone resulting from a deficiency of calcium, phosphorus, or vitamin D3. Vitamin D3 deficiency is the usual cause. A feed mixing error (under-fortification) or the presence of mold toxins that interfere with normal metabolism may cause deficiency of vitamin D3. Rickets resulting from a phosphorus deficiency may be the result of insufficient available phosphorus in the ration. Calcium deficiency is uncommon when limestone, oyster shell, or meat/bone meal are included in the ration.

Signs of perosis include swelling of the hock joints, slipped tendons, and severe shortening of the long bones. Deficiencies of the trace minerals - manganese and zinc - and the vitamins - choline, niacin, folic acid, biotin, and pyridoxine - produce a perosis-type condition.

Tibial dyschondraplasia (TD) is the third nutrition-related condition. TD is a mass of cartilage at the end of the leg bones. The causes of TD are genetic, nutritional (calcium, chlorides, Vitamin D3, etc.), and environmental (flooring).

Infectious agents are identified as direct or indirect causes of leg disorders. Staphylococcus and viral arthritis/tenosynovitis are two common agents. Leg disorders caused by these agents may be confused easily with nutrition-related conditions.

In most cases, treatments for leg disorders are ineffective. Most likely, the treatment does not remedy the current problem. An exception is the use of water-soluble vitamin D^3 in the drinking water and the addition of a trace-mineral mix to the feed. This treatment may be beneficial for rickets if administered at the first signs of trouble. A positive response indicates the need for a more highly fortified ration.

Producers can minimize the potential for leg disorders in a flock by following good management and sanitation practices, using quality rations, and minimizing stress. If problems persist, obtain a laboratory diagnosis of the condition to distinguish between infectious and nutritional causes.

DISEASE PREVENTION AND CONTROL

Disease control measures include (1) reducing contact between birds and infectious organisms, (2) maintaining sanitary conditions, and (3) strengthening the bird's defenses against invasion by infectious organisms. The ability of an organism to cause disease is not a fixed characteristic. It depends upon many factors, such as the ability to invade tissues and produce chemical toxins. Although it is impossible to prevent all losses from disease, prevention should be the goal because it is more economical than treatment.

Maintaining Sanitary Conditions

Sanitation maintains an environment conducive to good health. Sanitary practices disrupt the life cycle of the disease organisms by reducing their numbers and by exposing the remaining ones. Effective cleaning and disinfecting are important sanitation practices.

Proper cleaning is especially critical. Organic materials (manure, dirt, dust, feathers, and litter) serve as lodging places and protective cover for disease-producing organisms. Disinfectants reacting with these materials may be inactivated or have their effectiveness reduced before reaching all of the disease-producing organisms. Proper cleaning exposes the organisms to the full power of the disinfectant.

There are many good cleaning agents and disinfectants available, including some relatively inexpensive and effective ones.

- Scrubbing poultry houses and equipment with soap and hot water is effective if surfaces are thoroughly scrubbed. A limiting factor is little carryover or residual action.

- A creosol compound in solution is especially effective in spray or brush applications and in footbaths located at the entrances to pens or houses.

- A chlorine-based compound, such as hypochlorite, is most effective on clean surfaces.

- A quaternary ammonium compound is especially effective as a water-sanitizing agent.

- An iodophore (a combination of iodine and an organic stabilizing agent) is effective against a wide spectrum of organisms.

- Time, freezing and thawing, and sunshine are effective and inexpensive disinfectants.

Regular cleaning and disinfecting procedures.

Disinfect flock environments on a regular basis. Disinfection reduces the pathogens in the flock environment, which thereby reduces the risk of disease. Disinfecting involves two steps: cleaning and applying a disinfectant. Always clean first. If the area is not cleaned thoroughly, the disinfectant will not work.

•Step 1. Clean.

Remove all bedding, feed, and manure.
Sweep out loose dirt, cobwebs, and other loose materials.
Scrub all surfaces with a detergent or disinfectant cleaner
(a high-power spray may be helpful).
Rinse away all detergent and organic matter (a high-power spray may be helpful).

•Step 2. Apply a disinfectant.

Follow the directions on the disinfectant container, and use only the appropriate disinfectant. Disinfectants will not be as effective if they are excessively diluted to cut costs or if they are
used improperly. Improper mixing decreases the effectiveness of the disinfectant and increases
the probability of a disease outbreak.
Allow the disinfectant to dry completely.
Re-apply the disinfectant and allow it to dry a second time (optional)

Choose the right disinfectant. A disinfectant's effectiveness at destroying various pathogens (viruses, bacteria, fungi, and protozoa) depends on its chemical composition, its mode of action, and the type of organism. Some disinfectants do not kill all types of microorganisms. Choose the appropriate one for each situation. Disinfectants can be divided into the following classes based on their chemical composition.

- **Phenols** are effective against bacteria, fungi, and many viruses. They are commonly used in footbaths and to sanitize hatcheries and equipment. Also known as coal-tar derivatives, these disinfectants have a characteristic pine-tar odor and turn milky in water. They retain more activity in the presence of organic material than disinfectants containing iodine or chlorine.
- **Quaternary ammonium compounds** are effective against bacteria and partially effective against fungi and viruses. They are widely used in commercial hatcheries. Quaternary ammonium compounds are generally odorless, colorless, nonirritating, and deodorizing. They also have some detergent (cleaning) action. Some soaps and soap residues, however, inactivate quaternary ammonium compounds. Choose detergents carefully when using these compounds. Their antibacterial activity also is reduced in the presence of organic matter.
- **Iodophors** are effective against bacteria, fungi, and many viruses. They are commonly used to disinfect equipment, walls, and water. These are good disinfectants but do not work well in the presence of organic material.
- **Hypochlorites** are effective against bacteria and many viruses. They are effective only on clean surfaces. These compounds contain chlorine and are quickly inactivated by organic matter. Moreover, they are much more active in warm water than in cold water. Chlorine solutions can be somewhat irritating to the skin and are corrosive to metals. They are relatively inexpensive.

- **Oxidizing agents** are effective against bacteria, bacterial spores, viruses, and fungi. They are used in commercial poultry operations. Hydrogen peroxide and other oxidizing agents are active at quite low concentrations
- **Natural agents** are effective against some microorganisms. They are helpful on the exterior of buildings. Sun light, heat, cold, and air can inhibit the growth of some microoganisms. The ultraviolet rays of sunlight are tremendously effective in killing microorganisms on the exterior of buildings. Unfortunately, ultraviolet rays cannot penetrate through glass, roofs, or dust.
- **Heat**, like any other method of disinfection, is not effective in the presence of organic material like feces, feathers, or egg material, probably because heat does not penetrate organic debris well. The practical application of heat as a disinfectant may require long contact in order to completely dry the environment and heat-inactivate the disease agent. Heat has been used effectively to disinfect poultry houses contaminated with avian influenza virus.

Apply the disinfectant properly:

- For the period of time specified on the label. No disinfectant works instantaneously. All require a certain amount of con- tact time to be effective.
- At the appropriate temperature and concentration specified on the label. The temperature and concentration of a disinfectant influence its killing effectiveness. Using the recommended concentration of disinfectants is important.
- Only after cleaning the area thoroughly and removing as much organic matter as possible. All disinfectants are less effective in the presence of organic material like dirt, dust, and cobwebs. In other words, you cannot disinfect dirt. Organic matter interferes with the action of disinfectants.

Take bacterial counts before and after cleaning and disinfecting flock environments to be sure.

Strengthening the Bird's Defenses Against Invasion by Infectious Organisms

Well-bred, well-fed, vigorous birds maintained in a good environment have a better chance of remaining healthy in the presence of infectious organisms.

Proper nutrition is also important in maintaining health and resisting disease. Poultry must have adequate nutrition to overcome the stress of disease. The environment is an important influence in disease resistance. Birds exposed to extremes of temperature, moisture, or poor ventilation are much more susceptible to infection than are birds kept under good conditions. Proper housing protects poultry from contact with disease agents; it also provides feed and water free of contamination.

A bird's body has natural resistance to infection. This includes the physical and chemical types of barriers that hinder invasion by infectious agents such as intact skin and mucous membranes, secretions such as mucous, hair-like filtering structures on some mucous membranes, and agents that combat infections which invade the body (white blood cells and non-specific proteins). Certain species of birds are more susceptible than others to certain diseases. For example, turkeys are more susceptible to blackhead than are chickens. Some strains of chickens are more resistant to leukosis than are others.

A second type of natural resistance--one that is more controllable and can be used intentionally--is immune system. It can be stimulated to produce specific antibodies by vaccination or exposure to an infectious agent (active immunity). Passive immunity is the passage of antibodies from the hen to the chick by way of the egg yolk.

Vaccination is one of the most useful practices in the prevention of certain diseases. Vaccines introduce large amounts of a tame-down or killed version of the disease-causing organism. This causes the bird's immune system to produce antibodies against the disease. Live or killed forms of the infectious agents are used in the vaccines. The primary immune response (the first time the bird is exposed to an agent) requires 14 days before very much detectable antibodies are present. When the bird is given a booster vaccination the antibody response take only 3 days and the antibodies are produced at a higher level. The best responses to vaccination are obtained from healthy birds.

For best results, store vaccines in the refrigerator away from exposure to sunlight. Avoid outdated vaccines. Destroy any vaccine remaining after use. Administer according to manufacturer's instructions. Record serial numbers of vaccines used, dates of application, and route of administration. Keep the vaccine refrigerated after it is mixed for vaccination and use it within the allotted time after it is reconstituted. Keep it cold to avoid exposure to heat and sunlight when vaccinating the flock.

Poultry Flock Disease History

If a disease condition should occur, a flock history is very important in the investigation to determine of the cause of a disease condition in a flock. A flock history includes such information as age of the birds, source, nutritional programs, lighting, housing, disease signs, when the disease condition was first observed, **mortality rate** (death loss), when mortality occurred and frequency, **morbidity** (frequency of birds displaying signs), vaccination programs, etc. Accurately recording and compiling this information and having this available during flock health review and in case a disease outbreak should occur.

Disease outbreaks are uncommon in carefully managed flocks. Disease, however, may gain entrance into a flock despite rigid preventive measures. Daily observation of activity levels and monitoring of feed and water consumption can provide early clues to developing problems. Quick response by the producer can reduce losses. If a problem develops, the first and most important step is prompt identification of the cause of the disease. Treatment without this knowledge is may be ineffective.

Producers should contact their land grant universities for locations of diagnostic laboratories in their states for assistance with poultry disease problems. Many feed, drug, and breeder companies also offer information for their customers.

Here are some key points to remember when selecting and submitting a sample of birds to a diagnostic laboratory:

Submit any birds that have died to the laboratory. When birds are dying rapidly with few preliminary symptoms, bring in several dead birds and ailing live samples. Dead birds should be put in tied, waterproof plastic bags, packed in dry ice in an insulated container and brought or shipped to the laboratory. Before packing, wet the feathers with a detergent solution so heat can escape the body more quickly.

If death loss is not a problem select three or more live sick birds. The live birds that selected should show representative signs of the condition observed.

Submit a case history with the specimens that contains information such as age, medication, feeding program, mortality, evidence of illness, and name, address and telephone number of owner.

When the diagnostician can diagnose the cause of trouble without time-consuming tests, recommendations may be made directly to the individual submitting the birds. In other cases, extensive laboratory tests may be required before a final diagnosis can be made. There are nominal charges for most diagnostic services. Contact the diagnostic laboratory in the state.

FEDERAL AGENCIES AND REGULATIONS RELATING TO POULTRY HEALTH:

National Poultry Improvement Plan (NPIP): a voluntary cooperative federal, state and industry program designed to prevent the spread of poultry diseases in commercial poultry operations.

National Veterinary Services Laboratories (NVSL): at the Federal level, USDA's NVSL in Ames, Iowa serves as the national veterinary diagnostic and confirmatory laboratory. NVSL coordinates activities, participates in methods validation, and provides training, proficiency testing, assistance, materials, and prototypes for diagnostic tests. NVSL is the only AI (avian influenza) reference laboratory in the United States recognized by the World Organization for Animal Health, known as the OIE. Although there is a network of laboratories across the nation approved to conduct AI screening tests, confirmatory testing in the United States is conducted only at NVSL.

National Animal Health Laboratory Network (NAHLN): a cooperative effort between two USDA agencies-the Cooperative State Research, Education, and Extension Service and the Animal and Plant Health Inspection Service-and the American Association of Veterinary Laboratory Diagnosticians. It is a multifaceted network comprised of sets of laboratories that focus on different animal diseases using common testing methods and software platforms to process diagnostic requests and share information. These labs run preliminary tests for AI and determine if an AI virus is present and whether it is an H5 or H7 subtype. Because of the potential for H5 or H7 subtypes to mutate into highly pathogenic strains, those samples are forwarded to USDA's National Veterinary Services Laboratories (NVSL) for confirmatory testing.

Food and Drug Administration (FDA): An agency within the Public Health Service of the Department of Health and Human Services. FDA is a public health agency, charged with protecting consumers by enforcing the Federal Food, Drug, and Cosmetic Act and several related public health laws. Importantly for agriculture, a major FDA mission is to protect the safety and wholesomeness of food. In this regard, its scientists test samples to see if any substances, such as pesticide residues, are present in unacceptable amounts, it sets food labeling standards, and it sees that medicated feeds and other drugs given to animals raised for food are not threatening to the consumer's health.

Animal (Veterinary) Drugs: Drugs intended for use in the diagnosis, cure, mitigation, treatment, or prevention of disease in animals. The Food and Drug Administration (FDA) has the broad mandate under the Federal Food, Drug, and Cosmetic Act to assure the safety and effectiveness of animal drugs and their use in all animals, including farm animals. Before FDA formally approves an animal drug, the sponsor or manufacturer of the drug must show in its premarket approval application that the drug is "safe and effective" in scientific testing. Such testing data, included with the application, must demonstrate a methodology to detect and measure any residue left in edible animal products and show that edible animal products when ready-to-eat are free from unsafe residues. Farmers and veterinarians treating farm animals must adhere to any restrictions about withdrawal times, or any warning or use constraints stated on the drug label.

Center for Veterinary Medicine (CVM): An agency within the Food and Drug Administration that is responsible for assuring that all animal drugs, feeds (including pet foods), and veterinary devices are safe for animals, properly labeled, and produce no human health hazards when used in food-producing animals.

Centers for Disease Control (CDC) and Prevention: An agency within the U.S. Department of Health and Human Services that monitors and investigates food borne disease outbreaks and compiles baseline data against which to measure the success of changes in food safety programs.

CLINICAL SIGNS, MODES OF TRANSMISSION, AND PREVENTIVE MEASURES FOR SELECTED DISEASES OF POULTRY[1]

Disease	Major Gross Symptoms	Major Mode of Transmission	Preventive Measure
BACTERIAL			
Pullorum	Vent pasting in young chicks and poults	Egg transmission	Purchase stock from pullorum-free sources, test breeders
Cholera	Sudden death, swollen wattles, cyanosis of head, yellow diarrhea	Bird to bird via droppings and feed, wild animals	Good sanitation, vaccination with bacterins

Mycoplasmosis (MG)	Slight respiratory stress, lower productivity, swollen sinuses in turkeys	Egg transmission	Eradication, vaccination, test breeders
Infectious Coryza	Swelling around face and eyes, foul odor	Bird to bird	Isolate infected birds from noninfected birds
Staphylococcal Arthritis	Swollen, warm hock joints	Physical or mechanical injury	Reduce leg injuries
Aspergillosis	Respiratory stress, cheesy eyes	Contaminated feed or litter	Avoid moldy litter, feed
Infectious Synovitis	Swollen hocks and foot pads, breast blisters	Egg transmission	Purchase clean stock, sanitation
Necrotic Enteritis	Lower productivity, inflamed intestines	Oral contact with infected droppings	Sanitation, medication
VIRAL			
Newcastle	Respiratory distress, twisted shell in	Bird to bird necks, quality, egg	Vaccination poor drop production
Infectious Bronchitis	Respiratory distress, poor shell quality, drop production	Bird to bird and air in	Vaccination egg
Laryngo-tracheitis	Respiratory distress, nasal discharge, bloody windpipe	Bird to bird, contact, mucous	Vaccination carriers in
Fowl Pox	Lesions on skin and in mouth, drop in egg production	Bird to bird, carriers such mosquitoes,	Vaccination as air

Leukosis	Enlarged internal organs, weight loss	Bird to bird, carrier such as insects	Sanitation, buying clean stock
Marek's	Paralysis of wings or paleness	Bird to bird legs,	Vaccination blindness,
Epidemic Tremors	Paralysis, trembling	Egg transmission	Vaccination of breeders
PROTOZOAN			
Coccidiosis	Pale, droopy, diarrhea, huddling	Direct or indirect contact with droppings	Sanitation, medication infected
Blackhead (turkeys)	Droopiness, darkening of head, diarrhea	Consuming cecal worms infected with organisms	Sanitation, separating turkeys from chickens, medication
MISCELLANEOUS			
Mycotoxicosis	Lowered productivity	Ingestion of moldy feed	Use mold-free feeds
Botulism	Weakness, paralysis, limp neck muscles	Consumption of decaying organic matter	Remove decaying material
Bumblefoot	Hot, swollen footpads	Bird to bird, irritation from bedding	Sanitation, reduce danger of injury to feet
Water Deprivation	Dehydrated head parts, loss in body weight and productivity		Provide fresh water at all times

1 This table is intended as a guide only. Use the services of local veterinarians or diagnostic laboratories for assistance with diseases.

SUGGESTED VACCINATION PROGRAM*

Newcastle and infectious bronchitis — Vaccinate at seven to 25 days, 7-8 weeks, and 14 weeks of age, and 30 days before egg production, with B-1 strain of Newcastle and multiple infectious bronchitis strains if appropriate.

Fowl pox — Vaccinate chickens after 8 weeks of age. Other species are not usually vaccinated.

Laryngotracheitis — Do not vaccinate unless the disease has been a problem or is prevalent in the area. Vaccinate chickens after 8 weeks of age with appropriate form of vaccine. This will protect the flock for a year. Vaccinate immediately if an outbreak occurs. Some states may require a permit.

Marek's — This disease is not a concern unless you are losing many birds from the disease. Vaccine is given to day-old chicks at the hatchery. Mail-order chicks most likely are not vaccinated for Marek's disease unless specifically requested.

Diseases that can be controlled by vaccination are Newcastle, infectious bronchitis, infectious laryngotracheitis, fowl pox, avian encephalomyelitis (epidemic tremors), gumboro (infectious bursal disease), Marek's, erysipelas, and fowl cholera.

** Vaccinate chickens for diseases only after getting expert advice.*

Drugs and chemicals are used widely, but only as necessary, in poultry production to prevent and treat disease. A tremendous amount of money is spent by poultry producers for drugs that are of little or no value in preventing or reducing disease. Drugs have a valid use as known, effective treatments for specific diseases that have been identified by a reliable diagnosis. Always use drugs according to the manufacturer's recommendations that consider safe levels, approved combinations, and adequate withdrawal time to avoid residues in meat and eggs.

Summary

Poultry diseases continue to affect world food supplies, trade and commerce, and human health and well-being throughout the world. An awareness and knowledge of poultry diseases are basic to preventing and controlling them in poultry flocks.

** Leg disorders information was adapted from original publication by R. Scott Beyer, Cooperative Extension Specialist, Poultry Science, Kansas State University, Manhattan, Kansas, http:// www.oznet.ksu.edu/__library/lvstk2/EP66.pdf.*

** Jesse Lyons, Poultry Extension Associate, University of Missouri, developed and revised this topic. Dr. Dan Shaw, University of Missouri, reviewed this topic. Kirk C. Edney, Ph.D., Instructional Materials Service, Texas A&M University, edited and formatted this topic.*

POULTRY WASTE MANAGEMENT *

INTRODUCTION

The poultry industry's meat and egg producers bear the responsibility of being good stewards of the environment and must comply with environmental regulatory policies and procedures.

Collection, storage, treatment, use, and disposal of poultry manure, dead birds, and other wastes are daily concerns for poultry producers. Natural wastes must be managed properly to protect environmental quality, and more importantly, to maintain biosecurity for the flocks.

Poultry producers use various methods to collect, store, and treat poultry waste. The option selected depends on type of bird grown, facilities used, and waste regulations and restrictions.

WASTE COLLECTION

Collection simply refers to the method of initially containing the waste at its point of origin. Collection methods include pits and manure belts located beneath caged layers, concrete or earthen floors of high-rise layer houses, and earthen floors of broiler and turkey houses.

In some poultry houses, wastes are scraped or flushed into pits, storage tanks, or lagoons to be later collected and spread on pastures and crop land.

WASTE STORAGE

Storage refers to the use of temporary holding facilities, including in-house pits, settling tanks, high-rise storage, floor storage, dry-stack storage (barns and temporary covers), and other storage ponds.

In-house Pits

Deep concrete pits within the house contain wastes, in liquid or slurry form, for a specific holding period. The duration of storage depends upon location, climate, and cropping systems. Pits may be 2 to 6 feet deep, depending on number of birds and storage time.

Producers usually schedule 90 to 120 days of storage to prevent spreading wastes on pastures for slow-growth or dormant crops when nutrients are not fully used. Wastes may be transported with a liquid manure spreader directly from the pit to a land application site. Before choosing a pit size, the producer must consider the spreader equipment size and number of trips required annually. Leaking waterers and other sources of excess water must be eliminated to prevent premature filling of the pit and to reduce the number of trips taken to the land application sites.

* *Adapted from "Poultry Waste Management and Environmental Protection Manual," USDA-NRCS, and Alabama CES, Auburn University, Alabama. Dr. Craig Coufal, Assistant Professor and Extension Specialist – Animal Waste and Litter Management, Department of Poultry Science, Texas A&M University, and Mr. Dale Hyatt, Research Service Farm manager, Department of Poultry Science, Texas A&M University reviewed this topic's information.*

Disadvantages in using in-house pits for wastes include —

Constraints on management. When the pit becomes full, it must be emptied regardless of weather conditions. If premature filling of the pit becomes a problem, it may become necessary to build a settling tank or lagoon to catch the overflow during critical times.

Pest problems. If improperly managed, the pit can become a breeding ground for fly larvae, etc.

Cost. Concrete or concrete-block structures can be costly, especially if they are deep.

Toxic gases. This is a critical consideration. During pump-out or agitation of the pit, hydrogen sulfide gas can be emitted in concentrations that can cause fatalities. Adequate ventilation during pump-out is essential. Hydrogen sulfide is heavier than air and can remain in the pit after wastes are pumped out. DANGER: No one should enter a manure pit without a self-contained breathing apparatus, attached rescue lines, and helpers located outside the pit.

Settling Tanks (Lagoons)

A concrete or concrete-block structure can be constructed outside the poultry house to collect settleable solids and to skim floating material from the flush water. The typical settling tank or lagoon is approximately eight feet deep at the deep end and has a ramp to allow access by loading equipment. The wall at the deep end may have slots to allow drainage of the settled wastes. A floating baffle can be installed to remove egg shells, feathers, and other floating debris.

A pair of settling tanks is recommended, so one tank can be drained and dried while the other tank remains in operation.

Disadvantages in using settling tanks (lagoons) for wastes include —

Cost. Concrete or concrete-block structures can be costly. However, the initial expense can help the producer avoid the later cost of dredging solids from the lagoon.

Equipment needs. The lagoon requires an irrigation system. Also, the use of a solids separator requires a solids spreader.

High-Rise Storage System

Cages in a high-rise laying hen facility may be 15 to 30 feet above ground level. Waste from the caged hens drops to the earthen or concrete floor. If the storage area has walls extending to the ground and large fans to circulate air, the manure forms rows of dry mounds or cones, which extend the length of the building. Wastes can be stored for extended periods with a high-rise storage system, and the number of trips to the field can be reduced if excess water is controlled. Birds may also be reared on slat floors, allowing manure to deposit beneath the slats and dehydrate. Disadvantages in using high-rise storage for wastes include —

Polluted drainage. Excess water from leaking waterers or a wind-driven rain can turn manure piles into a slurry that may drain from the house. Once exposed to rainfall and roof runoff, the slurry may wash across property lines or into nearby streams or ponds.

Pest problems. Serious fly infestations can develop, especially if the manure remains moist.

Ammonia. Moist manure piles have the potential to release excessive amounts of ammonia, affecting air quality.

Floor Storage System

Producers raise nearly all broilers, breeders, and some laying hens (at small facilities) on concrete, wooden, or earthen floors. Pullets reared for cage egg production are raised in cages prior to placement in laying cages. A 2 to 6-inch layer of softwood shavings, peanut hulls, rice hulls, etc. serves as a bedding. The litter (manure and bedding mixture) is removed at different intervals. Depending on requirements of the integrator, this is usually after seven or more flocks, unless a disease situation requires a change-out at more frequent intervals.

The quality of poultry litter used on pastures depends on storage time, method of removal, and whether the material is raked or fluffed between flocks. Nitrogen content of litter increases with the number of flocks and generally peaks after four flocks. Of course, any additional bedding placed in the house between flocks will lower the nutrient content of the litter.

Disadvantages in using floor storage for wastes include —

Constraints on management. Wastes are usually removed from all houses on the farm at one time. Regardless of weather conditions, the waste must be removed after a designated flock and either spread or stored.

Foreign material. If the litter is to be spread on land, the owner must make sure that no foreign material (wire, screws, light bulbs, etc.) drops into the litter.

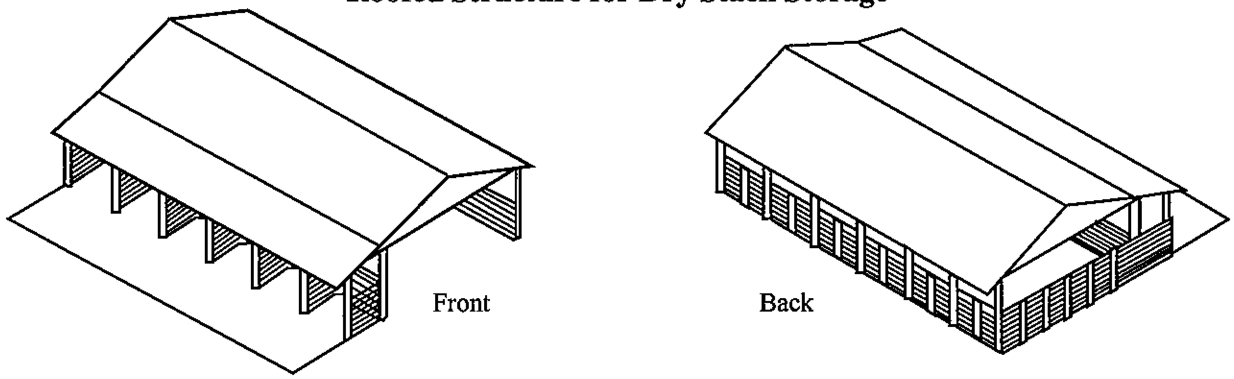
Dry-Stack Storage System

Temporary manure storage allows better nutrient use, either as a fertilizer or soil amendment. Wastes can be applied in split applications during the growing season rather than in one heavy application during house clean-out. This practice increases crop production, helps reduce nitrate contamination of groundwater, and provides management flexibility.

A gable-roofed building with an earthen or concrete floor is one method for temporary storage of manure generated by a broiler operation. Large quantities of manure are stored and kept dry in such a structure, thus promoting easy handling and uniform distribution. The storage building may be simply a pole barn with an earthen floor and no sides. It may also have walls made of concrete blocks, poured concrete, or treated wood.

Although a storage building with wooden walls is more economical to install, such a structure requires certain precautions. The producer must prevent excessive heating by keeping the litter dry and stacking it no higher than five feet. Spontaneous combustion of manure can cause loss of a wooden structure by fire.

Roofed Structure for Dry Stack Storage



Almost 10% of the ammonia nitrogen may be lost from broiler litter stored in a roofed structure after two months. But, only a small amount of nitrogen is lost if the litter has an airtight cover.

Therefore, a second option is a stack covered with a well-secured tarpaulin or 6-mil polyethylene sheeting. The stack must be kept dry to prevent fly and odor problems and ensure ease of handling and application. It must be located on high ground and away from drainage ways and surface water sources. If manure is to be stored in this manner for more than a month, the producer should use an impervious pad under the stack to reduce nutrient losses.

WASTE TREATMENT

Treatment refers to any system that reduces the pollution potential of the waste or otherwise alters its original condition. Treatment systems include anaerobic lagoons, composters, and biogas generators.

Anaerobic Lagoons

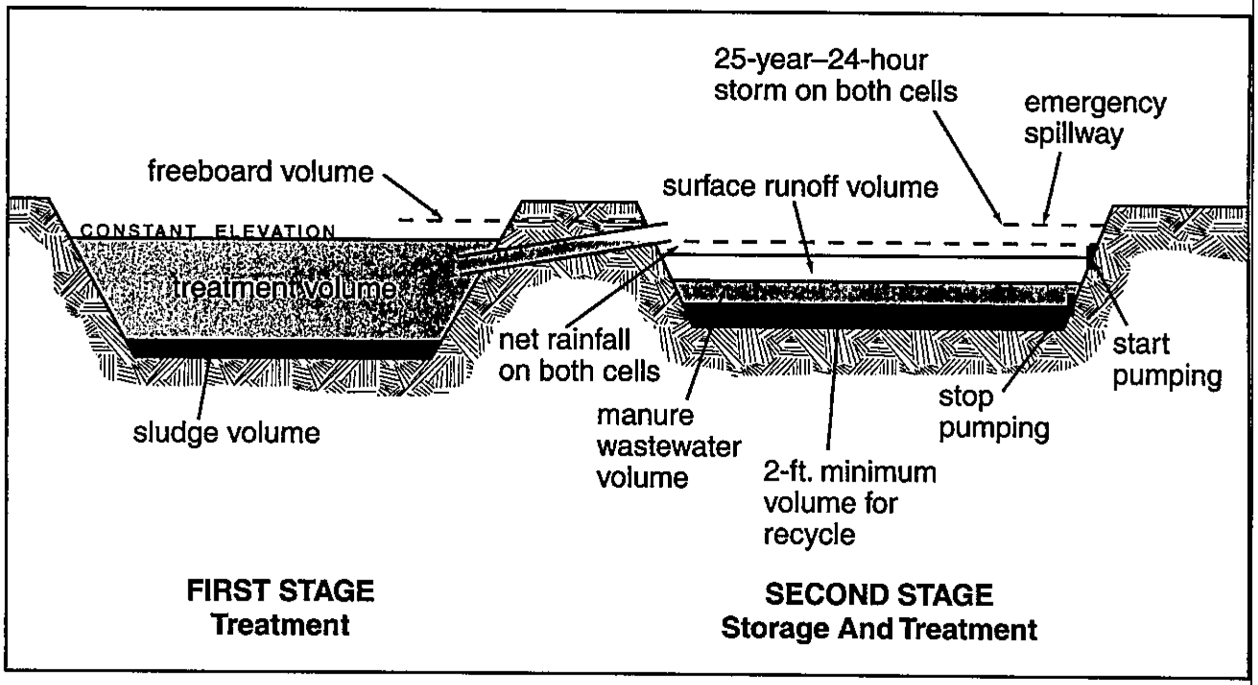
In warmer climates, anaerobic (without oxygen) lagoons are used to degrade poultry wastes.

A two-stage lagoon (see next page) has some significant advantages over a single-stage anaerobic lagoon. The first stage or cell (single-stage) is usually a deep, anaerobic structure that overflows into a shallower aerobic cell, thus producing an effluent with less odor and less sludge than that for a single-stage lagoon. This is an important consideration, especially when the pumping of effluent can cause plugging, which could occur when irrigating the waste lagoon or when recirculating water from the lagoon to flush wastes from poultry buildings.

A typical anaerobic lagoon for 60,000 laying hens is ten feet deep and has 1.8 acres of surface area at optimum water level. It is located downslope from the laying house so wastes can be gravity flushed to the lagoon. The lagoon is a minimum of 300 feet from the closest underground water well to prevent water supply contamination.

TWO-STAGE ANAEROBIC LAGOON

Illustration courtesy of Alabama CES (ANR-971).



The FIRST STAGE contains only the treatment volume and sludge volume.

The SECOND STAGE contains the 2-foot minimum sludge volume, the manure wastewater volume for the desired treatment period (180 days minimum), the net rainfall, the surface runoff volume, and the allowance for the 25-year-24-hour storm.

Definitions

Treatment volume provides enough dilution volume for breaking down volatile solids by bacteria. This volume is not removed during pumping operations.

Sludge volume is the bottom sludge resulting from manure solids settling to the bottom after poultry wastes are added to the lagoon. Sludge volume is reduced during cleanout operations.

Freeboard volume is the minimum extra depth (usually one foot) above total full pool level. Any volume above freeboard volume will enter the emergency spillway.

Surface runoff volume provides storage for rainfall runoff plus additional wash water or freshwater that may come from cleaning buildings. This volume is removed during pumping operations. A reduced runoff area will reduce the surface runoff volume to be pumped.

Manure wastewater volume provides for wastewater storage of treated poultry manure volume that accumulates over the designed treatment period.

Net rainfall is typical annual rainfall less surface evaporation plus allowance for the 25-year-24-hour storm moisture from meteorological records. Lagoon design must provide for storage of net rainfall.

When the lagoon fills, waste water (from the second-stage lagoon) is recycled for use as flush water. Recycled water is advantageous when fresh water must be purchased or is in short supply.

With a lagoon, up to 70% of the nitrogen is lost from the wastes through volatilization (loss to the atmosphere) and to settling. Approximately 90% of the phosphorus from the wastes settles within the sludge at the bottom of the lagoon.

Disadvantages in using a lagoon for wastes include —

Cost. A lagoon is larger and more costly than a waste storage pond.

Settled material. After a few years, the lagoon eventually fills with sludge if it is not routinely agitated and settled material removed. Sludge buildup can be costly to remove.

Composters

Composting is a process that converts one form of organic matter, such as dry poultry waste or dead chickens, into a more uniform and relatively odorless substance (humus or compost). Usually, composting is an aerobic (oxygen-requiring) process. However, processing manure anaerobically in a static pile, called deep stacking, is another form of composting.

Key ingredients for successful aerobic composting are a proper carbon to nitrogen ratio (nearly 30:1), the proper moisture content (40% to 50%), and an adequate oxygen supply (5%) for the bacteria. The carbon source may be wood chips, wheat straw, peanut hulls, or a similar material. Because broiler litter usually contains wood chips or peanut hulls, the producer may need to add more carbon-containing material for composting; after running seven or more flocks, the carbon to nitrogen ratio may be above 40:1. Daily bird mortality may serve as a source of additional required carbon.

Microorganisms that function in the composting process are thermophilic (heat-loving). They may cause the temperature of the mixture to rise as high as 170°F. The typical temperature range is 140°F to 160°F. The producer should carefully monitor the temperature to make sure the composting process is progressing properly.

The nitrogen content and crude protein value of the material can be reduced as much as 40% through composting. This is an advantage if the owner has a limited land area for spreading waste and plans to reduce nitrogen application rates. Composting also reduces the weight, volume, and moisture content of the original material. If properly managed, compost is a rich, uniform mixture suitable for use in landscaping, gardening and nurseries.

Three basic composting methods are windrowing, forced-air composting, and in-vessel composting.

Windrowing involves placing the manure on an all-weather surface in long rows, typically 3 to 5 feet high and 5 to 10 feet wide at the base. The windrows are mixed regularly, usually every 10 to 15 days, to ensure adequate ventilation for the aerobic bacteria. Although mixing can be performed with available agricultural equipment, specialized equipment is more efficient. Outdoor windrowing can be a difficult venture in high rainfall areas.

Forced-air composting is performed in bins or enclosed structures equipped with blowers and ducts to force air through the material. The air can be drawn through the pile or forced into it. The temperature in the pile is usually monitored automatically, and the blowers operate only when needed, as indicated by the pile's temperature.

In-vessel composting is usually accomplished in a long, shallow concrete channel. The litter is placed at one end of the channel and a roto-tiller machine travels the length of the channel, mixing the contents and gradually moving the material from one end to the other. The waste to be composted is placed at the "upstream" end of the channel and removed as compost only after it is worked to the lower end. This process must be performed under a covered area.

Rotary-drum composting is a proven technology that can be applied on the spot. The rotary drum provides agitation, aeration and mixing of the compost to produce a consistent and uniform end product. In warm, moist environments with ample amounts of oxygen and organic material available, aerobic microbes flourish and the waste decomposes faster.

Composting can be performed to some degree within the poultry house. It should begin soon after adding bedding and the new flock to the building; otherwise, the litter will be difficult to dry. To effectively compost the manure, the litter must be mixed regularly and additional dry bedding added. Completely composted litter seldom carries disease to the next flock. However, in-house composting is more difficult and does not produce a completely stabilized material.

Biogas Generators

Biogas production is the conversion of manure into a combustible gas. The gas consists primarily of methane (CH_4) plus small amounts of water vapor and other gases, such as hydrogen sulfide (H_2S). Methane, the gas desired in this process, may represent 60% to 70% of the final mixture, with carbon dioxide (CO_2) making up nearly 30%. Biogas is used to heat buildings. It has also been used in conjunction with other fuels to generate electricity.

Methane alone has an energy value of nearly 1,000 BTU per cubic foot. Biogas yields almost 600 BTU per cubic foot. Because of the hydrogen sulfide and other trace gases, biogas may have an odor similar to rotten eggs. It may also be corrosive to metal parts.

Biogas is developed from liquid or slurry wastes under anaerobic conditions. During the warm season, nearly all anaerobic animal waste lagoons produce large volumes of biogas that appear as large bubbles continually breaking at the surface. Poultry manure produces more biogas than does other livestock manure. Producers should consider several factors concerning the generation of biogas.

Approximately 25% of the gas is needed to heat the biogas generator (digester) during cold weather because an optimum temperature must be maintained at all times.

Nearly all nutrients entering the digester leave the digester. The nutrients and solids, including water added to create the necessary slurry, must be disposed of on land.

Biogas is explosive, and extreme care must be taken to prevent disaster.

Biogas generation requires high level management skills.

Biogas is most effective when the nonessential gases are removed through scrubbing. Separating methane from other gases requires skill.

Biogas can be corrosive to metal parts.

Traditional fuel costs must increase dramatically for biogas to be a practical option.

USING POULTRY WASTE

Poultry waste is mainly used as fertilizer (or as a soil amendment) on land. Many publications discuss the concentration of nutrients in the typical or average broiler litter. However, not everyone's litter is "average."

Using Litter for Fertilizer

The first step in using poultry waste as a fertilizer is to determine the available nutrients in the waste. Nutrient content of poultry waste is determined by analyzing samples, nutrient content estimates, and feed intake data of poultry. Sample analysis in a testing laboratory provides the most accurate indication of the nutrient values in poultry waste. However, other than the actual analysis, two other factors must be considered in this approach — the method of collection and interpretation of laboratory report.

Laboratory results are only as good as the quality of the sample collected. The sample for analysis must be representative of the entire amount that will be spread on the land. If a waste sample cannot be analyzed, the producer can use published data to arrive at an approximation of nutrient contents. However, this method has shortcomings. The nutrient content of waste varies widely from one producer to another and from average values shown in tables.

The following table lists soil nutrient values of poultry manure for nitrogen, phosphorus, potassium, and calcium. The nitrogen values should not be used to determine fertilizer application rates because part of the nitrogen is lost during storage.

Soil Nutrient Values of Poultry Manure *

Nutrient (%)	Egg Layer	Broiler	Turkey
Nitrogen	1.0 – 1.8	1.4 – 2.2	1.2 – 2.5
Phosphorus (as P_2O_5)	0.8 – 1.2	0.9 – 1.2	1.0 – 1.4
Potassium (as K_2O)	0.5 – 0.7	0.5 – 0.8	0.5 – 0.8
Calcium	3.3 – 4.8	1.2 – 2.5	1.0 – 2.3

* Source: The Ohio State University (http://ohioline.osu.edu/b804/804_3.html)

Nutrients from animal manure applied to fields as fertilizer contribute to the degradation of surface water. Phosphorus is the nutrient of greatest concern in fresh water systems because it has the most limiting effect on algae growth. Many methods have been developed to try to reduce phosphorus losses from animal manure applied to fields, including modifying the diet to reduce supplemental phosphorus inputs and chemically treating the manure with chemicals to precipitate the phosphorus. Research indicates that phosphorus losses from animal manure are reduced more effectively if diet modification and manure treatment are jointly considered for any phosphorus reduction program.

The amount of manure produced by a given flock of poultry can be roughly estimated from the amount of feed consumed by the birds. Estimates of manure production for three types of birds are listed in the following table.

Manure Production by Poultry *

Type of Poultry	Daily Feed Intake (pounds per 100 birds)	Daily Manure Output (pounds per 100 birds)
Egg Layer	20 – 26	20 – 34
Broiler (6 weeks of age)	26 – 30	30 – 35
Tom Turkey (16 weeks of age)	93 – 115	108 – 132

* Source: The Ohio State university (http://ohionline.osu.edu/b804/804_3.html)

The moisture content of poultry manure is approximately 75% as excreted (varying from 20% to 40% for moist, crumbly broiler litter to 95% for liquid hen manure). When poultry manure is analyzed, the results provide a value for moisture percentage. A producer can use this value to compare estimates of the quantity of manure generated per year under various types of poultry management systems.

After the available nutrients in the waste are determined, the next step is to calculate the land application rates. Application rates for animal wastes are usually based on the crop's nitrogen requirements, but phosphorus levels must be monitored as well. A nutrient analysis will determine the nitrogen and phosphorus content of the waste.

Poultry wastes are often spread in the spring of the year. This is also the time of year when much of the annual rainfall occurs. For this reason, the producer should pay close attention to weather reports when planning waste spreading activities. Wastes should not be spread within three days of a predicted rain to prevent runoff from carrying nutrients into surface waters. In addition, wastes should not be spread within 150 feet of wells or within 100 feet of streams.

CONTROLLING PROBLEMS RELATED TO WASTE MANAGEMENT

The producer can encounter problems if dead birds and poultry manure are handled improperly. Proper management of these two waste products reduces problems, improves sanitary conditions, and protects the environment.

Disposing of Dead Birds

Dead bird disposal is an on-going problem for the poultry industry. The flock size, or the number of birds on hand, dictates the number and weight of dead birds that must be disposed of daily. Before choosing a disposal system, the producer must know the daily mortality rate. For broilers, the mortality rate is usually at a maximum during the final seven to ten days of the production cycle.

Dead birds, occurring under normal operating conditions, can be safely disposed of in several ways. The methods are not intended for use during massive die-offs, which are often associated with heat, equipment failure, or disease. The particular method chosen must be compatible with the individual producer's situation and management abilities.

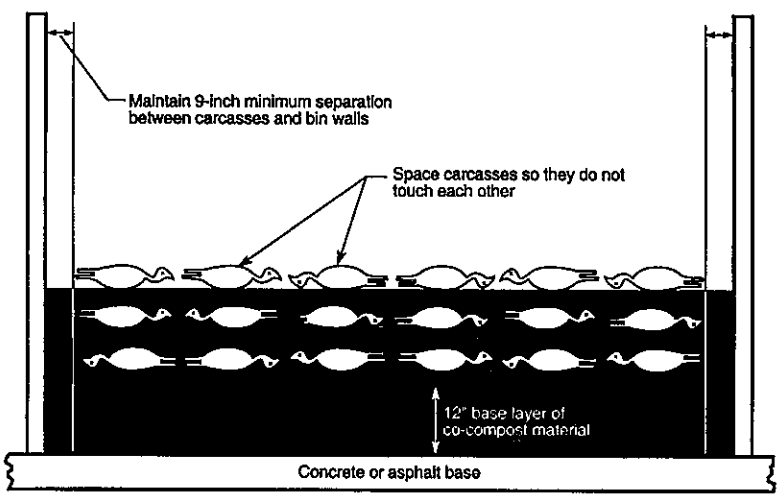
In some states, dead birds must be frozen or refrigerated prior to disposal. Permits may be required for bird disposal. For complete environmental quality rules and regulations on disposal of poultry carcasses, the producer should contact the State Animal Health Commission.

Composting. A composting method involves mixing dead birds, co-compost material (manure and a carbon source - wheat straw), and water according to a formula. Water is added to maintain a moist but unsaturated condition. Typically, one pound of water is added for every two pounds of carcass.

FORMULA FOR DEAD POULTRY COMPOSTING

Material	Parts by Weight
Poultry Manure	20 to 30
Poultry Carcass	10
Carbon Source (wheat straw)	1
Water (add sparingly)	0 to 5

The formulated mixture is placed in a bin in layers. A 1-foot layer of co-compost material (straw and manure) is first placed on the bin floor (concrete or asphalt). Carcasses are then placed on top of this layer, making sure they do not touch each other. Carcasses should not be within nine inches of the bin walls. Water is added, followed by co-compost material to fill in the void areas. Then, a 4-inch layer of co-compost material is added above the first layer of carcasses. This completes one batch. The second, third, and additional batches each begin with a layer of carcasses, followed by water and a 4-inch layer of co-compost material. After the last batch is added, the final cover or cap is a double layer of co-compost material. Water is not added to the final cap.



Source: Iowa State University – Cooperative Extension

As bird mortalities continue, successive layers are added to the bin. After a few days, temperatures increase rapidly because of bacterial action, rising to 145°F to 165°F. When temperatures begin to drop, the material is moved to a secondary bin or treatment alley. The moving process re-aerates the material. Then the bacterial action begins again, and temperatures rise again. After the second heating, the compost is moved to a storage area.

The entire composting process takes almost 60 days; the end product is an odorless, spongy, humus-like material with a small amount of hard tissue (bones and feathers) remaining. Disease-causing organisms are eliminated through heating. Producers can use the compost as a soil amendment.

Incinerating. The incinerator is a popular choice because it causes no water quality problems. It is the most biologically safe method of bird disposal. Incinerators with dual-burning chambers or afterburners that recycle fumes to reduce odors are recommended. However, improper operation of an approved incinerator can cause more nuisance complaints than any other disposal method. The producer must carefully consider incinerator design, fuel cost, maintenance, and proximity to neighbors before choosing incineration as a method of bird disposal.

Rendering. This disposal method is used by growers living near rendering plants. Assuming a rendering plant is reasonably close, this method is cost-effective and also safe if the dead birds are rendered properly. Other than the cost of fuel for delivery of birds, the only possible drawback to this method is the risk of vehicles picking up disease organisms at or near the plant and transporting them to the production flocks.

Marketing Poultry Manure

A growing acceptance of poultry manure as a valuable soil amendment and the increasing cost of inorganic fertilizers will increase the commercial value of manure. Producers can speed this process through more aggressive marketing of waste products. Marketing involves both selling manure as a resource and finding customers who wish to purchase it.

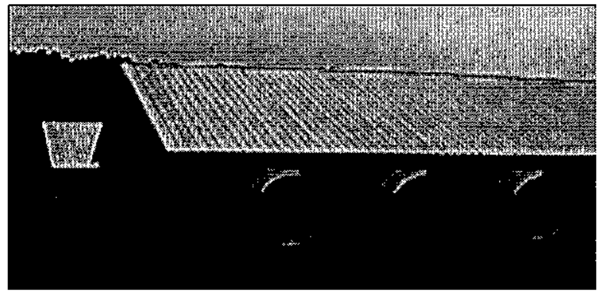
One approach is making arrangements with neighboring ranches and farms to apply the manure. Using custom operators or better equipment to ensure that manure is applied properly would promote poultry manure sales. Groups of producers could work together on collecting and distributing manure. Marketing takes more time and effort than producers typically devote to manure handling, but the benefits can be substantial. A producer should review city, county, and state ordinances to see if poultry manure is approved for marketing to the general public.

SUMMARY

Poultry waste management includes existing practices and also new alternatives. A practical approach emphasizes enhancement of standard practices. If poultry waste handling is moved further along from waste disposal to resource management, along with prudent use of composting, producers are in a good position to ensure the environmental sustainability of the poultry industry.

POULTRY ENVIRONMENTAL CONTROL MANAGEMENT *

INTRODUCTION



Poultry have a high body temperature, strong pulse rate, and elevated respiration rate. Without sweat glands to assist in reducing body heat, poultry (especially those raised in buildings) must be provided an adequate air exchange.

Two types of mechanical ventilation systems provide year-round climate control for the high production requirements of poultry flocks. Depending on geographical location, most poultry producers ventilate buildings with a fan and pad system during hot weather and a convection tube system during cold weather. This image from the Cooperative Extension Service, University of Georgia, shows part of the ventilation system in a poultry facility.

BENEFITS OF MECHANICAL VENTILATION IN A POULTRY BUILDING

- Mixes fresh outside air throughout the building to maintain a uniform environment
- Adjusts the ventilation rate in response to changing weather conditions
- Lowers building temperature as much as 25°F on the warmest days
- Controls moisture levels
- Removes odors and unwanted gases
- Reduces supervision and labor requirements for building temperature regulation
- Permits an increase in quantity of birds raised in a building
- Allows use of light controlled and windowless operations

The basis for using a mechanical ventilation system is knowledge of the scientific principles involved in regulating moisture, controlling temperature, and removing odors and unwanted gases.

MOISTURE REGULATION

Regulating moisture is an important function of a ventilation system. A great amount of moisture is created within a poultry building, and most of it must be removed by exchange of air.

It is essential to maintain an optimum moisture balance within the building. If air exchange removes too little moisture, the building becomes damp or wet. If an excessive amount of moisture is removed, the building becomes dry and dusty.

* *Adapted from "Environmental Control Handbook for Poultry Confinement Operations," ACME Engineering and Manufacturing Corporation, Muskogee, Oklahoma. Reviewed and edited by Dr. Richard Gates, Professor, Agricultural and Biological Engineering, University of Illinois, Urbana, IL.*

Air Mixture

Air is a mixture of water vapor, nitrogen, oxygen, carbon dioxide, and traces of other gases. Although the water vapor content of air is often less than 1% of the total, it is a major factor in determining the condition of the air mixture. This is not only because of the necessity of water for body processes, but also because of its latent heat potential in vapor form. The latent heat (heat that cannot be felt) in water vapor is the largest for any common liquid. Latent heat is the energy required to change water from liquid to vapor without any change in water temperature. Even the smallest amount of water vapor in the air contains most of the total heat energy of the air mixture.

Psychrometric Science (Psychrometry)

Psychrometry is the study of moist air and the changes in its conditions. The psychrometric chart on the next page is a graphical representation of the thermal properties of moist air and is used by environmental engineers to analyze and solve thermodynamic problems of air. Poultry producers can use to chart to monitor the environmental conditions in their poultry buildings. Computer versions of the psychrometric chart are also available.

Dry Bulb Temperature

Refer to the psychrometric chart and observe the vertical lines with numbers along the bottom axis. These lines represent "dry bulb" (DB) temperatures, which are air temperatures measured with an ordinary thermometer. All points falling on a vertical line represent the same dry bulb temperature. The DB temperatures on the left side of the chart represent the coolest temperatures, whereas those on the right represent the warmest temperatures.

Water Vapor Content

Horizontal lines on the psychrometric chart are "water vapor content" lines, called humidity ration (HR). The numbers on the right side of the chart designate the water vapor content of air (grains of moisture per pound of dry air). Water vapor content, HR, is expressed in grains rather than in pounds to avoid use of small fractions (there are 7,000 grains in a pound). The highest HR is at the top of the chart; the lowest HR is at the bottom of the chart.

Relative Humidity

The curved lines radiating from the lower left side of the psychrometric chart to the upper right side are the relative humidity (RH) lines. The horizontal line at the bottom of the chart is the 0% RH line, which coincides with the zero HR line. The uppermost curved line is the 100% RH or "saturation" line.

The intersection of horizontal lines of HR with the saturation line designates the maximum water vapor that saturated air can hold at a given DB temperature. For example, at a DB temperature of 50°F, a pound of air can hold a maximum of 54 grains of moisture. This point (54 grains) on the chart is the intersection of the 100% RH line with the 50°F DB temperature line. If air contains 80% of this amount (0.80 x 54 = 43 grains), the air is said to have 80% relative humidity. This point (43 grains) on the chart is the intersection of the 80% RH line with the 50°F DB temperature line.

Effect of Temperature on Moisture Removal

As an example, if air inside a building is at 50°F DB temperature and 80% RH, each pound of air exhausted from the building contains 43 grains of water vapor. If the cooler outdoor air coming in is at 40°F DB temperature and 90% RH, each pound of cool air brings in 33 grains of water. There is a net removal of 10 grains (43 grains minus 33 grains) of moisture per pound of air from the building.

Using another example, if the ventilation rate is reduced by nearly 50% so that the building temperature increases to 60°F DB temperature and 80% RH, the moisture content now increases to 62 grains in the exhausted air. The net removal rate is 29 grains (62 grains minus 33 grains) of moisture per pound of air. That is almost three times the removal rate as in the previous example. Although the air flow is only 1/2 as much as before, the net removal rate is 1.5 (50% of 3) times greater.

What is the significance of those two examples? They show that temperature greatly affects the water holding ability of air. In general, for each 20°F rise in DB temperature, the moisture-holding ability of air doubles. Continued reduction in ventilation rate increases the moisture removal rate until maximum heat loss prevents further proportionate temperature increases, thus reducing further moisture removal in the poultry building. Without ventilation, moisture cannot be removed; and too low of a ventilation rate, results in damp, muggy conditions for the birds.

In cold weather, an optimum flow rate occurs for maximum moisture removal. This varies from day to day, and even from hour to hour, depending on outdoor weather conditions and building construction. Either too much or too little ventilation results in a wet building. Specifically, too much air flow results in a cold, wet building. Too little ventilation produces a warm, wet building with a strong ammonia odor. A big advantage of mechanical ventilation is that it can be programmed to maintain an optimum flow rate without the effect of outdoor wind. In the summer, the air temperature is already high enough to have good moisture-holding capacity, and moisture removal at that time is not usually a problem.

To remove moisture from a building in cold weather, the outdoor air being brought in must be heated to increase its capacity to hold moisture. Considerable heat (1,060 BTUs per pound of water) is required for water vaporization. Fortunately, poultry generate considerable heat. If this heat is not wasted through unnecessary building heat loss due to inadequate insulation or a poorly managed ventilation system, it will be sufficient to do the job. However, inadequately insulated buildings, located in extremely cold climates, or housing very young birds require a supplemental heat source.

Wet Bulb Temperature

Wet bulb (WB) temperature is the lowest temperature that can be obtained by evaporating water into the air at a constant pressure. "Wet bulb" comes from the technique of placing a wet cloth around the bulb of a mercury thermometer and then blowing air over the cloth until the water evaporates. Because evaporation takes up heat, the WB thermometer cools to a lower temperature than the DB thermometer. WB temperature is measured with a hygrometer or a sling psychrometer.

Perfectly dry (0% RH) air at 98°F DB temperature has a WB temperature of 56°F. This air contains only sensible heat (heat that one can sense). It has no latent heat because of the complete absence of moisture. However, if water evaporates into this dry air until it attains 100% RH, the air's DB temperature will drop to 56°F. On the psychrometric chart, locate 98°F DB temperature at 0% RH and follow the diagonal 56°F WB temperature line upward to the 100% RH line, which coincides with 56°F DB temperature.

The decrease in DB temperature is caused by using up some of the sensible heat of the air to evaporate water in the air. This loss in sensible heat energy (reduction of the DB temperature from 98°F to 56°F) is exactly balanced by an equal increase in the latent heat energy.

Consequently, the total heat energy (latent plus sensible) content of the air mixture remains unchanged. This process follows along any of the diagonal WB temperature lines on the psychrometric chart and is referred to as the "adiabatic cooling of air by the evaporation of water." Therefore, the WB temperature is the lowest temperature to which adiabatic cooling can cool the surrounding air.

To better explain the WB temperature, it is the temperature that a human would feel when stepping out of a swimming pool on a windy day. The chilly feeling exists because as long as the swimmer's skin is wet while in a strong breeze, the temperature of the skin will quickly drop to the prevailing WB temperature.

As another example, if the outside air at 40% RH and 95°F DB temperature is passed through the wet cooling pad of a poultry building, it would evaporate water from the pad. In doing so, the air would increase its moisture content (latent heat) and reduce its DB temperature (sensible heat) from 95°F to nearly 75°F. On the psychrometric chart, the WB temperature line running through the intersection of 95°F DB temperature and 40% RH is the 75°F WB temperature line.

In theory, the WB temperature indicates to what DB temperature evaporative cooling can cool air. In actual commercial practice, the WB temperature is not quite reached, but the air can be cooled down to within 3°F of the WB temperature. In the previous example, the 95°F DB temperature could be cooled down to nearly 85% of the difference between the WB and DB temperatures, or to a 78°F DB temperature.

Because the WB temperature (not the RH) determines to what temperature air can be cooled by evaporation of water, it has paramount importance. Wet bulb temperatures are compiled for many years from meteorological data. They are available from government sources for most localities.

For reference, this information is shown on the United States map at the end of this unit. It shows that the average maximum WB temperature for the four hottest months (June through September) ranges from 70°F to 80°F. For regions at higher elevations, WB temperature is even lower.

As previously stated, air can be cooled in commercial evaporative cooling applications to within 3°F of the WB temperature. One can therefore look at the map and tell almost exactly what temperature such a cooling system can reach. It would range from 73°F to 83°F during the normal hottest summer afternoon throughout most of the United States.

Contrary to some opinions, evaporative cooling works in most parts of the country, especially in areas where the air is dry. The DB temperature change is quite large during the 24-hour day, but the WB temperature is more consistent and changes only 1/3 as much as the DB temperature.

During the heat of the day when both the DB and WB temperatures are at their peak, the difference between them is the greatest. Consequently, the greatest potential for evaporative cooling is during the hottest part of the day when a temperature reduction is needed the most.

An evaporative water cooling system should be used in a poultry building whenever and wherever hot weather conditions exist.

Movement of Air (Aerodynamics)

If a poultry producer only moves air through a building, the air flow will not accomplish the desired result unless the air is introduced uniformly, mixed well with the building air, and circulated properly through the building. This is especially true when the producer wants air to move over the poultry litter where it can contact and absorb moisture. Thus, the air flow pattern in the building is important and is controlled almost entirely by how the air enters the building.

Jet Flow

Jet flow is the rapid flow of air from a hole into an open space because of the difference in air pressure. The jet, being a relatively high velocity stream of air, is turbulent with its air particles swirling about as they travel in the stream. However, because of its extremely turbulent flow, the jet immediately begins mixing with the surrounding air and gradually slows down.

The jet's velocity affects both its mixing and throwing ability, but its velocity is determined by the area of the inlet opening for a given amount of air flow.

For example, a 2" diameter hole throws a jet a distance of approximately 3.5 feet. At 20 diameters from the opening, that jet becomes eight diameters (16 inches) wide. The jet slows down to a centerline velocity of 20% of its original outlet velocity but is 90% mixed with the surrounding air. It expands at an included angle of nearly 22 degrees because of its mixing action.

As another example, a jet from a 16" hole, approximately the size of a missing window pane, travels more than 30 feet before it mixes with surrounding air. Such a large jet size produces a very objectionable draft during cold weather.

Therefore, it is important for the poultry producer to regulate the inlet areas in the ventilating system to match the total air flow produced by the fan to maintain the proper jet velocity.

During cold weather conditions, the ventilation system should allow the outside air brought into the interior of the building to flow through a large tube and then out through small jets to be then mixed with the inside air before it reaches the birds. This system has the advantage of continuous air circulation within the building that is completely independent of the fresh air ventilation rate.

If jets are of proper size, velocity, and distribution, they will produce good mixing, uniform distribution, and thorough circulation within the building.

Exhaust Fans

Ventilation systems are based on the principle that all flow is caused by pressure differences and that the pressure is constant within an enclosed space. Exhaust fans create a slight vacuum that is essentially uniform throughout the building. Therefore, air will enter at the same velocity through any and all openings, regardless of their locations.

The mixing and circulation of air within a building are mainly determined by how and where the air enters the building. Where it goes out is of little importance. The locations of both the exhaust fan and the air inlet openings are important for proper fan and pad cooling during hot weather conditions. However, the location of the exhaust fan is not significant during cold weather.

TEMPERATURE CONTROL

An important function of a poultry building ventilation system is to maintain a suitable interior temperature that is higher than the outdoor air temperature during the winter and as low as is economically feasible during the summer.

In the winter, the ventilation system uses part of the bird heat to warm the incoming air and evaporate the moisture. The remainder of the heat radiates through the building walls to the outside air. A slow air flow rate is needed during cold weather to keep the interior building temperature higher than the outdoor temperature.

In the summer, the ventilation system must remove all the heat plus all the solar heat that is transmitted through the walls and roof. Therefore, a much larger air flow rate is needed during hot weather to keep the building temperature near the outdoor temperature. A properly designed and operated fan and pad cooling system can keep the building temperature 15°F to 25°F lower than the outdoor temperature.

Importance of Surface and Air Temperature for Bird Comfort

Poultry generate internal heat that must be transferred to the surroundings at a proper rate for the birds not to be too hot or too cold. A bird loses this self-generated heat mainly by convection to cooler air and by radiation to cooler surrounding surfaces (ceiling, walls, and floor). Because these surfaces, if well insulated, are approximately at the inside building air temperature, both adequate insulation and the building air temperature have double importance to the birds' comfort.

Increased air velocity will improve a bird's convection cooling process at temperatures below the bird's body temperature and therefore, if properly used, will be beneficial in warm weather.

In general, humidity in the summertime is not as critical with poultry as it is with humans because a bird does not perspire. For further explanation, a human can easily dispose of all body heat through the evaporative cooling of perspiration, even at air temperatures above the body temperature of 98.6°F. Increased humidity reduces the rate of evaporation and cooling and thus is a major factor in human discomfort.

Because a bird has no evaporative cooling mechanism, the body heat that it dissipates through breathing (even when panting) during hot weather is only a small portion of its total necessary heat loss. The bird must rely almost completely on convection and radiation for its excess heat disposal. It cannot live long if air temperature is higher than its body temperature. Therefore, the temperature of the building air and the temperature of the ceiling and walls are more important than is the humidity for bird health.

REMOVAL OF UNWANTED GASES AND ODORS

Another important function of a poultry building ventilation system is removal of unwanted gases and odors.

Any ventilation system designed to handle the temperature and moisture problems will have ample capacity for removal of unwanted gases and odors. The air capacity needed for that function is quite low. Therefore, the established minimum flow rate must be maintained even in cold weather.

Maintaining sufficient air distribution and circulation within the poultry building becomes the biggest problem in avoiding pockets of odor laden air. Poor air circulation and distribution can be corrected or prevented by ventilation. However, the initial ventilation system must be built with sufficient flexibility through the use of multiple fans or timers to provide operation at low flow rates.

DESIGN OF A COLD WEATHER VENTILATION SYSTEM

Poultry building ventilation for cold climates is quite different from a summer ventilation system. The cold weather ventilation system should automatically provide a comfortable and healthy climate in the fall, winter, and spring. This requires supplying fresh air without any drafts and maintaining the desired temperature and humidity in the building without sudden temperature changes.

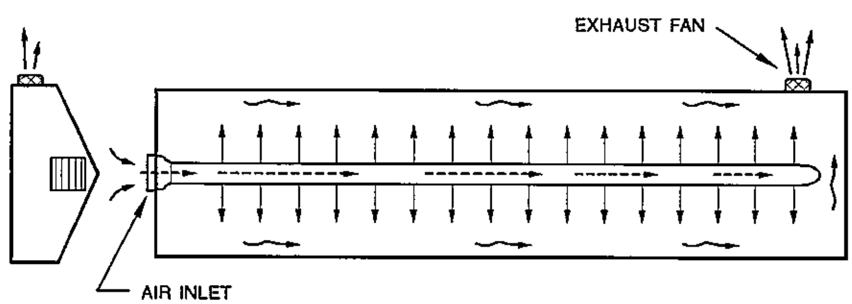
Also, proper air distribution is needed to provide uniform temperatures throughout the building. Correct air flow patterns are important to provide gentle air circulation around each bird.

COLD WEATHER VENTILATION REQUIREMENTS	
Bird Weight (lb.)	Air Flow (CFM per bird)
3.0	1.8
4.0	2.2
5.0	2.6
6.0	3.0
7.0	3.4
8.0	3.8
10.0	4.7
20.0	8.1
25.0	8.7
30.0	11.2
40.0	13.5

Fresh Air Convection Tube Ventilation

Description of the System

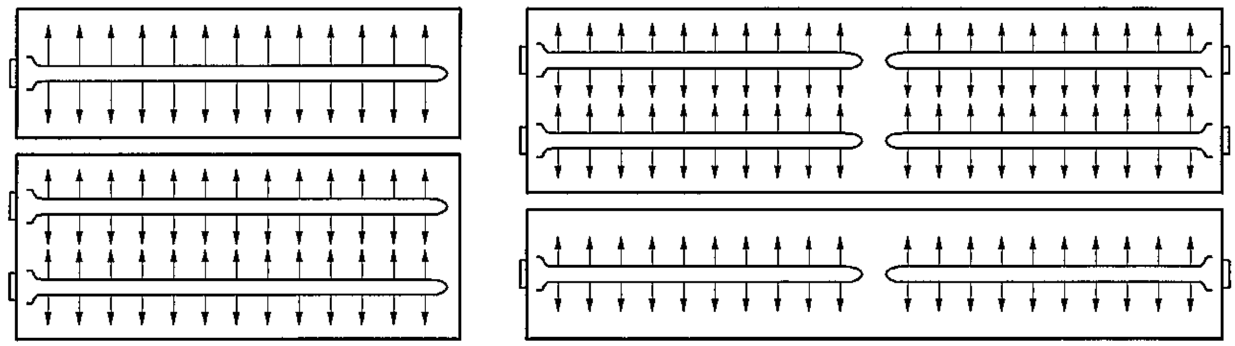
The convection tube ventilation system is a combination of matched high efficiency components consisting of a motorized inlet shutter, a streamlined air inlet orifice, a long plastic tube having precision sized holes at specified intervals along its length, and one or more exhaust fans.



When the building temperature or moisture conditions exceed the desired maximum, a thermostat or timer starts an exhaust fan and opens the motorized inlet shutter. The resulting vacuum created in the building draws cool air in through the shutter and inlet orifice. This inflates the full length of tubing and uniformly discharges air from the holes that thoroughly mixes with the warm building air, thus preventing cold drafts and promoting a desired air motion. When the desired temperature or moisture conditions are reestablished, the control shuts off the exhaust fan and closes the motorized inlet shutter. The tube collapses, and the ventilation process stops.

Because cool outside air usually is lower in moisture content than inside air, it has a drying effect when warmed up to building temperature. This helps prevent excessive moisture within the building.

TYPICAL TUBE ARRANGEMENT PLAN



During cold weather, the exhaust fans cycle on and off to supply the air needed to maintain temperature and moisture control. As the outside temperature increases, the exhaust fans run for longer intervals or run continuously to meet the control requirements. By this time, the outside air temperature is usually warm enough that any additional air required can be admitted through the pad opening or through other supplementary inlet openings.

Exhaust Fans

The locations of exhaust fans are not important when used with a convection tube ventilation system because the distribution of air is determined mostly by the convection tube. However, the fan location should be determined for the most effective summer cooling performance. For this reason, the convection tube ventilation system for winter ventilation is readily adaptable to exhaust fans used for summer ventilation.

Automatic Controls

The convection tube ventilation system should have a single controller, which ties the cold weather and hot weather ventilation systems into one unit. The system's components should be automatically controlled with thermostats and timers.

Converting to a Fan Jet System

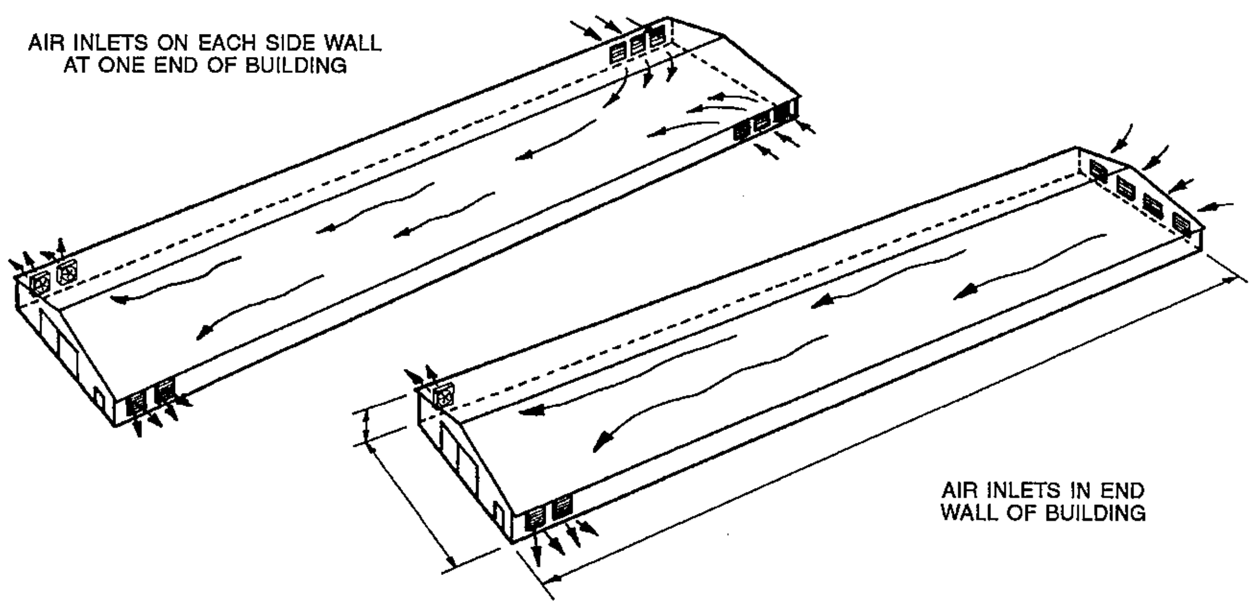
A convection tube ventilation system can readily be converted to a fan jet system, if later desired, by adding the proper fan jet unit and its corresponding tube.

DESIGN OF A HOT WEATHER VENTILATION SYSTEM

Heat to be removed from the poultry building comes from the birds and from heat transmitted into the building from solar radiation. Thus, both bird heat and solar transmitted heat must be considered separately to establish a rational basis for the needed air flow. The air flow capacity needed to remove the bird heat depends on the number of birds and their weights.

HOT WEATHER VENTILATION REQUIREMENTS	
Bird Weight (lb.)	Air Flow (CFM per bird)
3.0	3.4
3.5	3.8
4.0	4.2
4.5	4.6
5.0	5.0
10.0	8.9
15.0	12.1
20.0	15.2
25.0	21.0
40.0	31.5

Aerodynamic concepts emphasize that summer fan ventilation can be achieved by effective use of air flow patterns within the building. This is accomplished with improved design and arrangement of ventilating equipment. All exhaust fans are located at one end of the building - in the end wall or in both side walls. The entire air inlet is located at the opposite end of the building - in the end wall or in each sidewall. This usually consists of a number of motorized inlet shutters uniformly spaced along the length of the opening.



All the air enters through the inlet shutters and flows the length of the building to the exhaust fans at the opposite end. This arrangement produces a desirable "wind tunnel effect" throughout the entire building. It provides more uniform air velocity and distribution, eliminates blasts of high velocity air, and minimizes dead air pockets.

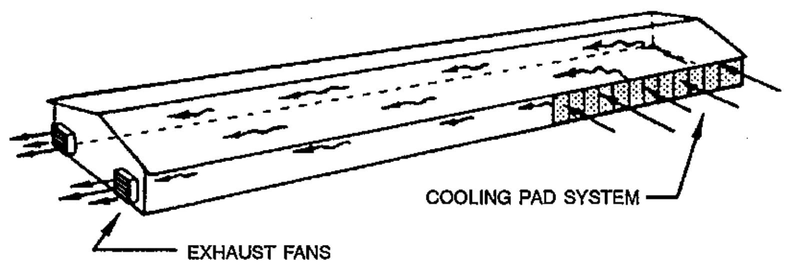
In buildings less than 150 feet in length, the cold weather ventilation system remains on in the summer to enhance air movement and mixing within the building. In long buildings, usually more than 500 feet, the exhaust fans are equally divided and installed at both ends of the building with the large air inlet openings in both sidewalls at the midpoint of the building. The ventilating air then equally divides and flows to the exhaust fans at both ends of the building.

Evaporative Cooling System

Excessive summer temperatures are a serious problem for poultry producers. Heat causes unprofitable operations – lower body weights and substantial flock losses. An effective method of lowering building temperature is by use of an evaporative cooling system, commonly called the fan and pad system.

Description of Fan and Pad System

The fan and pad system consists of a number of large, high-capacity, exhaust fans located at one end of the building and a series of wet fibrous pads in a continuous section located on one sidewall at the opposite end of the building.



FAN AND PAD COOLING SYSTEM

Outside air is drawn through the wet pads where it is cooled to within 3°F of the WB temperature. The air absorbs heat as it travels through the building. Exhaust fans then remove the heated air from the building. Because this system requires a tightly sealed building, the building will also be practically free of insects and other pests.

Exhaust Fans

The exhaust fans are all located at one end of the building and mounted in the end wall or the sidewalls at one end. Because winds can affect fan performance, they should be located on the end or side, downwind to summer prevailing winds. If the fans must face into the prevailing wind, the CFM capacity should be increased by 10%, and fans having 3/4 HP or larger motors should be used.

For a long building, the number of fans should be divided equally between both ends of the building.

Wet Pads

The cooling system must be properly designed to obtain maximum evaporative efficiency during periods of intense hot weather. This requires a nonturbulent potential flow through the poultry building to avoid mixing the cooled air with the warmer air in the top of the building.

The wettable, fibrous pad is in the form of self-supporting special fluted cellulose cooling cells. The pad is kept wet by water recirculating through it, thereby cooling the incoming air to within 3°F of the outdoor wet bulb temperature. The pad also distributes the air uniformly and because of its resistance, restricts the turbulence from the outdoor air. This effect delivers a smooth, laminar flow of cool air within the building.

The pad should be located on the summer prevailing wind sidewall of the building, starting at the end wall opposite the fans and extending along the sidewall a sufficient distance to provide the proper pad area. The length of the pad usually ranges from 1/4 to 1/2 the length of the building. For a long building, it is located midpoint of the sidewall.

If a long pad is needed, it is equally divided and installed on both sides. Its height is one to 1.5 feet less than the wall height and is usually attached to the outside of the wall.

All building materials except structurals are omitted at the pad opening, thus providing an opening equal to the pad area to permit full flow of cooled air into the building. Insulated doors or covers should be provided.

A greater air flow velocity from the pad to the fan can be achieved in an open truss building (without ceiling) by simply installing air flow restrictions in the upper section of the building. This consists of triangular-shaped baffles extending from the roof down to approximately eight feet from the floor or as low as equipment or personal convenience permits. The baffles consisting of film plastic or similar material should be placed 30 to 50 feet apart and held in a fixed vertical plane. In a building equipped with fan jets, the tubes may go through holes cut in the baffles.

The pad size should allow one square foot of pad for every 250 CFM of hot weather cooling requirement. Dividing the pad height into the area will result in the pad length.

Cooling Water

For adequate wetting and best evaporative efficiency, much more water than is actually evaporated should be supplied to the pad. To conserve the unevaporated water, a water recirculation system is necessary to recycle the water.

The water consumption rate will vary from little or none at night or on a rainy day to one gallon per minute per 100 square feet of pad area on a hot day. The water flow rate should provide a minimum of 1/2 gallon per minute per lineal foot of pad to ensure adequate wetting and optimum performance.

Excessive water flow must be avoided as it may cause a solid curtain of water on the pad. This will block the flow of air through the pad.

Water is supplied to the pad by an overhead pipe distributor having metered outlet holes for uniform water distribution. It is furnished with flush-out end plugs for cleaning when necessary.

The pipe supplying the water to the overhead water distributor should be connected near the midpoint of the distributor. The piping system from the pump to the water distributor should be equipped with the recommended size and type of filter. The filter should have a flush-out valve.

The water system should be provided with a sump sized for a 3/4 gallon capacity for each square foot of cooling cell system. This capacity provides for an operating level at the approximate midpoint of the sump. The sump should be located near the midpoint of the pad.

All water system components should be enclosed or covered to protect them from insects and other windborne debris. Recirculated water returning to the sump should be screened. The sump and pump should be installed inside, when practical. If located outside, the sump and pump should be drained for protection from freezing weather.

Because water is "used up" during evaporative cooling, a supply of make-up water is needed. An automatic float valve can be used to maintain a proper water level in the sump.

The evaporative cooling process quickly brings the temperature of the recirculating water and the make-up water to the prevailing outdoor wet bulb temperature. Therefore, the use of cold water rather than recirculated water to wet the pad to obtain more cooling is not significant. In fact, the use of cold water is impractical and costly.

Automatic Controls

The evaporative cooling system along with the other components in the environmental control system can be operated with thermostats and timers or a controller.

When using individual thermostats and timers, it is difficult to tie all components in the climate control system together and keep them in proper sequence. The controller ties all systems together and automatically operates the ventilating and wet pad equipment in the proper sequence to provide uniform conditions in the poultry building.

Other Equipment

With floor raised birds, a screen wire guard or fence is often required on the inside of the wall at the base of the pad to prevent the birds from damaging the pad. Algae may clog the pad and promote deterioration. Periodic addition of an algaecide in the cooling water system will help control algae.

BACKUP SYSTEM

Mechanical ventilation systems are subject to electrical power disruptions. To avoid catastrophic losses due to power failures, the poultry building should have a backup system operating at all times.

Controller Backup

Controller backups are needed to keep electronic systems within a safe zone. For example, if the regular control system fails to start the cooling system when the building temperature reaches 75°F, the controller backup will engage the cooling process at a preset temperature a few degrees higher than the 75°F setting.

Alarms

An alarm, such as a siren, should be installed on the exterior of the poultry building to announce a power failure and high and low temperatures. Computerized alarms for critical functions are available that will place emergency calls or page personnel who may be a long distance from the poultry building.

Portable Electric Generators

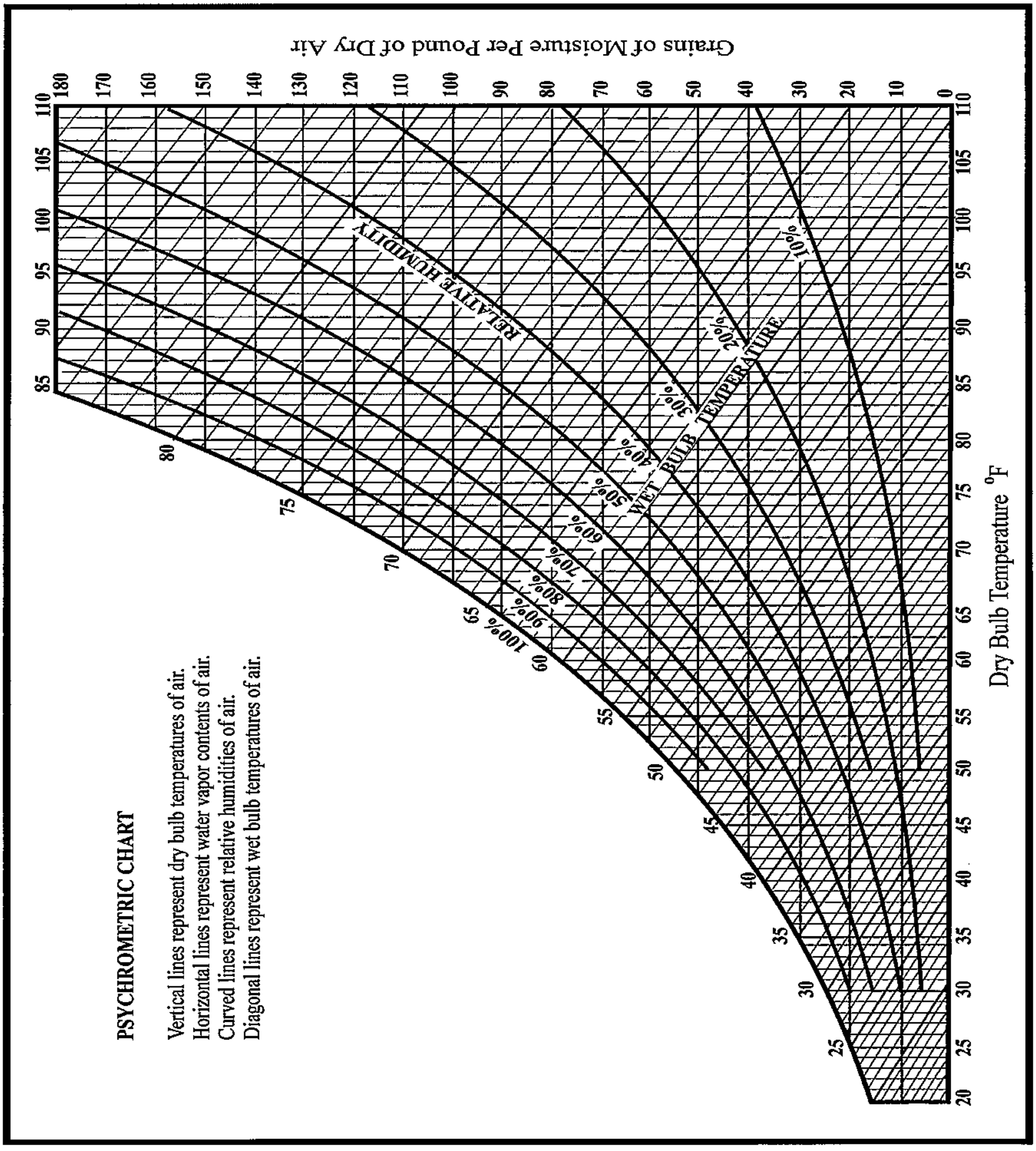
A totally enclosed poultry building needs a reserve power source that automatically provides electricity to operate equipment within seconds after the primary electric source is disrupted. Portable generators should be tested periodically to ensure emergency power needs will be met.

SUMMARY

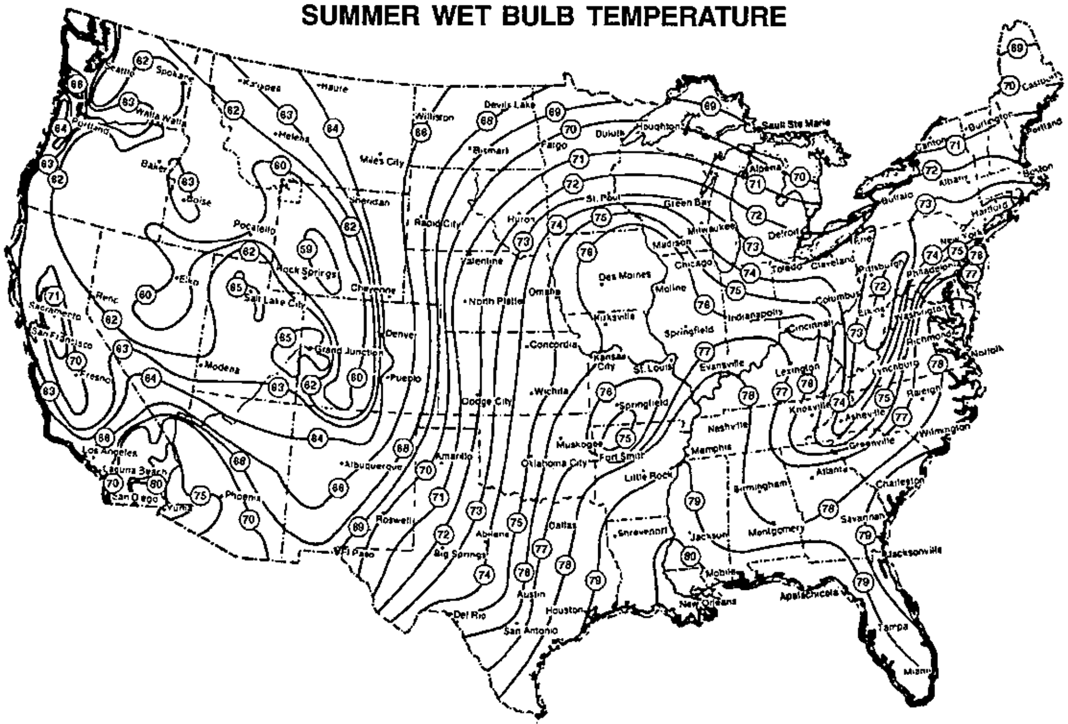
A controlled building environment can provide for a profitable poultry operation through higher production, better quality, improved feed conversion, less disease, and lower mortality rates.

Poultry producers should be knowledgeable of psychrometric concepts before planning and installing ventilation systems in buildings. Psychrometric charts are available to show the energy contents of air-moisture mixtures at different dry bulb and wet bulb temperatures.

Ventilation system design criteria described in this topic is for general applications and should be considered only as a guide. The actual design of a ventilation system for a specific installation is the sole responsibility of the installer. Effects of the installed ventilating system on confined poultry are entirely the responsibility of the poultry producer or equipment operator.

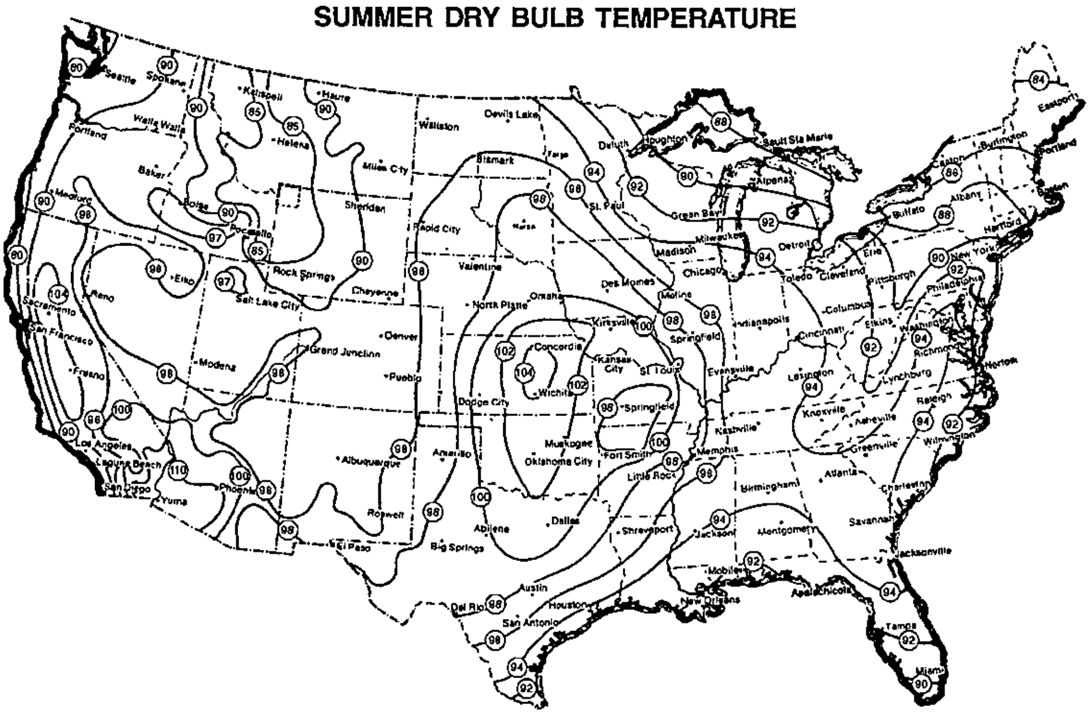

PSYCHROMETRIC CHART
Vertical lines represent dry bulb temperatures of air.
Horizontal lines represent water vapor contents of air.
Curved lines represent relative humidities of air.
Diagonal lines represent wet bulb temperatures of air.
Dry Bulb Temperature °F
Grains of Moisture Per Pound of Dry Air
RELATIVE HUMIDITY
WET BULB TEMPERATURE
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%

SUMMER WET BULB TEMPERATURE



Summer wet bulb temperature data. The wet bulb temperatures shown will be exceeded not more than 5 percent of the total hours, during June to September inclusive, of a normal summer.

SUMMER DRY BULB TEMPERATURE



Summer dry bulb temperature data. The dry bulb temperatures shown will be exceeded not more than 5 percent of the 12 hours during the middle of the day in June to September inclusive, of a normal summer.

POULTRY GENETICS

Material for this unit on Poultry Genetics will be used on the 2013 and 2015 Career Development Events. This information will be available after September 1, 2012. To receive a copy of this unit, contact Instructional Materials Service ims@tamu.edu. Thank you.

POULTRY NUTRITION

Material for this unit on Poultry Nutrition will be used on the 2013 and 2015 Career Development Events. This information will be available after September 1, 2012. To receive a copy of this unit, contact Instructional Materials Service ims@tamu.edu. Thank you.

PROCESSING POULTRY PRODUCTS *

INTRODUCTION

Poultry meat production, processing, and distribution have undergone many changes during the past 50 years as a result of consumer demand for poultry products. The National Chicken Council (NCC) estimated that in 1962, 83 % of chicken marketed in the U.S. was sold as whole birds, 15% of chicken marketed was cut-up parts and only 2% of the market was further processed products. In 2015, the NCC estimates that only 11% of the market will be whole birds, 40% will be cut-up parts and 49% of the chicken marketed in the U.S. will be further-processed products. Today, there is a great deal of diversification in the poultry products that are marketed and it is this diversification of product lines that has helped the industry to meet consumer demands as well as remain competitive with other meat industries. While significant changes have occurred in the market segments over the years, one thing that has remained constant is the need to convert a live animal into a safe, wholesome food product for human consumption, regardless of what the final product is. The Food Safety and Inspection Service (FSIS) of the USDA is the regulatory agency that oversees poultry processing. The Poultry Products Inspection Act enforced by the USDA and the Pathogen Reduction Act enforced by the FSIS defines the guidelines for poultry processing in the United States.

In a vertically integrated poultry meat processing operation, considerations begin well before the birds are brought to the processing plant. The genetic strains are carefully selected and bred, feed is properly selected and formulated, and housing conditions are closely monitored and maintained at appropriate conditions to enhance growth and reduce stress in the birds. Excessive stress applied on the birds at the farm or before processing may affect the quality of the meat produced. Additionally, a poultry veterinarian from the integrated company closely supervises flock health to control disease and dispose of untreatable birds. Birds are humanely cared for throughout their production and at the processing plant.

BASIC STEPS IN POULTRY PROCESSING

Chickens are marketed in a variety of market ages/weights depending on the end product. Most can range from 28 to 60+ days with weights of 3.6 pounds to over 7.5 pounds with the lighter weight chickens being the youngest. Typically, the lighter weight chickens are used for fast food and whole bird operations while the heavier birds are used more in further processing. Female turkeys are processed at 14 to 16 weeks of age, while the larger males are approximately 18 to 20 weeks old. The same general processing scheme is used for both turkeys and chickens. The basic steps are discussed briefly in this section. This image depicts a grading and processing line at KFC, Inc.

* *Original topic by Dr. Sarah G. Birkhold, former Assistant Professor and Extension Poultry Specialist, Texas A&M University, College Station, Texas. Casey M. Owens, Associate Professor, University of Arkansas, Fayetteville, AR revised this unit in 2012.*

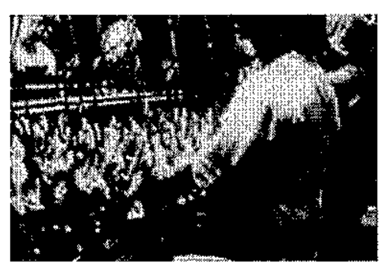
The first step in processing is the "withdrawal" of feed and controlled delivery of drinking water available to the chickens. Feed withdrawal is the length of time that birds are held without feed in the 24-hour period before processing. Usually, feed is removed first and water is removed in the last hours before catching. The process consists of raising the feeders above the reach of the birds at 8 to 12 hours for chicken broilers, or 8 to 10 hours for turkeys, before processing. Ideally, water is withheld for the last four hours before processing. The feed withdrawal period is necessary because it helps to clear feces from the lower part of the intestine. Limiting the amount of fecal matter in the intestine reduces contamination during processing, especially during the evisceration step. This practice plays a role in reducing contamination with pathogens such as *Salmonella* in poultry meat.

In the next step, the birds are caught and loaded into coops or crates for transport to the company-owned processing plant. Generally, the ride to the processing facility takes no more than 2 to 3 hours. The lengths of the transportation and holding times at the facility must be considered along with the time window for feed and water withdrawal. A shorter ride (~1 hour) is ideal as it limits the time that the birds are exposed to hot summers and cold winters decreasing exposure to potentially stressful environments. Catching can either be completed by a trained catch crew or by automated catching equipment. Manual catching crews are well trained in the proper catching procedure to prevent injury to people and the chickens. Automated catching equipment has been developed and consists of small vehicles that attach to transport coops. A series of rotating rubber fingers move right above the floor level and collect birds onto a conveyer belt where they are moved into the coops. Manual catchers and automated catchers are closely monitored to avoid injury during the catching process. It is critical to not injure the birds during catching due to animal welfare issues and because bruises and broken bones result in lost yield from the flock. After catching, coops are loaded on commercial trucks driven to the processing facility which are generally located within a close proximity to the farms. At the processing facility, the birds are held under ventilated sheds while they await their turn to go into the plant. Careful coordination is required to limit the time that the birds are held on the trucks before they go into the plant and to fulfill feed and water withdrawal time requirements. Birds are slowly removed from the transport coops onto a conveyor belt that takes them into a dark room to be loaded on processing shackles. The room is dimly lit to help calm the birds so that workers can more easily manually hang the birds on the shackles. Shackled birds are then mechanically conveyed into the processing facility.

After hanging, birds are stunned to render them unconscious before slaughter. In the U.S., typically the stun is delivered using a carefully monitored electrical current. Shackled birds are conveyed through the stunning area so that the head of the bird is in contact with a saline bath through which the current is delivered. Enough current passes through the saline water to render the birds unconscious, but it does not kill them. An alternative stunning method incorporated in certain facilities, consists of exposing birds to a gas mixture (carbon dioxide based) while the birds are held in the coops. This process renders the bird unconscious as carbon dioxide is an anesthetic gas. Because the birds are unconscious, stress during hanging on shackles is eliminated. Irreversible stuns can also be used in gas-stun facilities where the percentage of carbon dioxide is high resulting in asphyxiation of the birds due to the displacement of oxygen.

After stunning, unconscious birds go to an automatic cutting machine that cuts one or both sides of the neck, severing the jugular vein and carotid artery. The bird is then allowed to bleed (i.e., exsanguination) for approximately two minutes. Cutting must be carefully calibrated to avoid severing the spine, so that brain functions are not compromised. Continuous brain activity allows the pumping heart to assist in better bleeding of the bird.

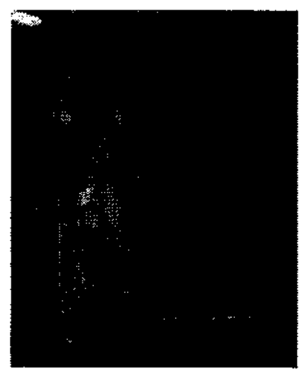
The next step is scalding, which loosens the feathers so that they can be easily removed during defeathering (picking). Shackled birds move along the processing line and travel through an aerated hot water bath. The hot water denatures the proteins of the feather follicle (i.e., breaks down muscles holding the feathers) to ease feather removal by the automated picking machine. Temperature of scald water can vary dependent on how the final product is to be used. Hotter temperatures remove the yellow pigment and provide a whiter-looking skin commonly preferred by most U.S. consumers. Scalding parameters can also vary some depending on the systems used. Poultry carcasses are immersed in 138°F to 140°F water for 30 to 75 seconds (batch-type system, small scale processing) to be hard-scalded. This hard-scald removes the waxy cuticle, or outer layer of epidermis and is typically used for birds that will be breaded with a water-based batter because removal of the cuticle allows for improved batter adhesion. Therefore, fast-food restaurants commonly use birds that have been hard-scalded. In certain regions of the U.S., the cuticle is generally left on birds that are sold in the retail market as some consumers prefer the yellow color provided by the pigments retained in the cuticle. These birds are soft-scalded at 123°F to 130°F for 90 to 120 seconds (batch-type system), a process that minimizes the removal of the cuticle layer of the skin. In a continuous system where birds are on shackle lines traveling through the scalder (industry, large scale processing), temperatures can range from 120°F to 136°F for a period of two to four minutes. Because scalding is a time- and temperature-dependent process, the combination of time and temperature can vary depending on results desired (hard or soft scald). For example, a shorter time combined with higher temperatures could result in a hard-scald. Furthermore, multiple tanks can be used in continuous flow systems and therefore, temperatures can vary from tank to tank, all dependent on desired results. Following scalding, birds are taken to the pickers or defeathering machines. Feather removal is completed by rubber fingers that pull the feathers from the carcass. After picking, the birds are carried through a bank of flames that remove any remaining filoplumes or hair-like structures on the carcass, a process known as singeing.



Next, the birds are transferred from the slaughter line to the evisceration line, as shown in this OSHA image. First, an automatic hock cutter removes the hocks and then birds are rehung by the end of the drumstick using automated equipment. Chickens are hung using a two-point hanging system that shackles the carcass by the drumsticks only. Heavier turkeys often use a three-point hanging system that shackles the hocks and the neck.

After rehanging, the oil or preen gland is removed from just above the tail and then the birds travel to the evisceration area. During evisceration, a continuous series of machines automatically open the body cavity and remove the viscera, or internal organs. The machines must be properly adjusted so that the cut is carefully made and the viscera are not torn during the procedure. A rupture of the intestinal contents may cause the remaining fecal material to be released, and cross-contamination may increase bacterial levels in the carcass. Cross-contamination can also increase the likelihood of *Salmonella* positive carcasses, considering that this organism is commonly present in fecal material. In turkey processing, turkeys are manually eviscerated due to their increased size. The three-point hang aids in this process as the carcass hangs in more of a horizontal position, thereby easing the evisceration process for the plant worker.

The USDA requires that the viscera remain with the bird for inspection by a USDA inspector. This inspection is paid by the U.S. government, and no meat can be commercially marketed in the country without USDA inspection. The FSIS branch of the USDA inspects every bird processed in the United States. The inspector is specially trained to look for disease or contamination that may make the bird unwholesome. It is important to remember, however, that the organisms (such as *Salmonella*) that make people sick cannot be seen by the naked eye. Therefore, processing plants must have an effective food safety system in place to control pathogenic bacteria from the farm through processing and distribution. A commonly-used plan for controlling and monitoring food safety is known as the Hazard Analysis and Critical Control Point (HACCP) system. This is a preventive plan that monitors the most critical steps during processing to minimize pathogen contamination and other hazards that may be associated with poultry products.



After inspection, the giblets, which include the heart, gizzard and liver, are removed and sent to another line for further washing, chilling, and packaging. After carcass inspection and giblet removal, the carcasses are washed a final time to remove any adhering material. During or after the final washing, a relatively recent step may be incorporated into the traditional poultry processing scheme. The application of an antimicrobial wash or rinse on the surface of eviscerated carcasses, as shown in this image provided by Auburn University, has been in use since about the year 2000 after being implemented by the Pathogen Reduction Act. The treatment is aimed at reducing or inactivating microbial organisms, specifically *Salmonella* cells. The incidence levels of *Salmonella* must be maintained at levels below 10% (10 out of 100 birds tested) to pass FSIS inspection. Therefore, the antimicrobial wash or rinse treatment assists processors in fulfilling regulatory requirements. The most common used antimicrobials include chlorine derivatives, organic acids, and other acidic components. This is a developing area and several products or product mixes have been recently released for use.

Reducing carcass temperature is a critical step in poultry processing. Birds must be chilled below 40°F within 4 to 8 hours, depending on the carcass weight. The USDA specifies the exact times and monitors its fulfillment. The main objective is the cooling of the meat to minimize bacterial growth. In the U.S., chilling is typically achieved in a water immersion chill tank. During immersion chilling, birds are placed in a 50-60F water bath for approximately 15 minutes (pre-chill) followed by a 34°F water bath for up to 105 minutes, depending on bird size. Chill tanks maintain a counter-current flow where cold water is added into the chill tank near the exit of the tank; therefore, as carcasses move through the tank they are always moving towards cleaner, colder water. An alternative chilling process most commonly used in Europe and Canada is known as air chilling. The water immersion tank is replaced by an air chilling room that cools the bird by the use of cold air drafts. This air chill process takes a longer time compared to immersion chilling because it is less efficient due to the medium used (air vs. water). Only a few facilities in the U.S. are currently applying the air chilling process with relative success. There are several arguments comparing the pros and cons of these technologies; however, the main objective of cooling the birds is properly achieved by both methodologies. Concerns such as water retention, bacterial cross-contamination and water usage are associated with water immersion chilling, while efficiency, costs, and yields are common problems associated with air chilling.

After chilling, carcasses are either stored for aging or taken into the further processing. To maximize product shelf-life, cut-up rooms are maintained at low temperatures to inhibit bacterial growth. Here, the carcasses are manually or automatically cut into the various parts to meet costumer (retail or foodservice) specifications, as shown in this O*Net image. For example, each fast-food operation has specific cuts and weight requirements for each carcass piece. Additionally, breast muscles are removed from the carcass and sold as boneless breast fillets and chicken tenders. The deboning of breast muscles is accomplished with either trained employees cutting the carcasses by hand, or by automated breast deboning machines. Beyond deboning, the breast meat may be further portioned into pieces of specific size and/or weight. Portioning can be done with water jets, band-saw blades, or by hand trimming.

Following cut up, the meat is moved into the packaging area. Here the parts are weighed, packaged, and placed into shipping containers for distribution. Most raw chicken sold in retail markets (i.e., grocery stores) in the U.S. is sold as fresh chicken that must be shipped quickly to the store and maintained under refrigerated conditions. This product is usually packed in Styrofoam trays with a oxygen permeable plastic overwrap. To extend shelf life, the products travel through a blast freezer for a short period of time so that the top quarter-inch of the product is frozen, a process known as crust freezing. This helps to insulate the product as it goes through the distribution and marketing. Other products are quickly frozen (and sold as frozen) to maximize shelf-life.

Most whole carcasses or product trays are graded, but grading is optional. USDA grades, definitions, and standards of identity or composition are described by the U.S. government in the Mandatory Poultry Products Inspection Act. Grades, definitions, and standards define the product to the consumer. Grading is conducted at point of cut-up or packaging by USDA AMS (Agriculture Marketing Service) federally licensed graders who are paid by the company. Grades will be indicated on the product with a USDA AMS shield (i.e., "USDA Grade A"). Grading aids the consumers in selecting poultry products because products are graded based on product quality. Typically, Grade A products (the highest quality grade) will be seen in retail cases. Lower quality grades will be used in further processed products where product grade does not affect the final product quality (i.e, breaded breast fillet). Grading can also be conducted internally by company employees, but a USDA AMS shield cannot be assigned to these products. Historically, products commonly carried USDA grades and these grades were used as a marketing tool. However, due to the market changes (how birds are marketed) and the costs of USDA grading to the company, many companies use internal graders as a way to sort product. Whether product is USDA graded or internally graded, the objective is to still provide the highest quality product to consumers. Typically, whole birds and parts sold in the retail cases will fit the high quality grades described by USDA, regardless if a grade shield is used or not.

The FSIS-USDA has regulations on labeling terms. Some terms relate to the temperatures that chicken meat can reach during shipping. The following labeling requirements must be met. If the meat has never been held below 26°F, it can be labeled as "fresh." If it has been held between 0°F and 26°F, it can be labeled as "hard chilled" or "deeply chilled." Meat that has been held below 0°F must be labeled either "frozen" or "previously frozen."

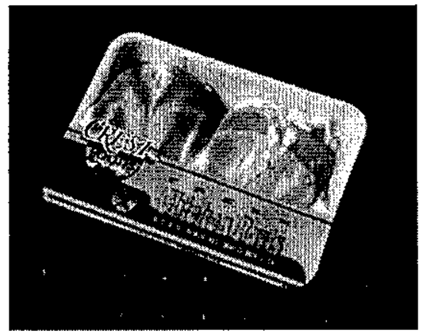
Finally, packaged poultry products are distributed. They are transferred to refrigerated trucks that transport the products to retail stores. Refrigeration maintains product quality and minimizes bacterial growth. After the packaged poultry products reach the grocery store, local regulations determine storage temperatures for raw meat. It is critical that all raw meat be maintained at 40°F or below to limit the growth of pathogenic bacteria as well as spoilage bacteria so that shelf life can be extended.

SUMMARY

Poultry processing has evolved in the past few decades into a highly synchronized sequence of steps that maximize production at a significant speed. From withdrawal of feed from the live bird to packaging and distributing the processed poultry meat product, the overall goal is to minimize costs while providing a high-quality, wholesome product to benefit consumers and support producers.

MARKETING POULTRY PRODUCTS *

INTRODUCTION



The Merriam-Webster dictionary defines marketing as "*the process or technique of promoting, selling, and distributing a product or service.*" Therefore, marketing poultry products requires processors to *promote* and *distribute* poultry products to be able to *sell* them to consumers. The goal of marketing is to increase the market share in front of competitors and reach more consumers for the sustainability of the company. However, because of the availability of several suppliers in a competitive market, processors must also know consumer needs to fulfill consumer interests and increase consumer purchases. Adding value to poultry products is a major marketing method used to increase sales and, therefore, the market share.

A CONSUMER-DRIVEN MARKET

The significant increase in per capita consumption of poultry products and value-added derivatives and successful competition with other meat sources demonstrate that proper marketing of poultry products has been important to sustain the industry. Poultry processors know consumer needs and have developed new and convenient poultry products that are currently leading poultry production to levels non-existent in the past few decades. Continuous growth assures the sustainability of the poultry industry and its presence in the minds of consumers.

In the U.S., food is packaged and sold in a consumer-driven market where the buyer determines many of a product's attributes including form, packaging, and method of distribution. Successful companies listen to consumers' demands for products and then develop those products to fit the consumers' demands. Therefore, product development in the poultry industry requires the addition of value to a given product to attract new consumers or retain current customers.

In the early 20th century, poultry was produced locally for home meat and egg consumption. Chickens were selected by the farmer for their ability to produce both meat and eggs. They were dual-purpose chickens because they produced both products. As more people moved to the cities, they raised less of their own foods and bought more from other producers. Local farmers who sold poultry in local markets began to specialize in either egg production or poultry meat production. They selected birds for the ability to produce either meat or eggs in a more efficient manner.

The Leghorn-strain hen was selected for her ability to lay many eggs efficiently. Today, a Leghorn-strain hen will lay approximately 265 eggs per year. Eggs produced by the Leghorn-strain

* *Adapted from the original topic by Dr. Sarah G. Birkhold, former Assistant Professor and Extension Poultry Specialist, Texas A&M University, College Station, Texas. Dr. Marcos X. Sánchez-Plata, Assistant Professor, Texas A&M University, College Station, Texas, revised this topic in 2005.*

when are traditionally white in color, and are commonly consumed in the Central and Southern regions of the U.S. Some consumers prefer to buy eggs with brown shells, especially in Northeast U.S. and most of Latin America. The brown-shelled eggs are produced by Rhode Island Red and Barred Plymouth Rock hens. No nutritional differences exist between brown and white-shelled eggs. Brown-shelled eggs are usually more expensive because Rhode Island Red hens lay fewer eggs per year and have larger bodies requiring more feed for maintenance and production.

In the 1930s, the poultry industry consisted of many small farms that grew poultry for local consumption. Most poultry meat was sold as New York dressed birds, retaining the viscera, feet and head; only the blood and feathers were removed during processing. Purchases were made for immediate consumption. Fresh whole poultry was the choice product. Introduction of refrigeration into nearly every home in the U.S. allowed consumers to buy and store fresh meat. The widespread availability of refrigerated trucks for hauling meat products also allowed the industry to move from some regions and to concentrate within others. At that time, the poultry meat industry was located primarily in the Southeastern U.S., Arkansas, and the Delmarva Peninsula (Delaware, Maryland, and Virginia). Widespread availability of feed and cheap labor were two incentives for poultry meat-producing companies to move into these areas. Changes in production practices were accompanied by changes in meat products. The focus of poultry processing shifted from New York dressed birds to whole, ready-to-cook (RTC) poultry that had the blood, feathers, head, feet and viscera removed.

In the 1940s and 1950s, the poultry industry moved toward fewer but larger poultry companies. These companies used the vertical integration strategy to optimize production, reduce costs, and increase market share. Poultry sells well because of its economical price. A key factor in keeping costs low is vertical integration. In a vertically integrated industry, a parent company owns many aspects of production and processing. A typical, vertically integrated poultry processor owns breeder flocks, chicks, a hatchery, a feed mill, transport trucks, a processing facility, and a product distribution system. Such integration eliminates many middle companies that add cost to the product. The company has field service representatives and veterinarians to assist poultry growers. Growers contract with the companies for chick placement and are paid based on yield. Growers receive additional incentives for efficient, top-ranking production and company loyalty.

Today, poultry meat is produced by chickens and turkeys specifically selected for rapid growth and optimum feed conversion. This means that fewer pounds of feed are required for each pound of meat when compared to production 30 years ago. This produces the rapidly growing broilers and highly efficient turkeys used for commercial meat production that are popular today. The U.S. broiler industry uses a cross between a Cornish male and a White Plymouth Rock female. This produces a broiler that grows rapidly and deposits a large percentage of breast muscle during a relatively short grow-out period. The commercial turkey industry uses Broad Breasted White birds that are ready for market in 14 weeks (for hens) to 20 weeks (for toms).

Popular chicken meat products in the U.S. are the boneless, skinless breast fillet and the chicken tender. Those products come from broilers that are typically processed at approximately six weeks of age. Commercial broilers yield about 23% to 25% of their live weight as breast meat.

Breast meat accounts for about 34% of the carcass weight without giblets (WOG). The dressed carcass without neck and WOG comprises 63% to 65% of a broiler's live weight.

Today more than ever, marketing begins way before the chicken reaches the grocery store or fast-food outlet. Most Americans are 2 to 3 generations away from the farm. Because of this, they are very sensitive to issues surrounding animal welfare. Many large companies require that producers of all food items follow strict guidelines for health and well-being. All poultry are raised on a natural grain-based diet; and contrary to the common belief, hormones are not fed to any poultry. Some buyers also have requirements for the amount of space per bird and processing conditions to maximize welfare. Currently, several operations are using welfare implications to target niche consumer markets that are willing to pay more for poultry produced under certain conditions. Natural poultry or organic poultry products are currently leading the trend of alternative poultry markets. Market indicators show continuous growth in these niche markets.

Most conditions for these natural or organic products required at the production level during grow-out are commonly based on types of diets and growing conditions. Organic poultry must be fed under a controlled diet composed of organic-only ingredients, which are produced without supplements, chemicals, or pesticides. Despite higher costs of these diets, consumers are willing to pay the difference, and this sustains growth of these alternative markets. Even the alteration of traditional processing steps has impacted market creation. Currently, consumers are paying more for poultry that has been subjected to air chilling rather than traditional water immersion chilling, as the perception of a better product has been introduced by processors of air chilled carcasses.

Food safety issues are an important part of marketing food products as well. Food safety begins before the birds are placed in the grow-out house. Chicks are obtained from parent flocks that are grown and housed on farms that strictly control access to the flock. Biosecurity, or keeping the birds isolated from biological hazards such as viruses or bacteria, is an important part of on-farm food safety programs. Workers are not permitted to travel from one farm to another in the same day. Feed delivery trucks are cleaned and disinfected before going from farm to farm to prevent spreading disease. This is the logo of the USDA Food Safety Inspection Service (FSIS).

Additionally, houses are constructed to keep out wild birds and animals. Birds eat strictly formulated diets that are obtained from specific feed mills to maximize nutritional content and to prevent transmission of diseases. Clean water is available 24 hours a day. House temperature and ventilation are constantly monitored and managed to keep birds healthy. All these biosafety practices are currently being re-evaluated and maximized because of concerns recently driven by the avian flu outbreaks in Asia. In the U.S., the highly pathogenic strain of avian flu has not been isolated. However, tougher controls and preparedness plans are in place and continuously upgraded to help protect the U.S. poultry industry from the devastating effects of this disease.

Food safety is also important in the poultry processing plant. The entire facility is constructed using materials and equipment that clean easily and meet regulatory requirements. The processing plant is cleaned many times during a 24-hour period. Usually, a "third-shift" (for the cleaning crew) is scheduled to thoroughly clean and sanitize the facility and equipment before a new processing day begins. Samples are collected and tested to verify cleaning and sanitation procedures. All these steps are important in producing the safest food possible. Food safety is an important part of the marketing program when the company's products are branded. In addition, the Hazard Analysis and Critical Control Points (HACCP) system is implemented in all facilities to prevent the potential of hazards associated with the branded poultry products.

Branded poultry products are those that carry a name or logo specific to a company. After consumers identify with a particular brand, they may be willing to pay a higher price for the product, but the company also assumes a higher risk. Any negative association (such as a recall) with a specific branded product can cause substantial financial loss. Therefore, the reputation of the processor must be carefully maintained to assure market presence and acceptability.

During the 1950s, the fast-food restaurant was introduced to Americans. They began to view this as another meal option. The fast-food industry not only changed where Americans ate, but also what they ate and how that food was processed. Consumers were introduced to the concept of ordering only those parts that they prefer rather than the traditional whole carcass. Soon, they began to request more white meat products, rather than the dark meat from chicken legs. This concept carried into the grocery stores.

By the late 1960s, the whole bird market became saturated and companies began to look for new ways to market their products. Since then, the demand for whole carcass products has been reduced to below 15% of the total poultry meat production. In the 1970s and 1980s, Americans welcomed the thought of buying cut up poultry, that is, the preferred parts of poultry. They were willing to pay a higher price for the convenience of cut up poultry. It saved time in the kitchen and allowed consumers to choose the parts that they wanted. It also caused poultry consumption to increase steadily over the past several decades.

Today, less than 10% of the chickens in the U.S. are sold as whole birds. Most chicken is sold cut up. Poultry processors and marketers have shifted their product mix to value-added products (such as all white meat packs, marinated products, patties, nuggets, tenders, hot wings, turkey jerky, etc.). Many of these products can be bought fully or partially cooked and only require heating in the oven or microwave in the household.

Changes in demographics and consumer lifestyles in the U.S. during the past several decades have also influenced the ways that poultry products are currently processed and marketed. Because consumers value their time, they prefer to spend less of it in preparing food. The average consumer wants to spend only 20 minutes from the time food is selected until the meal preparation is complete. Creating new products to meet that goal offers challenges for food industries. Different ethnic cultures and their food products also create a demand for new dishes and spices. Poultry product availability and variety have changed dramatically to meet these consumer demands.

Changing a product's utilities (time, place, and form) adds value to a product. Cutting up chickens adds value by changing the product's form. Time can be changed by precooking and then freezing. This change reduces the amount of time a consumer must devote to product preparation. Place can be changed by offering the meal in a restaurant versus the home. The poultry industry's response to consumer demands for value-added products is one reason for increased consumption to levels that are currently surpassing the production of other meats. Such is the growth of the poultry industry, that the leading poultry producer in the country was able to acquire the leading beef producer in the nation and currently represents a significant portion of the protein market in the U.S. and world.

American consumers are more sophisticated than ever before. They demand healthy, convenient foods at economical prices. The producers of poultry meat products have worked diligently to deliver just that. Prices for whole birds hover around $0.85 per pound for most regions of the U.S. Boneless, skinless breast fillets, the number one poultry product in the U.S., cost more, but they are also more convenient to use.

Poultry is viewed by consumers as being very healthful. The fat is primarily found with the skin or in select fat deposition sites that can be easily removed either in the processing plant or by the consumer. Poultry meat has a mild flavor that fits into many different recipes, so it can be cooked quickly in many different ways. This product versatility has helped the growth of the industry to its current levels.

Value or cost is highly critical to consumer perception. Consumers consider price when determining a product's value, but it is not the only factor. To have value, a product must deliver what the consumers expect for what they consider to be a reasonable price. Poultry processors do this in a variety of ways. They offer whole carcasses at a low cost per pound. They also offer thighs, drumsticks, or leg quarters at low prices.

Boneless, skinless breast fillets have a higher cost per pound, but the consumer gets consistently tender meat that is versatile. The meat easily accepts flavors of sauces, marinades, and broths. Therefore, breast fillets can be used in many different recipes and cooking methods. Other than frying chicken, consumers are creative in grilling and sautéing poultry meat. Both of these latter cooking methods improve the meat's flavor, but they do not add many calories to the meal.

Beginning in the 1970s, consumers became more health conscious. They became more aware of dietary fat and cholesterol levels of foods. This was an advantage for the poultry industry because consumers labeled poultry as a very healthy meat based on its natural composition. Consumers learned that removing skin was an easy way to lower the fat content of chicken meat and dishes containing chicken. Because it was identified as a healthy meat, consumers wanted to include more chicken in their diets. They demanded more poultry products.

Poultry companies responded by supplying chicken in different forms, including different types of packaging. Family packs and individual servings became available. Boneless, skinless breast fillets were placed in fresh tray packs and as glazed frozen products in resealable bags for convenience. Marinated products in the fresh meat case, as well as complete frozen dinners featuring chicken and turkey, became widely available. Poultry became more popular in the fast-food restaurant. A large assortment of products (nuggets, sandwiches, and salads) made use of poultry. The rotisserie-roasted chicken market increased in the mid 1990s. This revitalized product did not cannibalize existing markets. It opened new avenues for chicken to be placed on the American table.

Meal assembly kits were introduced to American consumers in the mid-to-late 1990s and continue to be important to American consumers. These kits consisted of the necessary ingredients to prepare a complete meal. The consumer assembled the meal at home in a short period of time, usually less than 20 minutes. This allowed the consumer to participate in preparing the food. Participation is important as it fulfills a basic emotional need felt by many consumers to be directly involved in preparing good food for their families even when they do not have a lot of time.

Many new products bear the labels or brands of their companies. Initially, poultry was sold fresh in the meat case with no particular company or brand designation. Poultry was shipped in large ice-filled boxes and placed for sale in the meat case. Later, it was packaged at the grocery store. In some cases, the packages bore the store's label. This merchandising evolved into product branding. Branded products, those that bear the recognizable label of a specific company, have done particularly well, and loyal customers can now easily identify their choice brands.

Marketing programs were instituted to focus consumers toward a given line of products. Using the same label design or color scheme for all packaging helped consumers find a particular line of products throughout the store. They could easily identify a line of products in the deli case, fresh meat case, freezer section, and on the shelf by the logo or color scheme.

The high demand for white meat in the U.S. created an excess supply of dark meat. In the U.S., this caused low prices for dark meat parts, such as drumsticks, thighs, and leg quarters. It also created a supply of dark meat for the increasingly important export market. Many consumers outside of the U.S. preferred dark meat and other products containing dark meat because of its relatively higher fat content and more "chicken" flavor.

By 2000, about 16% of poultry meat produced was exported. Russia and China were and continue to be the largest export markets for the U.S. poultry industry. As fast-food restaurants (such as KFC and McDonalds) became established in those and other global markets, the demand for poultry meat in those countries also increased. It was and is still important for U.S. poultry meat companies to recognize new markets for products.

SUMMARY

Poultry egg and meat processors and marketers continue to meet consumer-driven needs. Steady growth in per capita consumption of value-added poultry products and successful competition with other food sources indicate that efficient processing and marketing have been important in sustaining the poultry industry.

Continuous growth assures the sustainability of the poultry industry in meeting consumer needs for improved and healthy further-processed products. This growth will continue in both national and international markets.

Because of this favorable growth, jobs will continue to be available in the poultry industry - especially in the areas of food and health science, product processing, product research and development, domestic and foreign marketing, and international trade.

POULTRY HATCHERY MANAGEMENT *

INTRODUCTION

The measure of success of a hatchery is the number of quality chicks produced. This number, called hatchability, is expressed as a percentage of the fertile eggs set (incubated) that hatch as live chicks. "Percent hatchability" is calculated by dividing the number of live chicks hatched by the number of fertile eggs incubated. Percent hatchability differs from "percent fertility," which is calculated by dividing the number of fertile eggs set by the total number of eggs produced for use at the hatchery. For example, assume 9,500 of 10,000 eggs brought to a hatchery are fertile and incubated. The percent fertility is 95% (9,500/10,000). If 9,000 of the fertile eggs hatch as live chicks, percent hatchability is 94.74% (9,000/9,500). These are highly acceptable percentages within the industry.

HATCHING EGG MANAGEMENT

Various factors influence hatchability. Some are the responsibility of both the breeder farm and the hatchery, some are unique to the breeder farm, and others concern only the hatchery.

Factors Influencing Percent Hatchability	
At the Breeder Farm	**At the Hatchery**
Bird nutrition	Egg incubation
Egg fertility	Chick handling
Disease control	Disease control
Egg handling	Egg handling
Egg sanitation	Egg sanitation
Egg storage	Egg storage

The breeder farm has a major influence on hatchery results. Two egg hatchability factors originating at the breeder farm are bird nutrition (discussed in other sections of this manual) and egg fertility. Breeder farm personnel must stay on guard to improve egg fertility. They must maintain nests with clean shavings or nest pads (patio carpet). Eggs must be hand collected at least four times daily, thus requiring hygiene on the part of the workers. Nest eggs must be collected separately from floor eggs, which have suppressed hatchability. If they are to be incubated, floor eggs must be marked and packed separately from nest eggs. Eggs are not washed but can be sprayed with a disinfectant.

Egg handling and storage rooms must be clean. Sorting eggs involves weighing eggs carefully and discarding dirty, checked, cracked, small, very large, double-yolk, and misshapened eggs. Sorted eggs must be placed carefully into the transport trays with the small end of the egg pointed down. The eggs must then be properly stored.

Storage

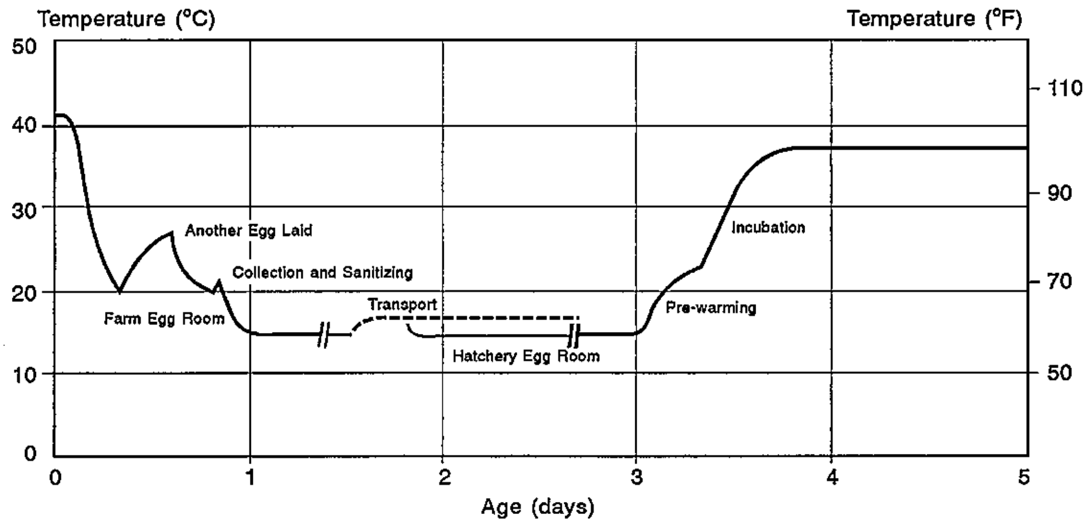
Hatchability and chick quality are optimized if the egg is held under optimum conditions between the time it is laid and time it is set in the incubator. After the egg is laid, it's hatching

* *Adapted from "Hatchery Management Guide," Cobb-Vantress, Incorporated, P.O. Box 1030, Siloam Springs, Arkansas 72761-1030, http://www.cobb-vantress.com.*

potential can at best be maintained, not improved. If mishandled, hatching potential quickly deteriorates.

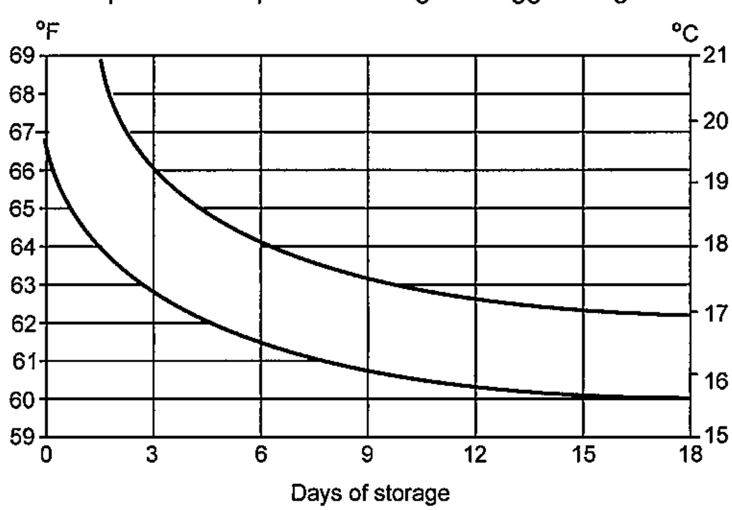
Stored eggs are transported from the breeder farm to the hatchery at least twice weekly. That means eggs are held prior to incubation at the farm egg room, during transport, and in the hatchery egg room. Storage conditions at those three places are matched as closely as possible to avoid abrupt changes in temperature and humidity, which lead to condensation (egg "sweating"), chilling, or overheating. Eggs are maintained at 65°F and 75% to 80% R.H. Temperature and humidity readings are recorded twice daily. Observe the transitions in egg temperature "from time of lay to time of incubation" shown in the graph below.

TEMPERATURE PROFILE FROM EGG LAYING TO INCUBATION



A relationship exists between egg storage time and optimum temperature and humidity for best hatchability. As a general rule, the longer the egg storage time, the lower the egg storage temperature, and vice versa, as seen in the following graph.

Optimum Temperature Range for Egg Storage



Courtesy of Cobb-Vantress, Inc.

Storage time depresses hatchability. On the average, one day's storage adds one hour to incubation time. This must be kept in mind when eggs are set, as fresh and stored eggs must be set at different times. The effect increases with storage time after the initial five-day period, resulting in losses of 0.5% to 1% hatchability per day. Egg storage for 14 or more days lowers chick quality and weight.

Gas exchange occurs through the pores in the egg shell during storage. Carbon dioxide (CO_2) diffuses from an egg. CO_2 concentration declines rapidly during the first 12 hours after the hen lays the egg. An egg also loses water vapor during storage. The loss of both CO_2 and water vapor contributes to decreased hatchability and chick quality.

Incubation

To avoid temperature shock to the embryo and consequent condensation on the shell, eggs must be removed from the egg room and pre-warmed before setting. Ideally, eggs are pre-warmed at approximately 75°F to 80°F (24°C to 27°C) to allow all eggs to reach the desired temperature.

Adequate air circulation and correct room temperature achieve the necessary even pre-warming of eggs. Uneven pre-warming increases variation in hatch time. This is opposite the desired effect of pre-warming. With good air circulation, it takes six hours for eggs to reach 78°F (25°C), regardless of their initial temperature. With inadequate air circulation, it takes twice as long.

Therefore, the recommendations are (1) provide good air circulation around the eggs, and (2) allow 6 to 12 hours for pre-warming.

Setting Time

Three factors influence the total incubation time of eggs.

* Incubation temperature – Normally fixed for any hatchery, but to achieve a desired pull time for chicks, the temperature at which eggs are set can be modified according to egg age and size.
* Age of egg – Stored eggs take longer to incubate. For each day's storage beyond six days, extend incubation time by one hour.
* Size of egg – Larger eggs take longer to incubate; for each 0.1 ounce past 2.1 ounces, add 30 minutes to incubation time.

Example Scenario

Four-day-old eggs from 32-week-old chicken breeders normally require 21 days and six hours (510 hours) to incubate. How much time is required to incubate 10-day-old eggs from a 60-week-old flock, with an average egg size of 2.7 ounces?

A correction for "setting time" must be calculated.

Egg size correction: 0.6 ounce difference x 0.5 hour / 0.1 ounce = 3 hours.
Egg age correction: 4 days extended storage x 1 hour/day of extended storage = 4 hours.
Total setting time correction: 3 hours + 4 hours = 7 hours.

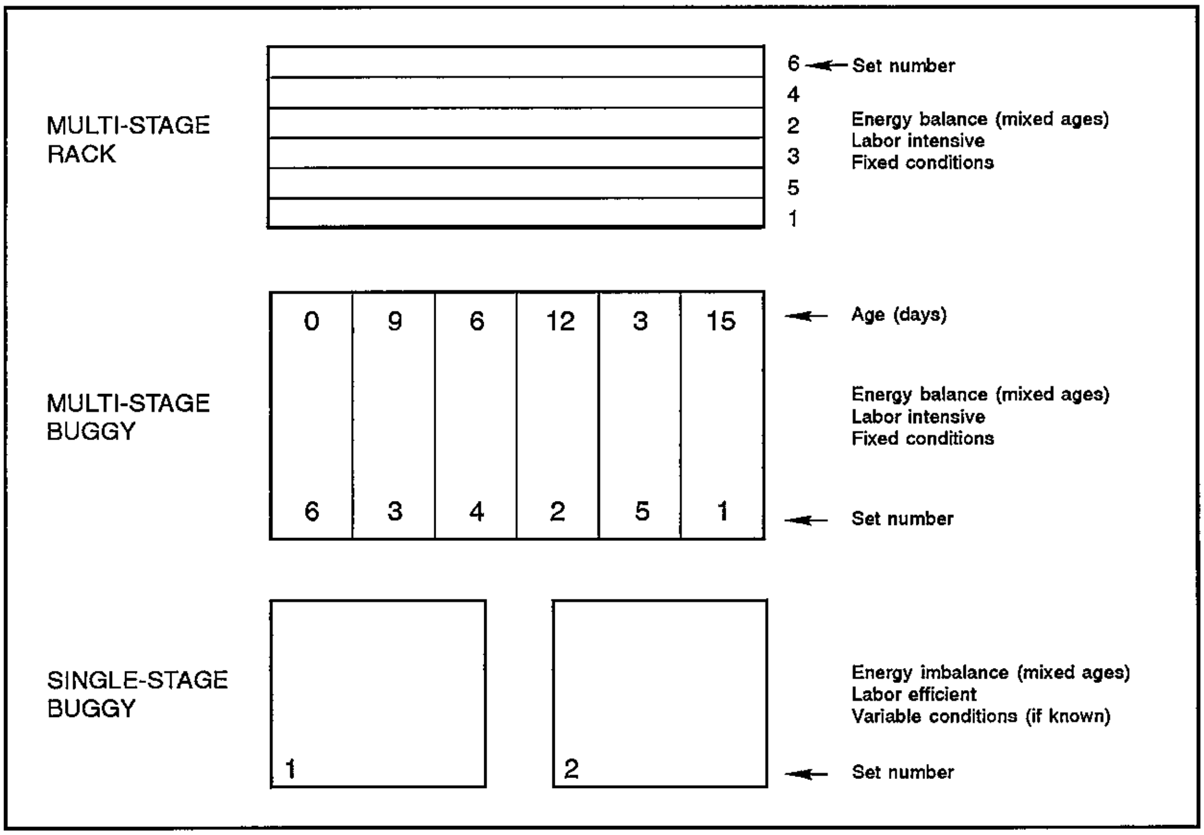
Answer: 510 hours + 7 hours = 517 hours (21 days and 13 hours).

The preceding "correction" factors serve only as a guide. Setting time is also influenced by time of the year, number and type of other eggs in the setter, and type of setter. Each of these influences the "effective" incubation temperature.

Operation of Setters

Commercial incubation systems include multi-stage fixed rack, multi-stage buggy, and single-stage buggy.

MAIN TYPES OF INCUBATION SYSTEMS



Actual quantity of eggs loaded in each setter at each set, frequency of loading (once or twice a week), and position of the set within the setter vary among manufacturers.

Ventilation

Setters normally draw fresh air from the room in which they are located. The fresh air supplies oxygen and some of the moisture required by the eggs. Air leaving each setter removes carbon dioxide and excess heat produced by the eggs.

- Air supply to the setter is 5 cfm/1,000 eggs (0.14m^3/min/1,000 eggs).

- A setter operates at almost 50% R.H. The fresh air supplies relatively little moisture. To reduce the load on the internal humidification system, air entering the setter is pre-humidified to 40% to 50% R.H. The temperature of this air is 76°F to 80°F (24°C to 27°C).
- A multi-stage setter requires a constant amount of air. The setter is adjusted so that the carbon dioxide (CO_2) level within it does not exceed 0.4%. Most fixed rack setters run at 0.2% to 0.3% CO_2, and most buggy setters run at 0.3% to 0.4% CO_2.
- Single-stage setters can be programmed to the requirements of the egg and its stage of incubation. CO_2 levels can be altered to "build up" from an initial 0.1% to 0.2% CO_2 during the first period of incubation to 0.5% to 0.6% CO_2 towards transfer.

Temperature

Incubation temperature determines the embryo's metabolic rate and hence its rate of development.

- In a multi-stage setter, temperature is to remain constant. The optimum temperature for both hatchability and chick quality is approximately 99.5°F (37.5°C). Higher and lower temperatures lead to faster or slower development, and consequent reduction in hatchability.
- In single-stage incubation, temperature can be reduced to reflect increases in embryo growth and animal heat production. Starting at 99.7°F (37.6°C), temperature reductions are made in stages down to 98.8°F (37.1°C) at time of transfer to the hatcher.
- Incorrect balance in loading a multi-stage setter can create major temperature variations. A partly filled setter may not achieve the correct temperature and will prolong incubation. Loading double sets can create overheating problems. Both conditions adversely affect hatchability and chick quality.

Humidity

During incubation, water vapor is lost from the egg through the pores of the shell.

- The rate at which moisture is lost from the egg depends on the number and size of pores (the gas conductance of the shell) and the humidity in the air around the egg. For best hatchability, an egg must lose 12% of its weight uniformly by the 18th day of incubation.
- Because of differences in shell structure and gas conductance, a variation in moisture loss exists when all eggs are incubated under the same humidity conditions. When age, nutrition, or disease reduce egg quality, it may be necessary to adjust incubator humidity conditions to maintain optimum hatchability and chick quality.

Egg Turning

Eggs are turned during incubation to (1) prevent the embryo from sticking to the shell membranes, particularly during the first week of incubation, and (2) aid development of embryonic membranes.

- Research indicates that eggs are to be set with the small (pointed) end down, and turned hourly through 45° either side of the vertical. In practice, this rarely occurs as most incubators turn eggs to a maximum of 40° and with wear, this turning angle may be less.

- As embryos develop and their heat production increases, regular turning of the eggs promotes air flow and cooling.

Egg Transfer

Eggs are removed from the setter after 18 days and transferred to hatcher trays.

- Placing eggs on their sides allows free movement of the chicks from the shells at hatching.
- Confining the large quantities of fluff that are generated at hatching to the hatcher trays assists in maintaining hygienic conditions at the setters.
- Earlier or later egg transfer causes lower hatchability.
- The transfer operation must proceed smoothly and quickly to avoid cooling the eggs.
- At transfer, eggs are candled to remove "clears" (infertiles and early deads with the "rots"). Eggs with live embryos are then placed in hatcher trays.
- Shells are more brittle at transfer time because the embryos have withdrawn some shell calcium for skeletal development. Care must be taken when transferring eggs to avoid breakage. Jolting the eggs at this stage will cause ruptures and hemorrhages.
- Hatcher trays are washed and completely dried before transferring eggs. Eggs in wet hatcher trays will cool rapidly as the water evaporates.
- "Rots" and "exploders" are disposed of in a container of disinfectant.
- In-ovo egg injection systems are considered for Marek's disease protection and administration of other vaccines.

Hatcher Operation

A hatchery will hatch twice a week from each hatcher. The hatcher must be washed and disinfected between hatches. This means the hatcher's durability of construction and ease of cleaning are vital considerations.

Ventilation and Humidity

Air flow to the hatcher must be at least 15 cfm/1,000 eggs (0.42 m^3/min/1,000 eggs). From point of transfer to pipping, air flow and humidity conditions in the hatcher must be maintained to closely match those in the setter.

Moisture is important during the hatching process. It ensures that the shell membranes remain soft and pliable to allow the chick to escape unhindered. When pipping starts, the moisture level rises to a wet bulb temperature of 91°F (33°C). At this point, the damper requires adjustment to maintain this temperature level. Additional moisture may be required from the spray system. A few hours before pulling the chicks, the damper is opened to allow the wet chicks to dry.

Temperature

Hatcher temperature is usually 0.5°F (0.3°C) lower than that of the setter to reduce the risk of overheating. Typical operating temperature is 98.8°F (37.1°C).

Factors Influencing Chick Weight

- *Egg size.* Chick weight is normally 66% to 68% of egg weight. Chicks from eggs averaging 25.5 ounces (60 grams) will average 1.4 ounces (40 grams).
- *Weight loss.* Egg weight decreases by 12% as a result of water loss during incubation. Variation in water loss contributes to chick weight variation from eggs of the same size.
- *Length of time between hatching and pulling-delivery.* Time spent in the hatcher has more influence on chick weight than time spent at the lower temperature of the chick room or delivery vehicle.

CHICK MANAGEMENT

Pulling Chicks

Chicks are ready to "pull" when most of them are dry and fluffed up, with a few (5%) still having some moisture on the backs of their necks. A common mistake is to allow chicks to stay too long in the hatcher, thus causing them to dehydrate excessively.

Dehydration may result from incorrect adjustment of setting time for egg age or excessive weight loss during incubation. Similarly, if eggs are "green" (not ready), the operator must check setting times and for opportunities for the eggs to have become cooled down during incubation, thus reducing development rate.

Processing Chicks

After pulling, chicks are separated from their debris, graded into first quality and culls, and then counted into boxes. Additional operations may include sexing (primarily using feather-sexing with broilers, but also vent sexing with breeding stock), vaccinating (by spray or injection, using hand or automatic vaccinators), and beak trimming.

During processing, chicks are held in a controlled environment to prevent overheating or overcooling. Chicks must not be overcrowded. To reduce weight loss, the correct humidity must be maintained in the chick holding areas. Aim for 73°F (23°C) with a relative humidity of 65% to 70%.

Transporting Chicks

The transport vehicle must control the chick's environment from the hatchery to the farm.

The vehicle must be equipped with an auxiliary heating system but may use fresh ambient air for cooling. If summer air temperatures exceed 86°F (30°C), cooling equipment is required.

The vehicle cab must have a display showing the temperature within the load to enable the driver to adjust air vents for cooling.

Chicks must be at an in-box temperature of 90°F (32°C), which can be achieved by a vehicle air temperature of 75°F (24°C) with plastic boxes [or 71°F (20°C) with cardboard boxes].

Chicks delivered in plastic boxes require greater care to prevent overheating or chilling than those delivered in cardboard boxes. Be sure the vehicle has adequate heating and cooling.

Boxes must be correctly stacked and spaced to allow free air movement around them. Each row of boxes are locked with a bar running the full width of the vehicle to prevent box movement.

Vehicles may have a rear plastic curtain to help retain heat while unloading chicks.

Chick delivery drivers must be well-trained and conscientious. Each driver must begin the day with clean clothing and use fresh coveralls/footwear for each delivery.

Delivery vehicles must be power-washed with a detergent/disinfectant on each return to the hatchery. Vehicles must carry a disinfectant spray for cleaning wheels between farms, if delivering to more than one location in a day. Drivers must not enter poultry buildings!

Chick boxes returning to the hatchery represent a high health risk. They must be kept separate and thoroughly washed and disinfected before re-use.

HATCHERY WASTE MANAGEMENT

Fertile egg hatchability of 94% means 6% of the eggs will be either infertile or contain dead embryos. These eggs, together with the egg shells remaining after pulling chicks, constitute hatchery waste. Few profitable outlets exist for this material, and most hatcheries have to dispose of this as waste. Legislation in many countries prohibits the incorporation of hatchery waste into by-product meal because of the risk of spreading pathogenic organisms.

Unhatched eggs from the hatcher tray must be ground to destroy any unhatched embryos. Pipped eggs and cull chicks are destroyed using CO_2 gas or other acceptable procedures.

Ground debris can be augered into a bin or removed by vacuuming into a sealed storage hopper. The wastes are disposed of according to local regulations and environment constraints.

HATCHERY FACILITY AND EQUIPMENT MANAGEMENT

Altitude Considerations

In some areas, poultry are produced at relatively high altitudes. Hatcheries operated at high altitude experience reduced hatchability. For example, hatchability is reduced to 80% at an elevation of 3,250 feet, and to 60% at an elevation of 8,200 feet.

Barometric pressure declines with higher altitude, as do partial pressure of oxygen and absolute humidity. Fresh ventilating air tends to be colder and drier than at sea level. Incubators must have temperature and humidity control systems to cope with these conditions.

Hatchability problems at higher altitude are caused by reduced availability of oxygen and increased moisture loss from eggs.

Oxygen Availability

The oxygen percentage of the air is nearly 21%, but the reduced partial pressure at higher altitude provides less oxygen from a given volume of air. This pressure reduction results in lower blood oxygen level and lower availability to the tissues.

Injecting oxygen into the setter and hatcher can increase oxygen pressure. Incubator ventilation rate needs to be reduced to avoid excessive use of fuel. The main drawbacks of using injected oxygen are cost and safety. Its use is usually limited to hatching parent stock.

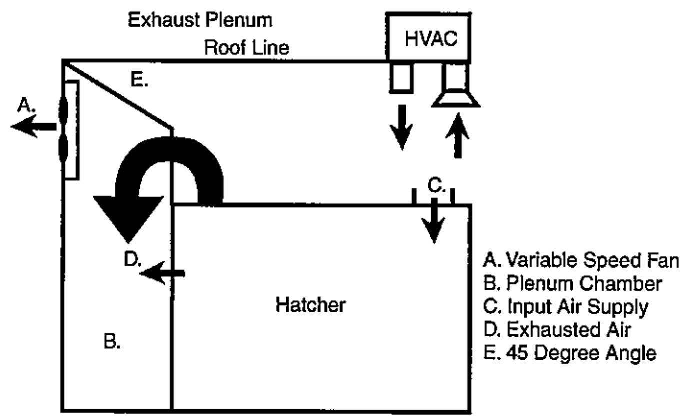
Moisture Loss

Moisture loss from an egg during incubation is greater at higher altitude because water vapor diffuses through the shell more rapidly. Setters need adjustment to ensure that uniform egg weight loss is 12% by 18 days of incubation.

Hatchery Design

A hatchery forms a part of the food chain, and its design must incorporate food hygiene standards. The conditions provided to maintain embryonic growth in the incubators are also ideal for growth of bacteria and molds.

All room surfaces, equipment, and incubators must be clean and sterile. The building must provide suitable egg-chick flow and positive ventilation. Walls and floors must be durable. An exhaust plenum must be installed to reduce the amount of chick down exhausted to the outdoors. Drains must be situated to easily remove waste water.



An exhaust plenum restricts flow of air borne debris to the outdoors.
(Courtesy: Cobb-Vantress, Inc.)

A hatchery must have an automatic standby generator for main power failure. Alarm systems are to be installed to alert hatchery personnel of power or system failures. Secondary alarms installed in all incubators and hatchers will indicate deviations in temperature settings.

Sanitation

Facilities and equipment must be regularly maintained and cleaned and sanitized thoroughly after each hatch. Egg and chick contact areas must be accessible for cleaning, sanitizing, and fumigating. Refer to the Sanitation chart at the end of this unit for specific applications.

Maintenance

- Obtain manufacturers' recommendations for routine servicing and maintenance.
- Carry out regular maintenance based on guidelines and experience.
- Calibrate all equipment.
- Thoroughly inspect and clean multi-stage setters at least once a year.

- Turn-around time for hatchers is extremely rapid and leaves little time for servicing and repair. Provide a spare hatcher to allow time for essential repairs on a malfunctioning hatcher.
- Maintain a stock of regularly required spare parts and an accurate inventory of purchased and used items.
- Train staff in use of setters, hatchers, and other equipment and alternative procedures to follow in emergencies.
- Adopt adequate safety precautions. Provide necessary guards and safety switches. Comply with safety legislation.

TROUBLESHOOTING

Any investigation of the cause of poor hatchability must include an examination of dead embryos or chicks in the shell. Refer to the Diagnosis of Hatching Problems table at the end of this unit for common conditions.

MALPOSITIONS

Abnormal positions of the body parts of dead embryos or chicks in the shell include:

- Head between thighs
- Feet over the head
- Head in small end of egg
- Beak above the right wing rather than underneath the wing
- Head to the left rather than under the right wing
- Embryo rotated in such a way that the beak is not directed toward the air cell

HATCHERY RECORDS

Hatchery records (1) assist in daily or weekly management decisions, (2) monitor and control egg and chick flow through hatchery, and (3) help determine overall hatchery policy.

Those three purposes require complete, neat, and accurate records on -

flock and incubator data for fertility, hatchability, number of culls, and other indicators; and

total production costs categorized into labor, electricity, vehicle, and others.

HATCH REPORT

FLOCK		EGGS SET					EGGS INCUBATED								CHICKS HATCHED					
Code	Age (wks)	No. Rec'd	Date Rec'd	Age When Set (days)	Date Set	Setter ID	Clears		Breaks		Rots		Hatcher ID		No. of 1st Quality		% 1st Quality		Culls	
							No.	%	No.	%	No.	%	No.	%	Actual	Std	Actual	Std	No.	%

SUMMARY

Both breeder farm managers and hatcher operators must know the principles of egg storage and incubation for effective and efficient operations. Breeder farms must produce a high percentage of fertile eggs for hatcheries. Optimum conditions in hatcheries for successful embryo growth include sanitation, correct temperature and humidity, adequate gas exchange, and regular egg turning.

Sanitation Applications

Area	Disinfectant*	Frequency
Hatching eggs	Formaldehyde gas	Before setting
Egg trays	Detergent sanitizer	Before return to farm
Farm buggies	Detergent sanitizer	Before return to farm
Egg storage room	Detergent sanitizer	Weekly
Setter room	Detergent sanitizer	After each set
Transfer room	Detergent sanitizer	After each transfer
Hatcher/Chick room	Detergent sanitizer	After each hatch
Setter - rack	Sweep and then fog with aerosol or iodine/chlorine	Weekly
Setter - buggy	Wash with detergent sanitizer	Every 18 days
Hatcher	Power hose with detergent, then disinfect after removing fluff	After hatching
	Allow formalin solution or iodine/chlorine to evaporate	After transfer
Hatcher trays	Soak in detergent, machine wash or power hose, and sanitize	After hatching
Chick boxes	Machine wash or power hose with detergent/disinfectant	Before re-use
Vehicles	Power hose with detergent/ disinfectant	On each return to hatchery

* *Provide safety masks/respirators to protect operators using formaldehyde/formalin.*

DIAGNOSIS OF HATCHING PROBLEMS

Infertility	Males: Too young or too old; Lameness resulting from poor litter quality Females: Broodiness Both sexes: Incorrect mating ratio; Disease; Excessive weight gain
Early dead	Chilled or overheated eggs in storage. Improper fumigation of eggs in setters. Washing eggs in very hot water. High numbers of contaminated floor eggs. Prolonged or improper egg storage. Broodiness leading to pre-incubation. Virus diseases - such as infectious bronchitis. Incorrect egg temperature in setter. Incorrect egg turning in setter.
Late dead	High/low setter temperatures. Incorrect egg turning. Poor egg storage. Egg contamination Faulty breeder nutrition. Power failure/inadequate ventilation.
Hatching early	High temperature (day 1 to day 19). Small eggs.
Hatching late	Low temperatures or humidity (day 1 to day 19). Excessive egg storage time. Large eggs. Low hatcher temperature.
Sticky chicks	Temperature too high (day 20 to day 21). Excessive egg storage time. Broken eggs in the tray. Inadequate turning.
Malpositions (see next page)	Eggs set upside down. Odd shaped eggs. Inadequate turning.
Unhealed navels	High temperatures (day 1 to day 19). High humidity (day 20 to day 21). Improper egg storage.
Crippled chicks	Temperature variation throughout incubation. Excessive flock age. Excessive egg handling first week of incubation. Genetic defects.
Abnormal chicks	Crossed beak (hereditary or virus infection). Missing eyes (high temperatures or excessive handling). Wry neck (nutritional deficiencies). Crooked toes (temperature and nutrition imbalances). Spraddle legs (smooth hatcher trays).

MARKET BROILER MANAGEMENT *

INTRODUCTION

Successful market broiler production depends largely on satisfying basic demands of the flock with a systematic management program. Because market broilers are grown throughout the world under a wide variety of climates, housing environments, and production systems, the recommended guidelines in this section can be modified to fit the individual producer's management experience. Almost all commercial broilers are grown under contract with an integrated poultry company.

SELECTION

Chicks selected for production must meet minimum qualifications for market broilers. Characteristics of quality broiler chicks are:

- **Produced from MG (mycoplasma gallisepticum) or MS (mycoplasma synoviae) negative (clean) stock**
- **Cleanly hatched from one flock source**
- **Weigh almost 8.75 lbs. per 100 chicks (1/4 oz./chick)**
- **Uniform in size and color**
- **Well-dried, fluffed, and with long down**
- **Alert and active, with round, bright eyes and bright, waxy shanks**
- **Free of unhealed navels, navel infection, mushiness, and pasted-up vents**
- **Free of deformities (crooked shanks 7 toes, defective head or eyes, or crossed beaks)**

HOUSING

Providing adequate floor space for each bird is essential to its growth, health, quality, and general well-being. Stocking density is determined by a combination of factors - weight of bird at processing age, housing type, climatic region, and time of year. The producer must know the internal dimensions of all houses to determine their stocking capacities for broiler production.

Recommended Stocking Densities for Market Broilers

Bird Weight (lbs.)	Floor Area (ft^2)
3	0.43
4	0.57
5	0.71
6	0.86
7	1.00
8	1.14

Controlled environment house: The Animal Welfare Code of Practice recommended by the Farm Animal Welfare Council stipulates that at no time should live weight exceed 7 pounds per square foot in the interests of welfare and good management.

* *Adapted from "Cobb 500 Broiler Management Guide," Cobb-Vantress, Incorporated, 2008,*

The stocking density may need to be reduced in summer, especially in units where problems previously occurred. Particular attention must be given to poorly insulated or under-ventilated houses.

Open (non-controlled environment) house: In using this house type, consideration must be taken of seasonal variations in temperature, particularly in summer when bird density must be reduced.

PREPARING FOR CHICK ARRIVAL

The key to success in raising market broilers lies in a systematic and efficient management program starting well before the chicks arrive. Giving birds a good start provides the basis for an efficient, profitable crop of broilers.

- Use the one age/one site (all out/all in) program. Management, sanitation, and vaccination programs become more difficult and less effective on a multi-age site.
- Make sure equipment, housing, and surrounding areas are thoroughly cleaned and disinfected to safeguard against disease carryover.
- Level the surface of the litter in the brooding area. Uneven litter creates uneven floor temperatures causing groups of chicks to huddle in pockets of litter or under equipment, depriving themselves of feed and water at a critical time when growth is most rapid.
- Aim to use a single-flock source to fill each house. If this is not practicable, always plan to match chicks hatched from parent flocks of a similar age. This reduces the risk of competition between chicks.
- Determine the expected delivery time and be ready to receive the chicks.
- Check heaters for proper working condition. Start pre-heating the house 24 to 36 hours before the chicks arrive to ensure the shavings are warm and the air temperature is correct.
- Be sure adequate fresh air enters the house (especially when using direct fired heating); take care to avoid drafts.
- Provide 14 to 16 waterers (or equivalent) per 1,000 chicks in the brooding area, of which 8 to 10 should be permanent hanging waterers, and 6 supplemental waterers which can be mini waterers, founts, or plastic trays. Fill waterers with clean, fresh, room temperature water immediately before placement. Use supplemental waterers with nipple systems.
- Add multivitamins in the water for the first few days to counteract loss of vitamins in feed caused by heating and to assist slow starting chicks.
- Ensure availability of fresh clean feed. Starter crumbs should be dust free and of consistent, correct size. Place feed in feeders immediately before chick placement. Provide additional feeding space for the first few days in the form of paper or polyethylene sheeting, covering at least 20% of the brooding area.
- Don't place feed and water directly under / too near brooders; chicks need freedom to move.
- Use maximum-minimum thermometers to check and record brooder and house temperatures. With whole-house brooding, check to ensure the temperature is the same throughout the house.
- Before placing chicks in the house, perform a final check to ensure all heaters are working correctly, waterers are free of litter, and feed is available in sufficient quantities.

Brooders, waterers, feeders, and other equipment should be upgraded to take into account improvements in growth rate. For example, a bird which 15 years ago took 50 days to achieve a given weight, will now only take a little over 35 days, almost a 30% reduction. This results in up to 30% more demand on all the systems in the house.

BROODING

Brooding guidelines in this section are for different heating/ housing systems. In view of the wide range of equipment used, some flexibility in brooding requirements may be necessary.

Warm Air Brooding

Warm air brooding involves using space heaters, usually gas or oil-fired. An initial house temperature of 85°F - 90°F will be required; reduce the temperature by 5°F a week to a final temperature of 65°F - 70°F at 35 days or market time.

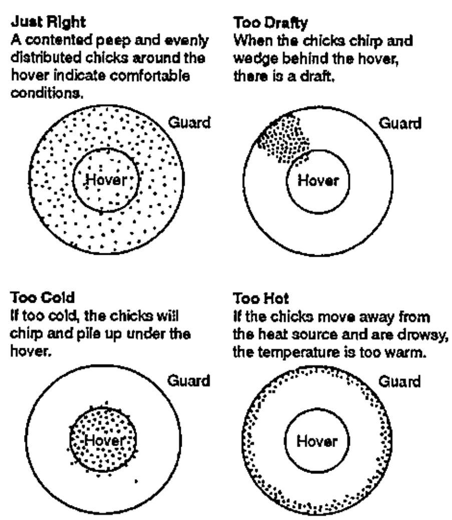
Hot air brooding systems can cause dehydration of chicks; provide extra waterers. Even air distribution is critical in this system and influences the precise temperature required. With whole house heating, it is more difficult to tell when a chick is too warm than if it is too cold.

Radiant Heat Brooding

This system involves using conventional brooders without surrounds but directing the chicks to the heat source by means of illuminating the brooding area in the absence of any other background lighting. Temperatures must range from 90°F under the brooder down to 85°F. Once settled, the chicks will quickly confine themselves to this area.

A good guide to brooder temperature is chick behavior. If chicks huddle together and sound distressed, it is too cool.

BROODING TEMPERATURE SCHEDULE		
Age (days)	*°F*	*°C*
01 - 07	90	32.2
08 - 14	85	29.4
15 - 21	80	26.6
22 - 28	75	23.9
29 - 35	70	21.1
36 - Market	65	18.3



If they congregate away from the brooders, it is too warm. Chicks should be evenly spread throughout the brooding area. After 2 to 3 days and depending on outside temperatures, the background lighting should be increased. Gradually reduce the ambient house temperature each day (5°F per week) until 65°F to 70°F is reached in 35 days.

Brooding Area Requirements

Brooder rings are normally used in non-insulated or open housing. Ideally, they should be no more than one to 1.5 feet high, which enables adequate heat to be retained while allowing air to circulate. Rings should be adjusted according to brooder output so the temperature is 90°F directly under the brooder and 80°F at the perimeter with a background temperature of 75°F.

Humidity Control

Relative humidity in a broiler house should range from 50% to 70%. This maintains quality litter conditions while preventing air from becoming too dry or dusty.

High humidity increases the cost of cooling the broiler house. Proper air flow reduces the effects of high humidity by removing warm air containing a high amount of water vapor.

LITTER

The type of litter used depends upon availability, suitability, and economics. Materials commonly used for litter include softwood shavings (preferably pine), rice hulls, chopped straw (preferably wheat), corn cobs, peanut hulls, and cane pummage. With rice hulls, it is advisable to place a thin layer of straw on top of the litter to minimize the amount of hulls entering the feeders and waterers. Hardwood shavings are not to be used because of their high tannin content and ease of splintering. Hardwood splinters can perforate the crops and gizzards of birds and also cause body abscesses.

Most broilers are grown on built-up (used or re-used) litter because of cost savings and litter disposal restrictions. However, the litter should not be allowed to become dusty, wet, or caked. Avoid musty or moldy litter to prevent occurrence of aspergillosis (brooder pneumonia).

To prevent downgrading of market broilers caused by breast blisters, breast burn, and hock burn, a friable litter condition must be maintained. A friable litter contains 30% to 35% moisture. Litter depth should be at least 2 to 3 inches.

FEEDING MANAGEMENT

Feeders

As discussed earlier, the first few days of feeding should include a crumb type of feed placed on polyethylene or paper sheeting. The feed should cover 20% of the brooding area so the chicks can find the feed easily. This supplemental feeding is to be removed gradually at 2 to 5 days.

With chain feeders, at least one inch per bird trough feeding space or 18 to 20 pan/tube type feeders are to be provided per 1,000 birds. A minimum of one line of pans for each 15-foot width of house should be installed.

Raise the feeders as broilers grow; allow the lip of the trough or pan to stay level with the height of the bird's breast. The feed level should be adjusted to obtain a balance between availability to the bird and risk of wasteful spillage. This can be checked by looking for traces of feed scattered outside the feeder. The feeding system should allow feeders to empty on a daily basis to prevent buildup of stale and dusty feed. However, feeders should remain completely empty.

Recommended Broiler Feed Consumption by Stage of Growth			
Desired Broiler Wt.	% of Total Feed Fed		
Pounds	Starter	Grower	Finishing
4.0	25	42	33
4.5	24	42	34
5.0	21	45	34
5.5	17	48	35
6.0	15	48	35

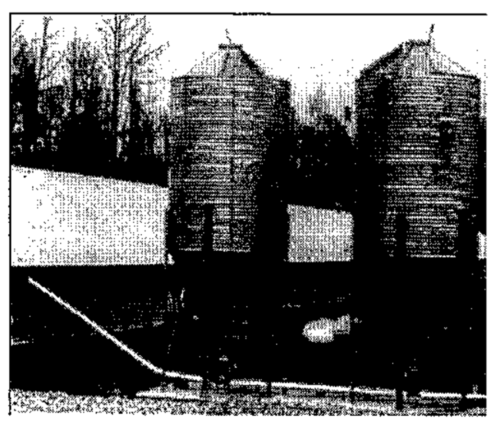
Feed Formulation

Popular feeding programs include feeding a starter ration and withdrawal ration, or feeding a starter ration, grower ration, and withdrawal ration. Broiler nutritionists have developed recommended nutrient levels for producers desiring a guide for formulating practical, least-cost rations. Tables at the end of this unit provide general information regarding broiler nutrition.

The feed supplier recommends the length of time the birds are on a ration. The preferred recommendation performs specific functions during given times with cost-benefit efficiency.

Feed Types and Storage

Crumbles and pellets are preferred over a mash feed. Feed conversion increases by 1/10 pound with crumbles or pellets as compared to mash. A fine to coarse crumble feed is used during the first few weeks of feeding.



Multiple bulk feed bins are highly recommended for storing feed. Each bin should have a capacity of five days supply of feed at maximum consumption. To reduce possibility of aflatoxins, it is important to prevent feed from getting wet in the bins. This requires constant checking for leaks in water supply lines and outside augers. Remove unused feed and clean bins between flocks. (bin image courtesy University of Georgia)

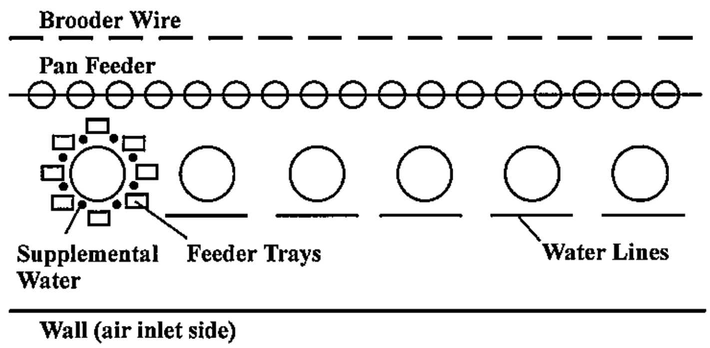
Feeding Assessment

Palpating the bird's crop is a useful tool to judge how effectively chicks find feed and water. The crop should be soft and pliable. If hard, the chick has not received adequate water. If swollen and distended with water, the chick has not found enough feed. Seven-day weights are an excellent indicator of the success of brooding management. The target for 7-day body weights is 4 to 5 times the one-day old weights.

WATER MANAGEMENT

Water makes up 60% to 70% of the chicken. A 10% loss of body weight through dehydration and excretion results in serious physical disorder. Death results when approximately 20% of body water is lost. A continuous and adequate supply of clean fresh water is essential as dehydration must be avoided. Optimum water temperature for broilers is 50°F to 57°F.

Closed Water System: Nipple waterers are becoming increasingly common in broiler houses. Compared to bell waterers (discussed later) nipple waterers have the advantages of minimal water contamination, less water wastage, and infrequent cleaning. Nipple heights and water flow rates should be adjusted to manufacturer's recommendations to allow easy access and availability.



To ensure adequate water availability, 10 birds per nipple for a 2-ounce/minute low flow rate for cupless nipples are to be provided. This may be increased to 12 birds per nipple with a high flow rate system that uses three ounces of water per minute with cups to catch excess water. As a rule of thumb, birds are to reach up only slightly to drink and never have to stoop down, and the water flow rate should be as high as possible without any leakage. A single line of waterers is to be installed for each 10-foot width of house.

Open Water System: When using conventional 16-inch hanging bell waterers, provide 8 to 10 waterers per 1,000 birds. Bell waterer height is to be continuously adjusted so the lip of the waterer is at the same level as the birds' back as the broilers grow. This adjustment ensures an adequate water supply and minimizes splashing and wet litter. Clean bell waterers regularly to prevent fecal, viral, and bacterial contamination, which lead to the rapid spread of diseases.

Supplemental waterers are to be provided at day one, using mini waterers, founts, or trays, and allowing ¼ inch linear space per bird. The waterers are not allowed to dry out and are cleaned and refilled with clean fresh water as necessary. Remove supplemental waterers approximately two days after placement.

At day one, it is important to ensure maximum water levels in all waterers to assist the location and ease of drinking. The water level is to be reduced when birds begin to knock the waterers and create spillage.

Water and feed intake are directly related and without adequate water intake, feed consumption is depressed and growth rate is reduced. At normal temperatures, water consumption is 1.6 to 2 times the feed intake. This factor can be used as a guide so deviations in consumption because of feed quality, temperature, or bird health can be noted and appropriate action taken.

The use of water meters to measure actual water consumption (and to also gauge feed consumption) is an effective management tool. This also assists in planning the timing and administration of vaccination and medication. As water consumption increases with temperatures above 86°F, additional waterers should be provided.

To accommodate waterers, foggers, and the cooling pad system, the pumping capacity of the water system should be 18 gal/min per 25,000 ft^2 of floor area. Auxiliary water storage must be available to meet a 24-hour demand if the main water system should fail.

VENTILATION

As growth potential increases, the bird's requirement for oxygen and heat removal increases. Therefore, the demand for ventilation in the broiler house is great. In addition to the bird's direct requirements, good air quality must be maintained in the house. To meet these requirements, the ventilation system and its controls must be regularly monitored.

Temperature Regulation

It is important to recognize basic principles of bird temperature regulation that relate to ventilation and temperature control systems. The chicken has the ability to adjust its feather cover according to the temperature. In cold weather, the bird holds its feathers erect to trap pockets of still air for insulation purposes. Conversely, as temperatures rise, feathers become flattened against the body to a point where this is no longer sufficient to maintain normal body temperature. The bird then begins to cool itself by evaporation through panting. As birds panting increases, evaporation increases.

This process is, however, affected by humidity. As humidity increases, the opportunity for the bird to dissipate body heat decreases. When humidity cannot be reduced where it is a feature of the local weather, the only solution is to provide as much fresh air as possible (at velocities ranging from 300 ft/min to 500 ft/min). Without this air flow, birds eventually become unable to control normal functions, the body's chemical balance is permanently upset, and death results through shock.

Temperature has a major influence on feed consumption. Generally, consumption will decrease by 1% for each 2°F rise in temperature. In practice, this means that if temperature rises from 75°F to 95°F, feed consumption will fall by 10% or more if air movement is not maintained. The provision for good light intensity during cooler dark hours encourages feed consumption at this time. At certain times of the year when changes in day and night temperatures are small, evaporative cooling may become necessary.

Ammonia Buildup

Never compromise air volume for the sake of temperature control. With insufficient ventilation, oxygen levels decrease while dust, moisture, and ammonia levels increase, which may damage the bird's respiratory system as well as cause discomfort to workers. Prolonged exposure to ammonia reduces the bird's sensitivity to ammonia, which results in higher ammonia levels than that realized.

Effects of Ammonia at Different Concentrations

Concentration (PPM)	*Effect*
5 to 10	Detected by smell.
20 to 25	Respiratory tract damage initiated; workers complain.
25	Maximum concentration level for a standard 8-hour working day.
30 to 35	Risk of respiratory disease increases.
35 to 40	Appetite decreases.
> 50	Eyes become watery and inflamed; dehydration begins. Growth rate is low, and risk of respiratory disease is high.

Ventilation Control

Ventilation systems must provide adequate air exchange for the birds and control house temperature across a series of climatic and house conditions, ranging from heating young chicks in winter to cooling older birds in summer.

Minimum Ventilation (Air Supply)

The minimum amount of ventilation required to maintain full growth potential ensures an adequate supply of oxygen while removing waste products of growth and combustion (heat, methane, ammonia, carbon dioxide, etc.). Minimum ventilation requires sufficient fan capacity to achieve a total air exchange within eight minutes and regardless of temperature control.

Evaporative Cooling

Performance of the broiler chicken varies little over the range of 65°F to 75°F. Therefore, with an outside temperature less than 65°F, an inside target temperature of 65°F allows maximum fresh air supply with minimum heat requirement. Conversely, with an outside temperature greater than 75°F, ventilation must result in some cooling effect on the broiler chicken. This is achieved in different ways, but primarily by evaporative cooling, which actually alters the temperature of the air.

The following systems lower house temperature by a maximum of 20°F when relative humidity is at 30%, but with relative humidity of 50% or more, the effect is reduced to approximately 10°F.

- Pad or filter system in which the incoming air is drawn over a filter, often of cellulose material, that is continuously soaked in water.
- Low pressure fogger nozzles set close to the fans or incoming air to assist in distribution of the mist.
- Spinning disc generating a spray of small droplets, which are passed into a stream of air.
- Ultra-high pressure mister using a pump to generate a high pressure into reinforced plastic distribution tubes fitted with special nozzles.

LIGHTING

Most broilers are grown in continuous light, but a period of darkness should be provided daily. This will ensure that birds experience total darkness and prevent panic in event of a power outage, which may result in crowding and suffocation.

It is essential to have an even light distribution throughout the house. An effective lighting system allows for one row of conventional tungsten bulbs or fluorescent tubes/bulbs over the brooding areas to attract the chicks to the heat source, feed, and water.

A minimum light intensity of 10 lux at bird height is recommended, with the maximum being 20 lux. It is also essential that a dimmer switch be available to dim lights to control vices, such as pecking, which may occur.

Controlled Lighting

Evidence indicates that control of light during a broiler's life cycle gives protection from ascites and improves broiler feed conversion. This light control starts early in the flock's life. In fact, if ascites is the reason to apply light control, the light control must start during the first week.

The typical light program restricts the bird to a sixteen-hour light day at four to five days of age. The birds remain on this program for two to three weeks. At the beginning of the third or fourth week, the birds are provided light for a two-hour to four-hour feeding in the middle of the night.

LIGHTING PROGRAM FOR MARKET BROILERS		
AGE IN DAYS	HOURS OF LIGHT DAILY / SUMMER	HOURS OF LIGHT DAILY / WINTER
0 – 3	24	24
4 – 14	Natural daylight only	15 – 16 (lights off at 9:00 pm)
15 - 21	3 hours in the middle of the night, not to conflict with timed feedings	4 hours in the middle of the night, not to conflict with timed feedings
22 – 28	4 hours	6 hours
29 – 35	6 hours	8 hours
36 - Market	6 hours	8 or more hours

DISEASE CONTROL

Prevention is the most economical method of disease control. Prevention is achieved with an isolation and sanitation program, effective management, and a quality vaccination program. However, diseases do occur, and when they do, the producer must obtain recommendations for treatment from a qualified poultry veterinarian or pathologist.

Vaccines and antibiotics are expensive; they also confuse the characteristics of a disease, thereby preventing the correct diagnosis. Use of the correct product and timing of the treatment are important in combating a disease problem.

The preferred product may be harmful if used for the treatment of other diseases. For certain diseases, effective treatment may be unavailable or economically unfeasible. The producer should submit 6 to 8 birds showing typical signs of the disease to a diagnostic laboratory. The pathologist will isolate the causative organism, conduct sensitivity tests, and then recommend a proper medication program for the specific disease.

ENERGY CONSERVATION

The following suggestions can reduce energy consumption in broiler houses.

- Insulate to conserve heat. Repair or replace torn insulation.
- Keep electric fans and other equipment in top running condition for maximum efficiency.
- Use partial house brooding to reduce floor area for brooding, thus minimizing heat loss.
- Brood the number of chicks recommended for the hover to decrease energy costs.
- Reduce brooding temperatures on schedule.
- Adjust light-control time clocks weekly to make the most of natural light in open houses.
- Keep light bulbs clean for maximum efficiency and turn off lights in unoccupied areas.

CONSIDERATIONS FOR CATCHING AND TRANSPORTING MARKET BROILERS

Shrinkage (reduction in market weight) of market broilers is often overlooked. Every effort must be made to process birds soon after they are put in coops/modules for transport to the processing plant. Shrinkage amounts to approximately 0.75% of the initial live weight of the bird for each of the first two hours after placement in coops/modules and 0.3% for each hour thereafter. The eviscerated carcass yield decreases approximately 0.66% for each 1% shrinkage in live weight.

Carcass downgrades result from -

- Bruises and broken limbs caused by poor litter condition, careless bird catching, poorly planned feeder and waterer layout, or weakness from poor health.
- Blisters caused by stocking birds too densely, hardwood shavings, insufficient litter, or poor litter condition.
- Poor feathering caused by excessive brooding temperature, crowding of birds, improper nutrition, or lack of proper ventilation.

- Rejects caused by disease (clinical or subclinical), overstocking, incorrect feeding and watering, or excessive temperature.

Bruises cause from 50% to 60% of carcass downgrades, with 30% of bruises occurring on the breast. Of these bruises, 90% are inflicted within a few minutes to 13 hours prior to slaughtering. This means that most bruises occur during catching, loading, hauling, unloading, and meat processing.

Some pointers for catching and loading broilers and reducing downgrades are as follows:

- Catch and load in darkness when birds are inactive.
- Remove portable equipment.
- Dim lights in the house. An alternative is to use blue or green light for catching birds.
- Remove drinking water supplies immediately preceding the time of catching birds.
- Operate fans to help move dust to the outside.
- Partition house into smaller units.
- Catch small groups of birds at a time to reduce smothering and bruising.
- Avoid abusing the birds.
- Hold birds by their shanks. The maximum load per hand is four to five birds.
- Carefully place birds in the coops, cages, or drawers.
- Keep carrying equipment clean and properly maintained.

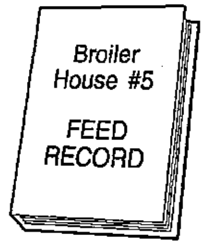
CLEANING UP THE BROILER FARM

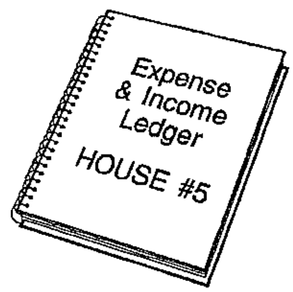
Eliminating or reducing disease exposure is necessary to improve profit margin in a market broiler operation. The following procedures are successful, but local government or agricultural authorities should be contacted to confirm they are permissible in the region.

- Use an approved insecticide and spray the house interior and within 20 feet of the house no later than one day after bird removal, but before removing the litter and equipment.
- Four days after spraying with an insecticide, clean and wash the house and equipment.
- If the building is reasonably airtight, close all openings and fumigate while the building is wet.
- When the building completely dries, apply an approved poultry house disinfectant.
- Remove feed from the bin between flocks. Then, wash the inside of the bin with a chlorine solution. Allow all surfaces to air dry.
- Add new litter and return cleaned and disinfected equipment to the house.
- Repeat an insecticide application no less than four days before chick placement.
- Restrict pets and all unauthorized personnel from approaching or entering the building.
- During bird rearing, remove and dispose of all dead, sick, or crippled birds promptly.
- Use an effective rodent control program.

RECORD KEEPING

Accurate records monitor the performance and profitability of broilers and allow for forecasting, programming, and cash flow projections. They provide an early warning of potential problems.





DAILY RECORDS

- Feed consumption
- Water consumption
- Water to feed ratio
- Maximum and minimum temperatures
- Maximum and minimum humidities
- Mortality and culls by house and sex
- Medications
- Water treatments
- Purchases of feed, fuel, litter, etc.

FLOCK RECORDS

- Stocking density
- Lighting program
- Water sampling (annually)
- Live weights and daily gain
- Weight of load at processing plant
- Feed sampling, from each feed load delivered
- Downgrades
- Postmortem results
- Standby generator and alarm tests (weekly)

FINANCIAL RECORDS

- Utility costs (electricity, water, and fuel)
- Chick costs
- Feed and labor costs
- Other variable costs
- Income and cash flow

SUMMARY

Market broilers are grown worldwide under a wide variety of climates, housing environments, and production systems. Contract broiler production is with an integrated company.

Chicks for market broiler production must meet the criteria for healthy and disease-free birds that are uniform in weight, quality, and color. Proper floor space, litter, brooders, feeders and feed, waterers and water, lighting, ventilation, and disease control must be provided for optimum broiler chicken growth, health, and well-being.

The recommendations for market broiler production presented in this topic can be modified to meet local and/or contract requirements.

General Recommendations for Broiler Nutrient Levels and Ranges				
Nutrient	**Starter**	**Grower**	**Typical Finish**	**Heavy Finish**
Feeding Period	0 – 10 days	11 – 22 days	23 – 42 days	42 days +
% Crude Protein	21.00	19.00	18.00	17.00
Calories/lb. (kcal ME)	1350	1400	1450	1450
Calcium	1.00	0.96	0.90	0.85
Available phosphorus	0.50	0.48	0.45	0.42
Sodium	0.22	0.19	0.19	0.18
Methionine	0.46	0.44	0.43	0.41
Methionine & Cysteine	0.90	0.85	0.80	0.78
Lysine	1.20	1.10	1.05	1.00
Arginine	1.26	1.17	1.13	1.08
Tryptophan	0.20	0.19	0.19	0.18
Threonine	0.79	0.74	0.72	0.69

General Vitamin and Trace Element Supplementation Levels				
Ingredient	**Unit**	**Starter Ration**	**Grower Ration**	**Finisher Rations**
Manganese (Mn)	g	100	100	100
Zinc (Zn)	g	100	100	100
Iron (Fe)	g	40	40	40
Copper (Cu)	g	15	15	15
Iodine (I)	g	1	1	1
Selenium (Se)	g	0.3	0.3	0.3
Vitamin A	MIU	13	11	10
Vitamin B^{12}	mg	20	15	15
Vitamin D^{3}	MIU	5	5	5
Vitamin E	KIU	80	60	50
Vitamin K	g	4	3	3
Thiamine	g	4	2	2
Riboflavin	g	9	8	8
Pantothenic Acid	g	15	12	12
Pyridoxine	g	4	4	3
Niacin	g	60	50	50
Pyridoxine	g	4	4	3
Choline	g	400	400	350
Folic Acid	g	2	2	1.5
Biotin	mg	150	120	120

MIU – million international units
KIU – thousand international units

MARKET TURKEY MANAGEMENT*

Introduction

Photo courtesy: University of Missouri

The turkey industry is a $14 billion industry in the United States. Similar to the production system of the market broiler, the majority of market turkeys are reared under a growing contract between the turkey grower with one or several large integrated companies or their subsidiaries. In these grower contract arrangements, the integrated company supplies the feed, poults, vaccinations, and delivers and loads out the turkeys and supplies technical assistance to the grower.

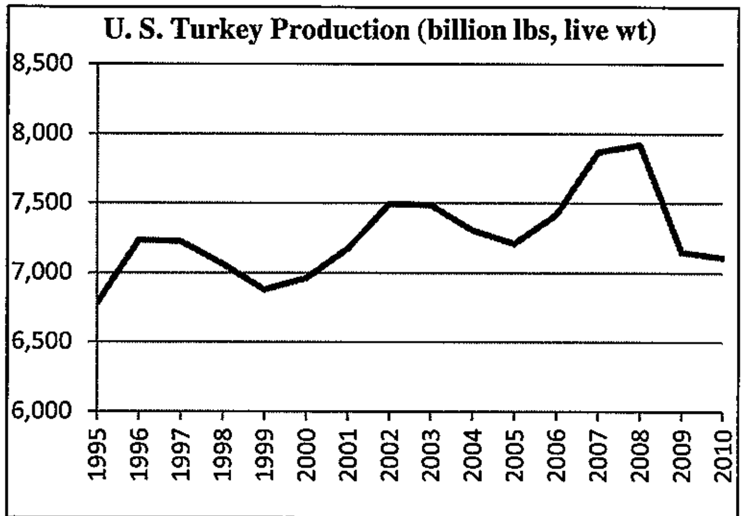
The grower furnishes facilities for the housing the live turkeys, electricity, water and labor associated with the daily care of the turkeys. Some smaller, independent operations contract a future sale of the birds they produce to a processor. These growers cover most of the cost of production and produce the birds under a product contract versus a growing contract.

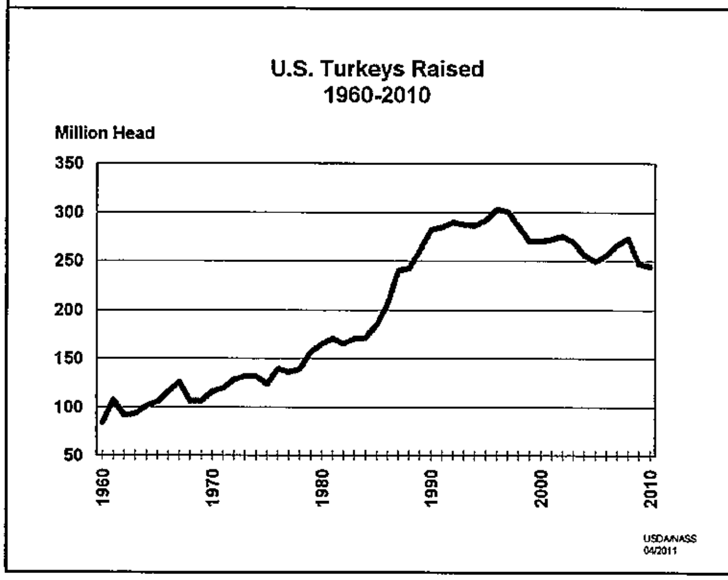
The turkey industry employs between 20,000 and 25,000 people in the United States. Tens of thousands more are employed in related industries, such as contract growing, product distribution, equipment manufacturing and a wide variety of other affiliated services.
The majority of the U.S. domesticated turkeys are bred to have abundant breast meat, meatier thighs, and white feathers and to be healthy with good livability and to efficiently convert feed to product. Commercially, the white feathered bird is preferred. The light feather color means that when plucked, there are no unsightly pigment spots under the skin to distract from the clean appearance of the processed carcass. The broad breasted white turkey was first used for commercial turkey production in the late 1950's. By the late 1960's the majority of the industry used the white turkey.

USDA 2010 ranking for number of turkeys produced by states:

Rank		# Turkeys 2010
1	Minnesota	45,000,000
2	North Carolina	35,500,000
3	Arkansas	29,000,000
4	Missouri	18,500,000
5	Virginia	17,000,000
6	Indiana	15,000,000
7	California	15,000,000

These 7 top turkey producing states account for 70% of the U.S. turkey supply of approximately 250,000,000 turkeys in 2010. In 2010, U.S. consumption of turkey is about 17 pounds per person, the number four protein choice for U.S. consumers.





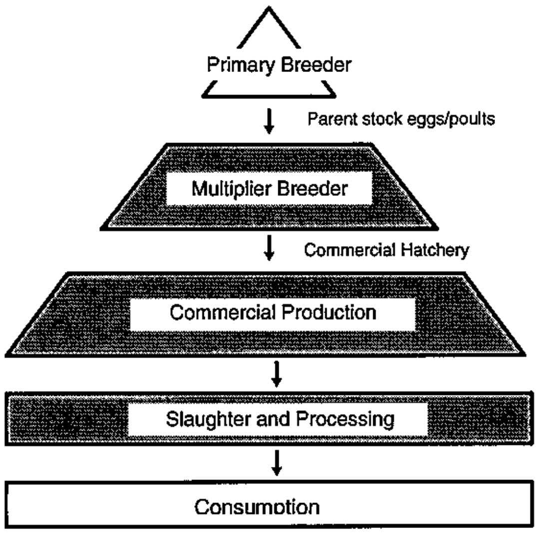
Considering long term trends, over the past few decades, Americans have been eating less red meat and a lot more chicken. During this time turkey consumption has been on a slow and steady upward path, while pork has remained fairly constant. Per capita consumption of turkey and that of fish (both fish and shellfish) has been in a range of 14 to 16 pound per capita each year.

Even though in recent years, consumption has been flat or down somewhat, turkey consumption has actually doubled over the past 30 years. In 1970, 50 percent of all turkey consumed was during the holidays, today that number is around 31 percent (whole and other turkey products) as more turkey is consumed year-round. The most popular turkey product continues to be the whole turkey, comprising less than a quarter of all sales. Several other turkey products are closing in on the whole bird's dominance in the marketplace. Ground turkey has experienced the largest sales growth among consumers in the last decade. The top three turkey products sold in 2009 were whole birds, cooked white meat (deli meat) and ground turkey.

Exports now comprise more than 9.6 percent of total turkey production, compared with 1.2 percent in 1990. In 2009, the top four export markets for U.S. turkey meat were Mexico (264.8 million pounds), China (65 million pounds), Russia (17.7 million pounds) and the Dominican Republic (16.8 million pounds).

SEGMENTS OF THE U.S. TURKEY INDUSTRY

Historically turkey producers supplied their own hatching eggs and hatched and raised market turkeys at the same location and either slaughtered on or close to where they were raised. Today, each production process of the turkey industry is now mainly represented by various specialized operations. These operations include the Primary Breeders, the Multiplier Breeders which include the breeder toms which are maintained for semen production to be utilized for the artificial insemination of the separately housed breeder hens which produce fertile eggs for the commercial hatcher which hatches poults for commercial production.



Pyramid structure and the flow of genetics in today's turkey industry

PRIMARY BREEDERS

Turkey geneticist have and are developing and improving a variety of lines of the white broad breasted breed have been developed by selective breeding practices to meet particular needs such as growing regimens, product usage and processing demands.

The primary poultry breeders utilize multiple breeding programs with a goal to maximize product improvement and new product development. The larger of these operations utilize geographically dispersed production centers to provide a security and to isolate their foundation stock of highly valuable diverse genetic lines, and to provide a global sourcing and distribution system. These operations utilize innovative technologies to enable selection of turkeys that give the best performance in a wide range of environments. Investment and innovation are keys to their product development. Many of the same global companies which are invested in broiler and table egg genetics also have turkey genetic programs. They furnish the male and female lines of turkey multiplier breeders which go to the turkey hatching egg operation.

For turkey operations to achieve this increasing genetic potential depends on:

- An appropriate environment, including temperature and air quality, which meets the birds' requirements.
- A dietary regime that provides nutrients, in both feed and water, in an appropriate profile.
- An effective biosecurity and disease control program.

TURKEY HATCHING EGG OPERATIONS –Multiplier Breeder

Young turkey breeder hens that will produce eggs to be hatched for market poults are grown for about 24 to possibly up to 30 weeks of age before moving them to a turkey breeding hen barn. Special growing protocols are followed relative to the feeding, body weight monitoring, and lighting programs for both the growing young male and female breeders. The facility for the hens and egg production has an arrangement of nests running down the length of the building. The laying females are caught and inseminated each week using fresh male semen collected from the breeder males. Eggs are collect twice to 3 times per day. Proper care and alert management is crucial to check the natural tendency of certain hens to go broody and also to minimize the number of eggs laid out of the nest on the floor. These floor eggs, dirty eggs, and of course cracked eggs do not hatch well and may contaminate other eggs in the hatchery.

During a 25-week laying cycle a breeder hen normally lays 88-93 eggs. At the end of this cycle, the hen is "spent" and will usually be slaughtered. Some breeders find it economically feasible to molt the hen (give her a resting period) for another production cycle. It takes approximately 90 days to molt a hen. The hen's second laying cycle will produce a slightly lower number of eggs (75-80). Eggs are immediately shipped from the hatching egg farm to hatcheries.

The developing toms are commonly selected at 16 to 18 week of age for health and fitness or soundness. The toms reach sexual maturity around 28 to 30 week of age. The semen is collected from each tom ("milked") twice weekly. About 1/10 as many male breeders as the planned female breeders are started as poults and following growing and culling of the males about 6 to 7 % as many male breeders are kept as the number of female breeders to be serviced. The males are light stimulated prior to moving them to the breeding farm. The breeding toms are raised in specialized breeder tom flocks and later housed in specialized tom holding barns. The male barn contains a series of "stag" pens throughout the length of the barn. Each of these stag pens may hold as many as 30 to up to 60 toms. A breeder tom turkey can father as many as 1500 poults during a hen's 6-month laying cycle.

HATCHERY SERVICES

Commercial hatcheries concentrate efforts on maximizing the hatching of fertile eggs and marketing viable turkey hens and toms. Hatcheries use the latest techniques for producing and servicing poults with minimal discomfort. Servicing refers to preparing poults for shipment to the producer and includes beak trimming, vaccinating, removing toenails, and desnooding.

Beak trimming to control pecking among poults is usually performed in the hatchery using an electric arc/microwave trimmer or hot blade. An electric arc/microwave trimmer leaves a small hole in the upper beak. The hot blade leaves a small indentation on top of the upper beak. Some market turkey producers trim the upper beak with a hot blade or clippers when the birds are between 2 and 3 weeks of age. Iodine should be placed in the drinking water for 1 to 2 days after beak trimming to reduce incidence of infection. Many operations currently use microwave beak and toe trimming. The microwave "burns" the tissue. It is slightly discolored following the treatment. The beak or toe drops off at 7-10 days of age. Because there is no open wound, the iodine treatment is not necessary.

Vaccinations, either by injection or aerosol sprays, are administered in the hatchery to protect poults from diseases prevalent in areas where they will be raised. Vaccination by injection in the hatchery is considered less stressful for the poults than when administered in the brooder or growing houses.

If done, beak trimming is commonly done at the hatchery. Breeder turkeys may receive a "touch up" beak trimming at selection/vaccination servicing at 17-18 weeks of age.

Toenail removal aids in poult identification and eliminates scratching. Poults awaiting shipment are held in ventilated, temperature-controlled rooms in clean and sanitized poult boxes. Each box is lined with an excelsior pad or absorbent mat to provide secure footing for the poults. Poults are shipped soon after hatching in ventilated, temperature-controlled vehicles.

Because of the availability of yolk material to a newly hatched poult, boxed poults can be held without food or water for up to 72 hours (3 days). However, turkey industry "best practices" strive to have poults in brooding houses and on feed and water within 24 hours after hatching.

* *Adapted from "Turkey Care Practices," California Poultry Workgroup, Cooperative Extension, University of California-Davis; http://www.vetmed.ucdavis.edu/vetext/INF-PO_TurkeyCarePrax.pdf. Supplemental information included in this topic was provided by Nicholas Turkey Breeding Farms.*

BROODING PRACTICES

Brooding refers to the period of the poult's life from one day of age to approximately six weeks of age. Poults are placed within brooder rings for the first 5 to 6 days. Then, from 1 week to 6 weeks of age, depending on sex of bird and the integrator's guidelines, each poult is provided from 1 to 1.5 square feet of floor space.

During the first 42 days, poults need supplemental heat, special starter feed, and protection from disease exposure. One method of reducing disease exposure is by separating the brooding phase from growing and reproductive phases. If it is necessary to have the brooder house on the same property with growing or breeding birds, it is to be located up-wind from older birds and a minimum distance of one-half mile to one mile away. Workers in the brooder house are restricted from working part-time with older birds or interacting with personnel taking care of older birds.

House Cleaning

Industry standards dictate washing and disinfecting the house prior to receiving a new flock of turkeys. Used litter is removed from the house. The lesser mealworm, *Alphitobius diaperinus* (Panzer), is considered an agricultural pest and may have the opportunity to re-infest the house being cleaned and other nearby facilities if the litter is not immediately removed. Using the same litter for a new flock may be a possible source of infection from residual microbes of the previous flock. However, reuse of litter is an economic necessity with some producers.

The floor is swept and the area around the house raked to remove litter and feathers before washing the house thoroughly with high pressure water. Washing usually removes at least 90% to 95% of residual microbial contaminants. Ceilings, walls, and curtains are sanitized with a disinfectant, such as quaternary ammonia. The entire house is then sprayed with another disinfectant.

A washed and disinfected brooder house is allowed to dry and air out before swabbing for bacterial cultures as a check on the effectiveness of the cleaning and disinfecting. If harmful bacteria are found, the prior disinfection is repeated. All workers are restricted from the clean and disinfected house until it is time to restock the house with a new flock.

Litter

At least two weeks "down-time" should occur between disinfecting and adding clean, dry litter such as softwood shavings. Quality litter is free of excessive dust and/or mold, large chunks, and sharp edges. Rice hulls are not to be used because poults ingest the hulls, thus causing digestive dysfunction. Furthermore, rice hull dust predisposes poults to aspergillosis and eye irritation. If rice hulls are used, then operation will try to be sure that they are covered with wood shavings during the first week or two, to prevent the young poults from eating them. The brooder litter is moved to the growout house after moving the flock from the brooding facilities to the growout barn. Rice hulls and wood shavings make a nice litter material. The wood shavings absorb water and rice hulls help keep the litter loose.

Hovers

Poults require supplemental heat from time of placement until they are "ranged" or relocated to growing facilities. A hover is usually saucer-like with a diameter of 3 to 4 feet and with the concave surface facing the floor. The hover is suspended from the roof and approximately 18 to 30 inches from the surface of the litter. It can be raised or lowered as needed. Each hover has a thermostat-controlled heat-producing element attached to the underside of the saucer. Most producers are using radiant brooders. They are more energy efficient and are easier to operate. Radiant stoves are usually operated 36-48 inches off of the floor, making it easier to see all of the birds and to fill hand feeders. Radiant heaters are most commonly controlled by computers with 20-25% of the stoves in a zone controlled/monitored with a single thermocouple.

Hover operation is tested at least 24 hours before the poults arrive to ensure the equipment is functioning and proper floor temperature is obtained. Feeders and waterers are filled the day before poult delivery to attain the proper room temperature.

Depending on season and house temperature, a hover is adjusted in such a manner as to provide a comfortable environment for the poults. The hover height may be increased slightly each day after the poults are two days of age. Hovers in curtain-type buildings do not require frequent raising, but do need adjustment to keep poults from roosting on them and burning their foot pads. This frequent adjustment is not necessary with radiant brooders.

In general, a hover is set to produce a temperature of 90°F to 95°F at floor level under the hover and a room temperature of 75°F when poults arrive. The temperature is gradually lowered 5°F per week for the following three weeks. However, actual temperature may vary because the best management practice is to adjust the temperature according to the poult's behavior. Some operations maintain nearly the same temperature for the first two weeks of age. The computerized control of the brooders allows the gradual reduction of temperature on a daily basis. The first two weeks we maintain a temperature of 90 degrees in the comfort zone around the brooder stove. At three weeks of age the turkey poults ability to maintain its own body temperature is becoming more developed. At this time the turkeys do not bed down around the brooder stove. Over a one to two week period of time there is a transition from brooder stoves to space heaters. The 42 day target temperature is 74-76 degrees. At this time we are moving birds to the growout houses. From 42 days to 140 days the temperature is reduced gradually to 55-60 degrees.

Brooder Rings

A brooder ring is used to keep poults close to the hover for heat, food, and water for the first 5 to 7 days of age or longer in colder weather. A single brooder ring may be used for a single hover or for two closely-spaced hovers.

In the summer, brooder rings may be made of poultry netting, 18 inches high, and placed in a 12 to 15-foot diameter around each hover. In colder seasons, solid wall brooder rings made with cardboard or other solid material are suitable. Poultry netting brooder guard is not very good.. It does not prevent drafts, which are a problem even in hot weather. Also the poults can see through it. Poults will follow people or move around in response to what they see. It is good to limit what they see, especially the first day or two, to prevent piling.

Poult Placement

Industry prefers the delivery of poults as soon after hatching as possible. Poults are placed quickly but gently around the hover within the brooder ring. They should not be placed directly under the hover. Immediately after placing all poults in the brooder rings, workers should leave the brooder house for at least an hour to allow the poults to settle and find water, feed, and warmth on their own. Place the new poults directly under the hovers or around the perimeter of the comfort zone to help train them to the heat. They will move out very quickly on their own. If the poults are removed from their shipping boxes too far from the heat source they will not learn it and may start piling immediately after being placed. This behavior is difficult to correct.

Waterers and Feeders

Four waterers (with additional satellite waterers) and four feeders should be provided for every 250 to 350 poults at each hover. Lips of waterers and feeders should be maintained at heights equal to the heights of backs and breasts of poults, respectively. To encourage day-old poults to begin eating and drinking, 3 to 5 clean egg flats full of feed are placed around (not under) each hover. Egg flats are usually use for the first 2-3 days as supplemental feeders for the starting poults. Three, three foot long, trough feeders are placed per stove. These are used until the birds are 14 days old and these are removed a few at a time, starting with removal of about a ¼ of them from 10-14 days of age.

Poult waterers are routinely sanitized 2 to 3 times daily during the first ten days to avoid respiratory and other disease problems. Drinking water is chlorinated to a level of 2 to 3 PPM total free chlorine measured at the waterer. Dirty water is removed, and each waterer is scrubbed and disinfected.

Feed on filler flats is checked several times daily and added as needed. A small amount of poult grit is placed on top of the feed to promote gizzard health and prevent feed impaction.

Feeders and waterers are relocated each day to avoid a buildup of manure around them. Accumulated fecal material should be removed to promote healthy foot pads in poults.

Brooder rings are removed when poults are seven days of age or whenever the poults attempt to jump over the barriers. At this time, automatic feeders are turned on and filler flats are gradually moved to a position near the automatic feeder. Near the tenth day, one-half of the feeder flats should be removed. On the following day, the remaining flats are removed. Now operations are putting automatic feeders in the rings prior to poult placement. These are keep capped full with feed until the birds are 18-21 days of age. Then the feed level is gradually reduced and the height of the feeder is raised in a manner that makes the feed easy for the birds to reach, while reducing feed waste.

Ventilation

Fresh air is vital to the poult's survival and subsequent performance. Adequate ventilation must be provided to supply oxygen necessary for respiration, maintain a comfortable temperature without drafts, remove excess moisture and CO_2, minimize dust, and maintain good litter condition.

Lighting

Most producers do not restrict natural light for poults. Lighting may remain on all night for the first 2 to 3 nights. Poults are checked every three hours during the first 2 to 3 nights to make sure they are comfortable, feeding properly, and not crowding.

The light intensity should range from a low of 35 lux to a high of 50 lux. The lighting should be uniform to reduce shadows, which can frighten poults and sometimes cause piling. After the poults locate feed and water, the light intensity can be lowered to reduce the incidence of pecking; however, this is done more in the chicken industry. Most of the turkey houses do not have the ability to reduce light intensity. Some of the solid side wall turkey houses have this capability.

GROWING HOUSE PRACTICES

The growing phase refers to the period of time between brooding and marketing. Housing requirements from the end of the sixth week until market will differ from the brooding house requirements.

Space Requirements

Amount of space required per poult varies with environmental conditions and the sex and market weight of birds. The turkey commonly finishes turkeys at 10-14 pounds per square foot depending on the type of bird.

Poult Transfer

Poults are routinely moved from the brooder house to growing houses in trailers. Birds are herded into the trailers and placed in divided sections to prevent scratching and piling. Hens and toms are moved separately and placed in separate houses.

Workers must ensure the proper numbers of birds of each sex are placed in each house. Approximately 8,300 hens or 5,000 toms can be placed in a 25,000 square feet house (50 feet wide by 500 feet long). Most farms are either tom farms or hen farms.

Feeders and Waterers

Growing houses must have adult size feeders and waterers. The number of feeders and waterers should be determined by the number of linear inches of feeding and watering space required. Each feeder or waterer type has a recommendation from the manufacturer. Individual producers may vary the number of feeders and waterers placed based on experience and comfort/performance of poults.

Ventilation

Ventilation is an important consideration in brooding and growing turkeys. Minimum fresh air flow should be 1.5 CFM per pound of body weight at all ages when the house is filled to capacity. Ventilation rates are adjusted to remove dust or moisture and to provide adequate oxygen and temperature control without drafts. Some operations now are using 3-5 CFM/ pound. A publication by the University of Georgia is used as a good reference for ventilation statistics.

To remove excess moisture, the temperature inside the house is allowed to increase from the body heat radiated by the turkeys and/or from supplemental heat. The excess moisture is then picked up by the warmed air and exhausted from the house during normal ventilation.

Cold fresh air moving through a warm house will dry the litter. In some cases, litter may become so dry that it needs to be dampened to reduce dusty conditions. Properly operated foggers (or a wet pad cooling system) can be used to maintain adequate moisture in the litter.

NUTRITION

Modem turkeys grow rapidly. A tom poult at day one weighs almost 0.25 pound, but at 21 weeks that same tom exceeds 40 pounds. The producer and feed supplier must work together to ensure proper nutrients are available to the flock in a palatable form. The following table provides expected weights and feed conversions at various ages of hens and toms.

Commercial Market Turkey Weights and Feed Conversion *

Age (weeks)	Hen Weight (pounds)	Hen Feed Consumption (pounds)	Hen Feed Conversion	Tom Weight (pounds}	Tom Feed Consumption (pounds)	Tom Feed Conversion
1	0.34	0.40	1.19	0.35	0.36	1.04
2	0..75	0.92	1.23	0.74	0.81	1.1
3	1.38	1.79	1.30	1.49	1.73	1.16
4	2.24	3.01	1.34	2.7	3.32	1.23
5	3.32	4.75	1.43	4.29	5.56	1.3
6	4.65	7.00	1.50	6.16	8.41	1.37
7	6.25	9.86	1.58	8.29	11.85	1.43
8	7.98	13.10	1.64	10.68	16.04	1.5
9	9.83	16.95	1.72	13.32	20.90	1.57
10	11.81	21.30	1.80	16.24	26.60	1.64
11	13.87	26.34	1.90	19.28	32.90	1.71
12	15.94	31.42	1.97	22.36	39.90	1.78
13	17.92	36.78	2.05	25.46	47.41	1.86
14	19.78	42.01	2.12	28.53	55.36	1.94
15	21.51	47.21	2.19	31.57	63.71	2.02
16	23.01	52.44	2.28	34.53	72.72	2.11
17	24.33	57.55	2.37	37.41	82.06	2.19
18	25.49	63.03	2.47	40.20	92.11	2.29
19	26.57	68.24	2.57	42.90	102.49	2.39
20	27.60	73.84	2.68	45.51	112.70	2.48
21				47.98	123.50	2.57
22				50.27	134.79	2.68

*Source Nicholas 85 x 700 (Aviagen Turkeys, Inc, Lewisburg WV)

Poultry are fed diets comprised primarily of grain, protein supplements, minerals, vitamins, and fat. By-product ingredients such as wheat bran, bakery by-product meal, meat meal, or dried brewers grains are sometimes used when they are cost effective.

Turkey flocks may utilize 4 to 8 different diets from hatch to market age. They may be fed on a slightly different schedule depending on their sex. Day-old poults require a high protein, low energy diet. Producers gradually change turkey diets to decrease protein levels and increase energy levels as the birds approach market age. Refer to the table on the following page.

Commercial Market Turkey Ration*						
Diet	**Pre-starter**	**Starter**	**Grower #1**	**Grower #2**	**Finisher #1**	**Finisher #2**
Age (weeks)	0-2	3-6	7-9	10-12	13-16	17-market
Protein (%)	29.0	28.0	25.0	29.0	20.5	18.0
Energy (kcal/kg)	2870	2870	2890	2930	2990	2990
Lysine (%)	1.75	1.63	1.43	1.26	1.00	0.85
Methionine (%)	0.69	0.63	0.54	0.49	0.42	0.36
Methionine + cystine (%)	1.19	1.13	1.01	0.90	0.84	0.71
Calcium (%)	1.37	1.35	1.27	1.17	1.07	0.97
Available Phosphorus (%)	0.79	0.76	0.73	0.69	0.60	0.57
Salt (%)	0.37	0.37	0.32	0.32	0.32	0.32
Sodium (%)	0.17	0.16	0.15	0.15	0.14	0.14

* Source: Nicholas Turkey Breeding Farms

Note: These recommendations do not guarantee performance of the feed product. Factors such as ingredient quality, milling, storage, time of year, and presence of contaminating organisms or chemicals can influence overall results. Turkey performance is greatly affected by diet.

As mentioned earlier, turkey feed should be palatable. If the crumbles or pellets are too large, the poults will not eat them. If the feed is too finely ground (e.g., a mash), it will stick to the beaks of the poults, thus decreasing consumption. Furthermore, the feed will fall from the beaks when the poults drink and increase the risk of bacterial contamination of the water.

HANDLING AND LOADING

Moving turkeys is one of the most difficult tasks for producers. Thus, producers move their birds as little as possible. The least stressful move is from the hatchery to the brooding area.

The second move from the brooding area to the growing area is more stressful for the young turkeys. The number of birds grown is extensive, and the poults must be walked onto a trailer to be moved. At the new growing area, the poults have to adapt to different sizes and placements of feeders and waterers. Workers should be informed about the stress of moving and strive to handle and transport poults in an efficient manner with minimal stress and injury.

Transport of turkeys to a processing plant is an important part of the overall production process. Birds incorrectly caught or improperly placed in cages may sustain injuries and bruises that could be harmful to the birds as well as cause downgrading. Therefore, all workers must be trained in bird catching, handling, and transporting.

Turkeys are often moved at night to reduce the stress of heat and because birds are calmer in the absence of light. Dimming of house lights creates a less stressful environment for catching. Another practice is to use blue or green light that provides adequate light for the catching crew but is perceived as very dim light by the birds. These practices minimize the stress on birds and help prevent piling.

The turkey industry uses cages that are fix mounted on the trailer. Cages used for live-haul are constructed to allow loading, transport, and removal without injury to the birds. The entire truck and especially all cages are cleaned and disinfected after each load. Stocking density for each cage depends on cage size, bird size, and transportation conditions (transit time and temperature). When the cage is full, floor space should be sufficient to allow all birds to rest on the floor simultaneously and have free head movement.

Maximum stocking density can be used during cold weather. When ambient temperature and humidity are high, bird transport should be rescheduled for cooler times of early morning and evening. Special care is to be exercised in securing all cages, thus eliminating the possibility of turkeys falling from the truck. In the winter board are mounted on the outside of the livehaul trailers to prevent the birds from getting too cold.

BIOSECURITY AND SANITATION

Biosecurity and sanitation are important on the turkey farm. All operations are intended to maximize flock health, minimize disease, and ensure production of clean poults.

Workers and visitors can be carriers of disease. A security fence should be maintained around the facility. Gates and buildings should be locked at all times. No one should be allowed inside the secured area without approval of the supervisor. Each person entering must follow sanitation procedures posted for the facility. These include signing in, removing clothes in special rooms, showering, wearing approved clothing, washing and disinfecting boots and hands, etc is commonly used in breeder operations.

Vehicles and equipment are also carriers of disease. Turkey farm traffic should be minimum. Supply houses and service areas should be located away from the brooding and growing houses. If entry is required, all vehicles and equipment should be thoroughly disinfected. Drivers of service vehicles are not to be allowed to step outside their vehicles.

Pests are carriers of disease. Areas that attract pests should be eliminated. These include tall grass and weeds, feed spills, and standing water. Buildings should be pest-proof. Rodenticides and insecticides are to be placed in strategic areas.

An all-in/all-out program is to be used. Houses and equipment should be cleaned and sanitized between flocks to reduce disease risks. A strict surveillance program should always be in place.

The vaccination schedule for turkeys should be based on the sex of bird and the incidence and prevalence of disease in the area. Vaccination should be periodically monitored and evaluated using the available test system. However, the best vaccination program can fail. Possible causes of vaccination failures are immunosuppression, incorrect mixing and dosage of vaccine, application errors, loss of vaccine potency, scheduling errors, and serotype variants.

Postmortem examination in the field (field necropsy) provides information that can be combined with flock history and field observations to determine causes of performance problems, clinical signs, and mortality. A turkey necropsy includes a case history of the flock, evaluation of and access to the problem, a supply of necropsy equipment, and performance of the postmortem examination.

ECONOMICS OF PRODUCTION

Most meat production units brood and grow from 50,000 to 75,000 birds three and one-half times per year. Many of the larger facilities have a single brooding complex with the capacity to brood up to 100,000 poults and which serves two separate grow-out facilities with the same capacity. In this scheme, the brooder facility broods seven times each year and furnishes the poults needed to fill both growing facilities three and one-half times per year.

Turkeys are no longer produced seasonally. Further processing and the structure of the turkey industry changed turkey production to a year-round activity. Most turkey facilities are built using borrowed money loaned on this basis. Therefore, the producer needs to maintain cash flow.

A typical facility costs about $1,250,000. This facility has two brooder houses (50 x 500 feet each with a capacity of approximately 17,000 poults each) and five growing houses (50 feet by 500 feet each with a capacity of 5,000 poults each). To this cost is added the land (20 acres minimum), one residence, fuel, water, electricity, and labor. The total cost to raise a bird is now $10-$20 per bird. This includes feed, poult cost, facility, labor/grower pay & supervision, utilities, litter, medications and disinfectants, and repair and maintenance.

Almost all birds are produced on a contractual basis. The producer furnishes the land, facilities, and labor and is paid based on the weight, grade, and feed conversion of the birds delivered to the processing plant. Each integrator has a different contract, but in general, the grower can expect a return of $1.50-$3.00.

For planning purposes, average bird mortality is usually 10%. The national average livability is 87% for toms and 92% for hens. Individual contracts take into consideration such things as house insulation, mortality, and feed conversion.

The integrator owns the turkeys and supplies feed, medicine, vaccines, and a grow-out supervisor that checks on the turkeys on a regular basis and decides if and when medication or vaccination is to be administered.

The turkey grower can expect to spend 20.4% of all costs for labor, 7.9% for energy, 11.6% for overhead, 13.4% for taxes and insurance, and approximately 46.7% for debt service.

Debt service or the cost of the loan for the turkey barns and facilities varies widely depending on the amount borrowed and the length of repayment. Typically, money borrowed from a bank or a more conventional source will be borrowed for a long period (10 years or more). Money borrowed from an integrator will usually be for seven years or less.

The integrator's feed cost varies depending on ingredient cost, distance from the mill to the turkey farm, the mill's efficiency, and feed formulation type. On the average, feed represents 70% of the cost of turkey production.

Debt service or the cost of the loan for the facility varies widely depending on the amount borrowed and the length of repayment. Typically, money borrowed from a bank or a more conventional source will be borrowed for a long period (10 years or more). Money borrowed from an integrator will usually be for seven years or less. USDA Farm Service Agency (FSA), Farm Loan Programs may provide guaranteed loans to lenders (e.g., banks, Farm Credit System institutions, credit unions) with a guarantee of up to 95 percent of the loss of principal and interest on a loan. Farmers and ranchers apply to an agricultural lender, which then arranges for the guarantee. The FSA guarantee permits lenders to make agricultural credit available to farmers who do not meet the lender's normal underwriting criteria.

Most of the turkey buildings and equipment on a typical farm are use specific. They function very well for growing the species for which they were designed, but have very little value except as salvage if not utilized in turkey production. If production is dependent upon a current contract, then loss of a grower's contract can substantially lessen the value of the farm if appraised without the possibility of a secured grower's contract that would utilize those buildings and equipment.

FSA guaranteed loans are for both Farm Ownership and Operating purposes. Like the Direct Loan Program, a percentage of Guaranteed Loan funds are targeted to beginning farmers and ranchers and minority applicants.

SUMMARY

A commercial market turkey producer grows poults under contract with an integrated poultry company. Turkey production management includes brooding and grow-out, feeding, watering, ventilating, lighting, biosecurity/sanitation, handling/loading, and financing.

http://www.epa.gov/agriculture/ag101/poultryphases.html

** Adapted from "Turkey Care Practices," California Poultry Workgroup, Cooperative Extension, University of California-Davis; http://www.vetmed.ucdavis.edu/vetext/INF - PO_TurkeyCarePrax.pdf. Supplemental information included in this topic was provided by Aviagen Turkeys.*

** Jesse Lyons, Poultry Extension Associate, University of Missouri, developed and revised this topic. Dr. Dan Britton, University of Missouri alumnus, reviewed this topic. Kirk C. Edney, Ph.D., Instructional Materials Service, Texas A&M University, edited and formatted this topic.*

EGG-STRAIN PULLET AND HEN MANAGEMENT *

INTRODUCTION

According to the Food and Agriculture Organisation (FAO the global population will increase by 2.5 billion people, to 9.1 billion by 2050. The FAO already estimates that 1 billion people worldwide are underfed and undernourished. Due to the rise in the global population and increasing wealth of those in developing countries, there is estimated to be a 50% increase in the global demand for animal protein products, such as eggs. Chicken eggs have long been a part of human diets. Eggs have exceptional nutritional value; they are affordable, and analysis indicates a low carbon footprint associated with the production of eggs.

Eggs are an excellent and one of the most affordable sources of high quality protein. Eggs also contain essential vitamins and minerals that are required for a healthy diet. Recent studies indicate that diets that include eating eggs helps people to lose weight by making them feel fuller for longer, and that eggs may reduce certain disease risks, age related eye disease and muscle loss. Eggs are so popular worldwide that egg production is increasing more than the production of some other protein foods. According to the International Egg Commission, over the last 35 years, poultry meat and egg production increased faster than beef /veal or swine production, with egg production more than tripling.

China produces many, many more eggs than any other country. Together, China, India and Japan produce almost half of the entire world egg supply. In 2005, the top ten egg-producing countries were:

1. China	41.1%
2. USA	9%
3. India	4.2%
4. Japan	4.2%
5. Russia	3.5%
6. Mexico	3.2%

About 98% of the eggs produced are eaten in the country where they are produced. Only about 2% of eggs worldwide are involved in export trade.

Overview of the US Egg Industry:

Here in the US, eggs have been sold by individuals owning small to medium sized flocks for many years. Most eggs were sold from the farm to the local produce store or grocery in many of

** This unit was developed by Mr. Jesse Lyons, Extension Poultry specialist, University of Missouri* the small cities. The store employees hand candled the eggs, and dry cleaned the shells using a sandpaper block to remove any visual dirt or stains and directly sold these eggs to local customers. In the 1960's and 70's many of these small egg processors closed as there became fewer small poultry flock owners and regulatory agencies took a closer look at agricultural products.

Today, the commercial egg industry has multiple flocks located on a farm with each location's laying house containing a flock of uniform age, different from the age of the hens in the adjacent laying house. These facilities range in sizes of up to more than one million birds on a single facility. The commercial egg industry is vertically integrated, as are other major components of the poultry industry. Egg producers own and manage nearly every aspect of their business from the rearing of birds, feed preparation, housing, husbandry, and marketing. Egg producers usually buy pullet chicks from primary breeder sources, rather than own breeding stock.

In the US the value of all egg production in 2010 was $6.52 billion. Egg production totaled 91.4 billion eggs. There were about 309 million people in the US in 2009 and there were 337 million laying hens producing an average of 268 eggs a year (NASS 2010). The high point in the US for per capita egg consumption was 402 eggs in 1945. Per capita consumption had been steadily declining due to lifestyle changes and to health concerns and declined to the lowest in 1991 (235 eggs per capita). In 2010 the per capita egg consumption was 246.2.

In recent years, the production of eggs has shifted much closer to the grain producing regions of the US. The most prominent growth has been in the Midwest, particularly in Iowa. Currently, the top five egg producing states (ranked by number of layers represented in thousands) are:

1. Iowa	52,598
2. Ohio	25,587
3. Indiana	23,751
4. Pennsylvania	20,461
5. California	18,312

These five largest egg producing states represent approximately 45 percent of all U.S. eggs. Within the US there are 60 egg producing companies with 1 million plus layers and 12 companies with greater than 5 million layers. Flocks of 75,000 hens or more represent over 95 percent of all layers in the US. In 1987 there were 2,500 companies with flocks of 75,000 or more and in 2010 there were 245.

As of 2009, 30.8% of US eggs were further processed (for foodservice, manufacturing, retail & export), 57.8% went to retail, 8.5% went for foodservice use, and 3% were exported. Important export markets for US egg products include Japan, Mexico, and Canada. Hong Kong is the top market for U.S. table eggs.

Source: U.S. Dept. of Agriculture, American Egg Board, USAPEEC

REPLACEMENT PULLET MANAGEMENT

Brooding (day old to 6 weeks)

Major Reference: Commercial Egg Production and Processing By Ryan A. Meunier & Dr. Mickey A. Latour, Purdue Univ

There are a number of ways to rear laying hens. It would be very unlikely that any two producers will rear layers exactly the same way. The information presented in this section is to describe a typical rearing program for laying hens.

PERFORMANCE GOALS FOR WHITE EGG-STRAIN PULLETS/HENS

Factor	Goal
Livability Percentage to 16 weeks / 60 weeks	98% / 97%
Body Weight at 16 weeks / 60 weeks	2.71 lb / 3.68 lb
Egg Laying Period (first egg to end of lay)	60 wk to 80 wk
Days to 50% Production (from hatch)	138 days
Percentage Peak	93.5%
Hen-day Eggs to 60 weeks & 80 weeks	252 eggs / 355 eggs
Hen-housed Eggs to 60 weeks & 80 weeks	248 eggs / 346 eggs
Total Feed Consumption to 16 weeks	11.1 lb
Daily Feed Consumption (17 weeks to 80 weeks)	0.15 lb / 0.23 lb
Feed Consumption per Pound of Eggs	1.87 lb
Feed Consumption per Dozen Eggs	3.01 lb
Egg Weight per Case at 70 weeks (65.6 grams / egg)	52.1 lb

Hatching and Placement: The term "brooding" has been carried on from its use to describe the setting "brooding" hen. Brooding is used to describe the caring for the chick through their early life. Laying operations normally purchase their layer stock (i.e., day old leghorn or brown egg chick) from an egg-type hatchery. At the hatchery, chicks are vaccinated according to the producer's specifications. This usually includes vaccination for Marek's disease. Hatcheries deliver chicks to the producer within one to two days of hatching. At arrival, chicks are placed in a brooding facility. This facility may be a pullet cage system consisting of several decks of cages or an aviary a system allowing for removal of divisions so that the chicks may be allow comingling with other groups of chicks in the unit.

General management procedures prior to placing chicks in the brooder facilities include-

- Cleaning the house and outdoor areas several weeks before chick arrival.
- Sanitizing and disinfecting the house and equipment several days before chick delivery.
- Emptying old feed from bulk bins and adding fresh feed several days before chick arrival.
- Adjusting equipment (including hovers, feeders, and waterers) for proper working condition and heights one to two days before chick arrival.

- Calibrating and adjusting the humidity level of the house the day before chick delivery.
- Setting the brooder house and hover temperatures to the recommended levels one day before chick arrival.

General Chick Care

TABLE: Example Vaccination Program for Commercial Layers* (source Merck Veterinary Index)

Age	Vaccine	Route	Type
1 day	Marek's disease	Subcutaneous to back of neck	Turkey herpesvirus and SB-1
14 -21 days	Newcastle/infectious bronchitis	Drinking Water	B1/Mass
5 wk	Newcastle/infectious bronchitis	Water or coarse spray	B1/Mass
8-10 wk	Newcastle/infectious bronchitis	Water or coarse spray	B1 or LaSota/Mass
12-14 wk	Newcastle/infectious bronchitis	Water or aerosol	B1 or LaSota/Mass
16-18 wk and every	Newcastle/infectious bronchitis	Water or aerosol	B1 or LaSota/Mass
60-90 days or 18 wk	Newcastle/infectious bronchitis	Parenteral	Inactivated
Other Vaccines Sometimes Used[1]			
14-21 days	Infectious bursal disease	Drinking Water	Intermediate
6 wk	Laryngotracheitis (LT)	Eye drop	Modified live
10-12 wk	Fowl pox	Wing web	Modified live
10-12 wk	Encephalomyelitis	Wing web	Live, chick-embryo origin
or 18 wk	*M gallisepticum*	Parenteral	Inactivated

*This is an example of a vaccination program. Individual programs are highly variable and reflect local conditions, disease prevalence, severity of challenge, and individual preferences. Be sure to check with your veterinarian for recommendations and check current state and federal regulations before administering a vaccine.

†The use of *M gallisepticum* vaccine is regulated or prohibited in some states. SB-1 or MDV301 may be combined with turkey herpesvirus in some areas. Vaccination for infectious bursal disease, laryngotracheitis, and fowl pox depends on local requirements. Other strains of infectious bronchitis (Connecticut, Arkansas 99, Florida 88, etc) are included in some areas. *M gallisepticum* and *Haemophilus gallinarum* (coryza) are used only on infected, multiage premises in some areas.

Depending on the temperature of the environment, brooding chicks need supplemental heat for a period of about six weeks or until the chicks are well feathered and can control their body temperature themselves. Temperature readings are helpful when preparing brooding facilities for housing the chicks; however, observing the behavior of the chicks will tell you whether or not the temperature is correct. If they are too cool, they will huddle near the heat source. If they are too warm, they will spread out away from the heat source. If there are drafts, they will huddle in groups to get away from the spot where the cool air enters the heated area.

Comfortable chicks will spread out uniformly, without huddling, throughout the brooding area. Once chicks can control their body temperature they still need to be protected from the extremes of climate. From day-old they usually receive chick starter feed which aims to ensure they have plenty of protein (19%) and energy for body growth.

Brooding Temperatures

Age	Cage Brooding		Floor Brooding	
Day	°C	°F	°C	°F
1-3	32-33	90-92	33	92
4-7	30-32	86-90	31	88
8-14	28-30	82-86	29	84
15-21	26-28	78-82	27	80
22-28	23-26	74-78	24	76
29-35	21-23	70-74	22	72
36	21	70	21	70

Cage Brooding

Almost 50% of all replacement egg-type chickens are raised in cages, a popular brooding system.

The following recommendations serve as a guide for cage brooding birds.

- Set the house temperature at 87°F to 92°F (31octo 33°C) at chick body level. Reduce the temperature 4°F (2°C) each week until 70oF (21°C) is reached. Observe chick behavior to determine proper temperature setting.
- Provide a relative humidity ranging from 40% to 60%. To raise the humidity, sprinkle water on the floor or walks to increase humidity.
- Cover the cage floor with nonskid paper to allow the chicks to reach both feed and water. Remove the paper when the chicks are ten days of age.
- Three hours after placing the chicks in the cages, sprinkle starter feed on the paper (along

with filling the feeder). This supplemental feeding occurs for 2 to 3 days and ends when the chicks are using the feeder.

- Provide fresh, cool water at all times.
- Provide fresh feed in automated feeders at all times.
- Beak-trim the chicks when they are 7 to 10 days of age.
- Use 20 to 22-hour lighting daily for the first week, with a light intensity of 3 foot-candles (fc).

Floor Brooding

Floor brooding is a conventional practice used for nearly 50% of the egg-strain pullets raised in the United States. Floor brooding of laying chicks has similarities to floor brooding of broilers.

The following recommendations are guidelines for floor brooding of laying breed chicks.

- Add clean litter at least one day before chick delivery. Old litter is entirely replaced under the brooder area after each flock of pullets. The remaining litter is stirred and a 1/2" to 1" deep layer of new litter placed over the entire surface. The litter should be economical, mold-free, dust-free, and highly absorbent. Examples of good litter material are cane pulp, softwood shavings, chopped wheat straw, peanut hulls, and peat moss.
- Stabilize the house temperature and attain proper brooding temperature 24 hours before chick placement. Maintain "warm room" brooding systems at a temperature of 90°F to 95°F (32°C to 35°C) at chick level (two inches above the litter) during the first week. With "cool room" brooding systems using brooder rings, maintain the temperature indicated above. Temperature in other areas of the house should be at least 70°F. A rule of thumb is to reduce the brooding temperature 5°F weekly after the first week.
- Maintain a relative humidity of 40% to 60% to prevent dehydration and respiratory problems. To increase relative humidity, sprinkle water over the litter but add water sparingly.
- Do not exceed the maximum chick capacities for hovers: A six-foot diameter hover is best suited for 500 chicks, while an eight-foot diameter hover is suited for 750 chicks.
- Position waterers before chick arrival at the recommended capacities:
  two-liter fount (approximately ½ gallon) per 50 chicks, one nipple or cup waterer per eight chicks, one inch trough space per chick.
- Place feeders and waterers alternately in a ring for easy access by the chicks.
- Protect chicks from drafts with brooder rings. Solid shields retain heat better than do wire-mesh shields. Allow enough space between the hover and the wall of the brooder ring to allow chicks to move away from the heat.
- Sprinkle feed in the feeder areas to initiate food consumption three hours after chicks have been in the brooding area and after having access to water.
- Use 20 to 22-hour lighting for the first week. Light intensity should be 3 fc. Afterwards, use a recommended lighting schedule.
- After two days, transition chicks from the feeder lids to trough or pan feeders. The chicks should be feeding from a mechanical feeding system by one week of age.
- Remove brooder rings when chicks reach ten days of age.
- Feed a coccidiostat and use a routine worming program to ensure healthy stock.

GROWING PERIOD MANAGEMENT

Growing to 20 Weeks

Older replacement pullets will receive a pullet grower feed which is less expensive and contains only 15% to 17% protein and less energy than the starter feed. Beak trimming and some vaccinations are done during the grower stage to prepare the birds for their adult life as laying hens. Any severe check to growth at this time can affect their ability to lay well. Remember also that excessive feeding at this time can be harmful, leading to poor egg production. The first 16 weeks of the flock's life determine if the birds will live up to their genetic potential.

NUTRIENT REQUIREMENTS FOR EGG-TYPE PULLETS

	Age of Pullet in Weeks		
Nutrient	**0 – 6**	**7 – 14**	**15 - 16**
Metabolizable Energy (Kcal/lb)	1,325	1,375	1,320
Protein (%)	20	18	17.5
Calcium (%)	1	1	4
Phosphorus (available %)	0.50	0.46	0.50
Sodium (%)	0.19	0.17	0.18

General Suggestions for Growing Pullets

Floor space required of course will be dependent on housing, age, breed, weather and climate, but there following can be used as general guides for adequacy of floor space and feeder and water recommendations.

GROWING SPACE RECOMMENDATIONS

CAGE		FLOOR	
Floor Space:	310 sq cm (48 sq. in.)	**Floor Space:**	835 sq cm (0.9 sq. ft.)
Feeder Space:	5 cm/bird (2"/bird)	**Feeder Space:**	5.0 cm/bird (2"/bird)
		1 pan/50 birds	
Water Space		**Water Space**	
Trough:	2.5 cm/bird (1"/bird)	**Trough:**	2.0 cm/bird (0.8"/bird)
Cups/Nipples:	1 per 8 birds	**Cups/Nipples:**	1 per 15 birds
Fountains:	—	**Fountains:**	1 per 150 birds

Management Outline

- Use the proper feed ration to provide adequate nutrition.
- Flush and sanitize the water system on a routine basis.
- Watch birds for any sign of disease.
- Check the water, feed, and lighting daily.
- Keep growing birds isolated from older birds. Restrict traffic in the growing house.
- Vaccinate using a schedule outlined for each flock. Keep accurate records of vaccine use, including product names, expiration dates, and vaccination dates.
- Routinely conduct postmortem examinations of fresh mortalities.
- Promptly remove dead birds and dispose of them properly.
- Keep a written flock history, including feeding program, lighting schedule, vaccination program, and bird weights. Transfer these records later to the layer house.

Beak Trimming

The following practices are recommended guidelines for trimming beaks of healthy birds.

- Permanent beak trimming is successful if performed on chicks between 7 to 10 days of age. Follow breed management or company guidelines relative to beak trimming recommendation s. If recommended, perform the second trimming when the birds are four weeks of age. If another re-trimming is necessary, do it when birds are 12 weeks of age. This allows pullets to recover from stress before being moved to the layer house.
- Add electrolytes and vitamins (including vitamin K) in the water two days before and two days after beak trimming.
- Increase the feed level in the feeders for several days after trimming.

During the growing period, proper management is essential to produce quality pullets. Production errors during this time cannot be corrected during the laying period.

Measuring Progress of Pullets

Body weight measurements taken during the growing period assist in preparing pullets of proper maturity level for the laying house. Breeding companies recommend what weight birds should be at each age.

- Commercial varieties of layers have the genetic potential to be uniform in body size and weight. If 80% of the birds weigh within 10% of the mean weight, flock uniformity is optimum.
- Weights are taken when birds are five weeks of age and every two weeks thereafter. Birds are also weighed at least one week prior to the date of a planned feed change.
- One hundred pullets randomly selected from throughout the house are weighed during each weighing period. Individual bird weights are recorded. Some producers use the criss-cross (X) sampling pattern (that is, sampling diagonally from the comers of the house).
- Research indicates that flocks uneven in bird weights early in life tend to remain uneven. Common problems causing lack of flock uniformity are crowding, disease, poor beak-trimming and inadequate nutritional intake.

- If the pullets are not at or near the weight indicated on the weekly body weight chart, maintain the same diet until they reach the prescribed age/weight range. At that time, they can be changed to the new diet.
- Avoid excessive weight gains from 12 to 18 weeks of age.

BODY WEIGHTS & HEN-DAY PRODUCTION - LEGHORN-TYPE PULLETS / HENS

Age (weeks)	Body Weight (grams)	Egg Production (Hen-day %) *
At start	35	-
2	110	-
4	260	-
6	40	-
8	650	-
10	850	-
12	1,000	-
14	1,130	-
16	1,230	-
18	1,320	8
20	1,450	48
22	1,550	84
24	1,580	91
26	1,600	93
30	1,620	91
40	1,670	87
50	1,690	83
60	1,710	77
70	1,720	73
80	1,730	66

* Hen-day % is the percentage of peak egg production per hen

Ventilation Requirements

The following ventilation rate guidelines are suggested for cage and floor raised birds. Allow 1 CFM air flow per pound of bird live weight. Increase air flow by 0.012 CFM per pound of bird live weight for each 1°F rise in temperature.

Moving

Pullets are usually moved into their laying quarters, at 16-18 weeks of age, before they reach sexual maturity. This ensures that they are settled in before egg production begins. Handling birds at any time must be done with care to avoid injury. As pullets mature into laying hens they are fed a layer ration designed to enable them to perform best.

Housing Systems for Laying Hens

Due partly to the economies of scale, larger producers can generally produce eggs at a lower unit cost than small producers. Except for small specialty markets, there has been little opportunity for small commercial farmers to compete with large scale producers in the general market of commodity eggs. Products considered as commodities are items that are all pretty much identical and when you purchase them you buy on the basis of price. Refrigerated trucks make the transport of eggs very easy so egg may easily be transported for one area of the country to another so location has not limited completion from eggs produced in a distant location at a lower cost. Some of the factors which affect how much it costs a farmer to produce eggs are:

1. Price of feed ingredients
2. Cost of rearing or purchasing pullets from day-old to point of lay (depreciation costs).
3. Level of mechanization. Unit labor costs decrease, but equipment total costs increases as farms become larger, more mechanized and automated. However; unit cost may not necessarily increase with level of mechanization.

Currently, 95% of all US table eggs are produced in cage systems. Cage systems have been used for the last 60 years and have undergone continual modifications to improve them. Breeding companies have conducted the genetic selection of egg laying hens in cage systems for at least 50 years.

Recently there has been growing concern among animal welfare advocates regarding freedom of movement and hen behavioral deficits in conventional cage systems such as the inability to perform nesting, dust bathing, and roosting behaviors. Because of increased attention on consumer health, on environmental concerns and in issues from the animal welfare groups, the production of have offered opportunities for certain smaller producers of designer and specialty egg. Organic eggs, range eggs, cage-free eggs and omega 3 eggs are some examples of niches that are of interest and have experienced growth in the marketplace. As markets are developed and production of these specialty products proves lucrative, the larger operations can be expected to identify the need to make these items available to preserve their sales locations and bases. This may include these operations entering the production of these products or sub-contracting production or product from a cooperating supplier.

In the area of hen housing and welfare, the "science" seems subject to interpretation and "welfare" appears not easily measurable. The type of housing system used in a state or any official domain or jurisdiction can be driven by consumer preferences or legislation. Producers with cage laying systems may be challenged to adapt if an alternative housing system is forced upon them by legislation if they:

- Cannot use existing cage equipment infrastructure
- Are forced to prematurely dispose of existing equipment (forced obsolescence)
- Face considerable uncertainty relating to changing requirements that demand large capital expenditures
- Have limited time for transition of financial and equipment assets
- Are paying off old assets ("double mortgage") while needing to finance new facilities.

In 1999, the European Union announced that conventional cages would be banned in 2012. While there are no federal laws that prohibit particular types of housing systems for farm animals in the United States, voters in California passed a ballot initiative in 2008 stating that hens must be able to "stretch both wings without touching another hen or the sides of their enclosure". This is thought to effectively ban the use of cages for laying hens in the state of California beginning in 2015.

In the area of evaluating egg production systems, Dr. Gail Golab, Director of the American Veterinary Medical Association (AVMA), Animal Welfare Division identified the following as points to consider:

1. Needs to be animal welfare-friendly across multiple parameters
2. Results in a product that's safe for human consumption
3. Is environmentally responsible
4. Is viable for adoption by producers
5. Must be acceptable to consumers."

Some people prefer to buy free-range and floor (barn) eggs because they object to hens being kept in cages. Organic eggs are purchased by people who value the ethos behind organic agriculture. As a result, these methods of egg production are becoming more common. The organic egg industry also has a comprehensive set of regulations they must abide by to maintain their organic certification.

Carbon Footprint

A carbon footprint quantifies the emission of greenhouse gasses (GHGs) along the entire life cycle of a product. The main GHGs related to animal production are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

Studying egg farms in the Netherlands, European Scientist examined CO_2 production at equivalent per kg of egg in various production systems. Their conclusions were that egg production has a lower carbon footprint than beef and pork production and, within the egg industry, barn and free-range systems have the highest carbon footprint, and cage production the lowest. Caged systems, produced the least CO_2, and followed by organic, barn and free range. However within each system various production factors made varying contributions, with feed production, being the largest overall contributor.

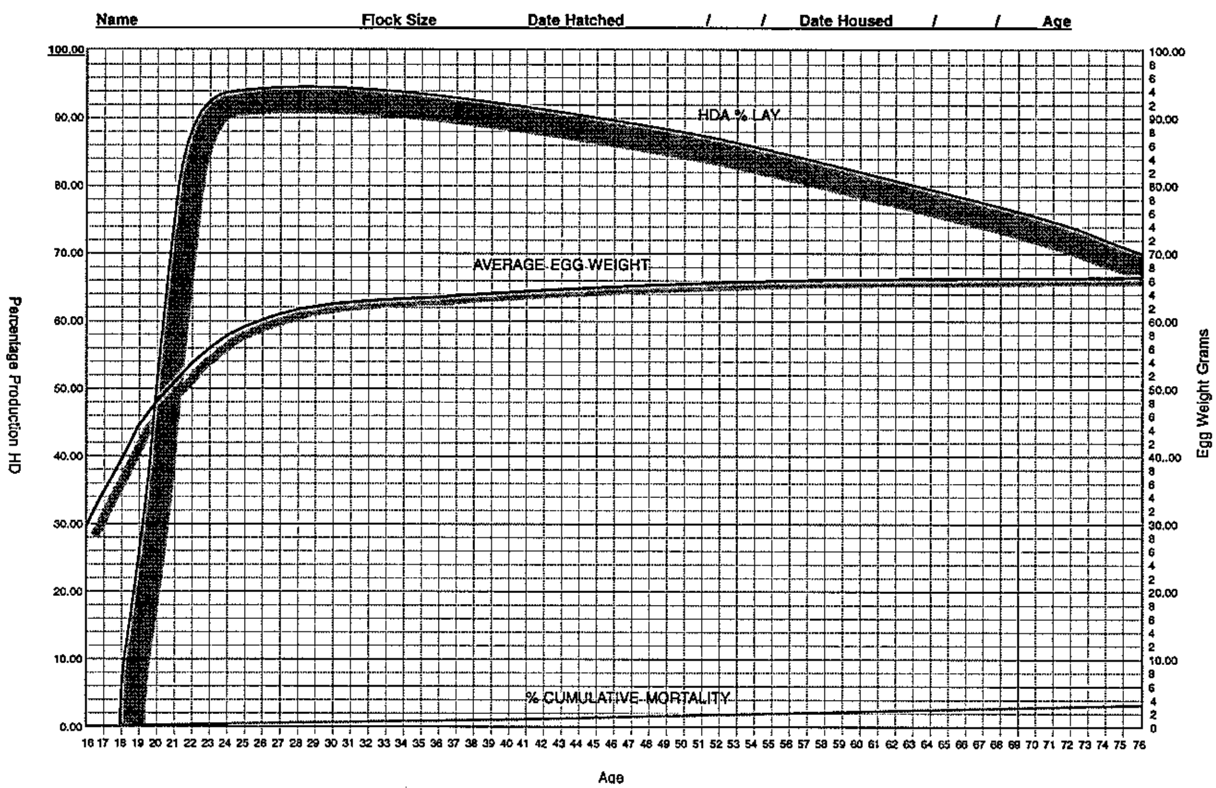
In the US, recent research from Iowa utilizing survey information submitted by operations representing approximately 50% of that state's egg production, indicates that a substantial portion of the greenhouse gas emissions in the production of eggs may be attributed to that emitted in the production of the feedstuffs they consume. They identified animal by-products used in the feed as a major contributor of the CO_2 generation. Nitrogen loss from bird manure is the second largest contributor to GHG emissions. The relative importance of manure management would increase if the feed contained less animal by-products.

LAYING HEN MANAGEMENT

Cage Systems

Egg Production: Producers begin to photostimulate and manipulate the diet around 18 weeks of age in order to support egg production. Minor nutrients have also been manipulated such that calcium levels in the diet are approximately five to seven times greater than phosphorus levels. When a flock (group of hens) first enters egg production, the rate of egg lay will be around 10 to 20 percent. The flock quickly reaches peak egg production (90 plus percent) around 28 to 30 weeks of age. Post-peak egg production (after 30 to 32 weeks of age) continually decreases to approximately sixty percent around 60 to 70 weeks of age. See the example production graph below for the Hy-Line Variety Brown.

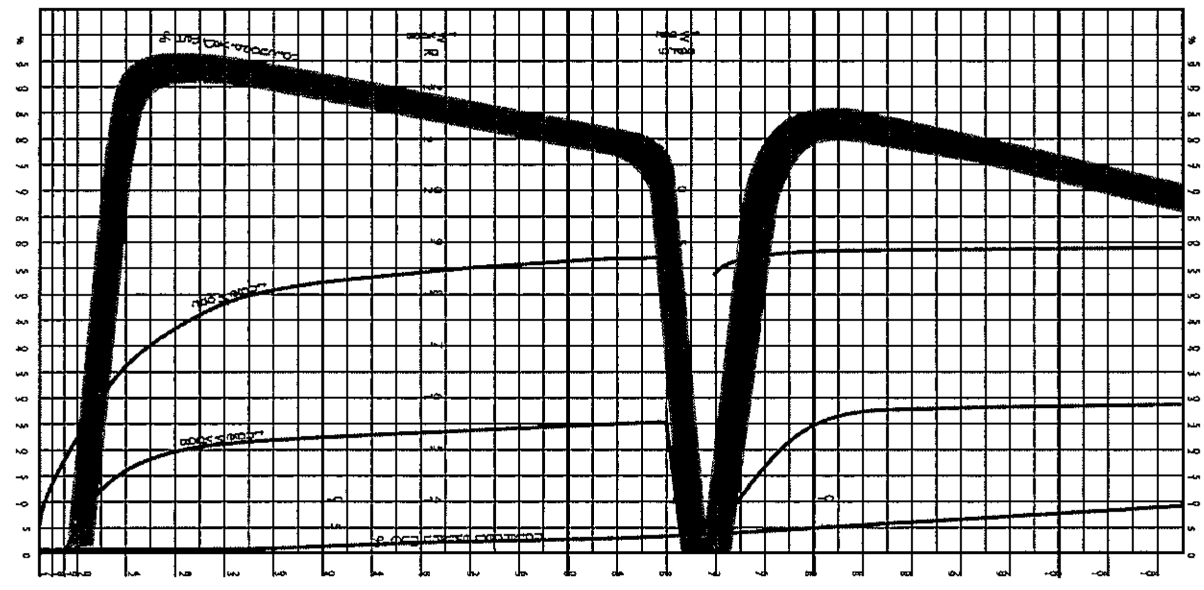
Hy-Line Variety Brown Production Graph for Intensive Systems



At this point an economic decision must be made by the producer; fifty percent production is near the "break-even" point for egg producers (e.g., feed cost = market price of eggs). When the flock reaches 50 percent production, producers commonly decide to molt the flock in order to achieve a higher level of egg production. As a rule of thumb, it takes approximately 10 weeks from the beginning of a molting program to be back at 50 percent production following the molt. Post-molt egg production will increase such that peak egg production reaches about 80 percent. (see the following W-36 Hen-Day Performance Graph for Molted Flocks). Peak production following a molt is short-lived and the flock generally returns to illustrated 60 percent production by 100 to 110 weeks of age. As previously stated, once flock egg production falls below an economical rate of production and an acceptable egg quality, an economic decision is made whether replace the flock and send the hens to a spent-hen processing facility. Because of welfare concerns, producers adjust their flocks' feeding and lighting programs to induce molting. Induced molting improves rate of lay, shell quality, and albumen height. Egg size remains essentially unaffected and continues to increase after egg production resumes.

Hy-Line LAYERS

W-36 Hen-Day Performance Graph
Molted Flocks



The majority of hens are between 100 and 130 weeks of age when they reach the end of their egg production cycle. The time span between 100 and 130 weeks of age can be accounted for by management decisions. Thus hens may be molted a second time and then sent to a spent hen facility (120 to 130 weeks of age) or sent directly to a spent hen facility following the first molt (100 to 110 weeks of age). After the flock vacates the layer house, the house is stripped of all organic matter and sanitized before another flock enters the house.

Non-Cage Systems

Floor Management

When pullets are placed into a new housing system, the manager should ensure that the feed and water systems in the growing and laying facilities are compatible. A change in watering device type, (for instance from a bell shaped device to a nipple or cup system) may require special attention. Also check the lighting program and light intensity and synchronize light times with the growing house. The birds will need lighting of at least 20 lux (2 foot candles). It is important not to have shadows in the laying house, as dark areas outside the nest will encourage floor eggs. Allow pullets access to the nests during the day when they arrive. In floor operations with partial floor covering with slats usually in the area of the nests, place the pullets on the slats as they are being moved to the building. Following placing new pullets in the laying house, walk through the pullets several times daily, particularly in the morning, and ensure the new pullets are finding feed and water.

Nest training is very important in non-cage systems. Training the pullets to use the nest will require frequent walks through the birds in the mornings for the first month after the birds are placed in the laying house. Use of an electric fence is helpful in training the birds not to lay eggs in corners or near the walls. Place the fence wire 5 cm (2 inches) away from the wall of the house and about 10 cm (4 inches) above the floor. It is common practice to lift the nest box curtain (curtain covers over the nest openings) as the birds train to the nests. This will help prevent smothering.

If nests near the walls are being used more heavily than nests towards the center of the house, use false walls of 1 m (3 feet) wide coming out and down from the nest down about every 12 m (39 feet) along the line of nest boxes. The litter area in layer houses should not be more than 60 cm (24 inches) below the slat area (the area with the nests similar to the arrangement in broiler breeder houses). Position lights so they do not cause shadows on the litter below the slat area. Ensure that the litter area has the highest light intensity with a lower light intensity at the front of the nest boxes. An all slat floor house provides an excellent environment; however, birds housed in this type of housing should also be grown on an all slat or wire floor.
Source Hy-Line floor management guide

Some European systems have an additional protected floor area available for the hens. A "winter garden" is a porch-like area adjacent to floor housing in which the hens have optional access through pop-holes (small doors for chickens). This area allows the hens to be under cover, but have increased exposure to open air and limited sunlight exposure.

Range Systems

Portions of this section from http://www.kerrcenter.com/publications/2002_proceedings/sustainable_poultry.pdf

Egg producer utilizing range systems; keep their birds outside (as the season and daylight hours permit), utilizing a movable or stationary house for shelter and keeping the birds on fresh-growing palatable vegetation. This system is labeled by some as 'free-range".

Terms have been coined to describe subset of "free-range' systems such as "day-range" and "net-range". Net refers to the electrified netting to fence a predator-resistant area around a portable chicken house. "Day-range" is indicating that the chickens are into fenced area during the day. The chickens are locked in the house at night. Predators are especially threats during hours of darkness and housing the chickens at night offers more protection. The terms "free-range" and "day-range" are commonly used interchangeably.

"Pastured poultry" is another term in popular usage and associated with use of broiler meat bird production methods outlined by Joel Salatin in his book "Pastured Poultry Profits ". Floorless pens of 10 X 12 X 2 foot high are moved (once or twice daily) around a green pasture. These pens are also commonly referred to as "chicken mobiles". These broilers have access to fresh air, grass and insects but are also protected from predators. Many producers have modified the pen size and configuration to better suit their own needs, but the basic method involved in raising "pastured poultry" remains and has carryover into laying hen nomenclature.

In most of North America, there are only "seasons" when nutritional feedstuffs may be scavenged by the chicken. In the winter months when the ground is covered with snow, and succulent or palatable forage is not available for the hens.

Hens utilizing well managed pasture or outdoor foraging systems can be expected to produce eggs with a yolk color darker than that produced by hens in conventional cage systems (Van Den Brand et al 2004). Free range eggs have been found to be higher in α-tocopherol (Vitamin E) and/or α-linoleic acid (omega-3 FA).

Although all housing systems require vigilance, special attention should be paid in outdoor systems relative to potential microbiological contamination of the egg by fecal microorganisms and potential chemical - environmental contaminants that might be consumed by hens and deposited in eggs. Worn down and destroyed vegetation can result if close management and attention to timing and number of hens allowed access to a particular range area and the rate of forage regrowth. Repeated use of the same area can lead to a buildup of parasites.

Cage Systems

There are 2 basic types of cage housing systems for layers. These are the conventional cage system and the enriched, or colony cage, system.

Conventional –Wire roll-out cages

- *Single bird cages:* One bird per cage.
- *Double deck cages:* Upper deck is offset to allow droppings to fall from both tiers of cages.
- *Triple deck cages:* Upper two decks are partially staggered or not staggered. Tilted boards below the top tiers of cages prevent droppings from falling on the tiers of caged birds below.
- *Four or five or more deck cages:* Four, five or even more decks of cages are used.
- *Flat deck cages (wall-to-wall cages):* All cages are on one deck and connected to each other without walkways. A motorized, overhead catwalk moves back and forth for servicing birds. This system is not in common use today.

Advantages and Disadvantages of Laying Cages

Advantages -

- Hens are easier to manage (no birds underfoot).
- Floor eggs are eliminated.
- Eggs are cleaner.
- Less feed is usually required per dozen eggs.
- High density, distributes hens more evenly
- Broody hens are eliminated.
- More hens are housed per floor area.
- Internal parasites are diminished.
- Mortality is lower.
- Labor requirements are lower.

which may decrease aggression.

Disadvantages-

- Damp manure requires frequent removal.
- Flies are usually more of a nuisance.
- Initial investment per hen is greater (50% to 100% higher).
- Interior egg qualities deteriorate quicker (more blood spots).
- Egg shells receive cage marks.
- Hens usually produce fewer eggs.
- Hens tend to have fragile bones.
- Some bird strains not adapted to cages.

Enriched Cage Systems

These systems are modified cage systems with these added components:

Perches
Curtained nest pad area
Scratch panels
Dust bathing area

These systems do limit wing flapping and flight.

Enriched vs. Conventional Cage System

- Comparison of costs from farms with both cage systems is indicating a 15 to 17 % higher cost per dozen eggs produced in enriched cage systems.
- May need for auxiliary heating of the laying facility since there are fewer hens in each house as a source of body heat especially in cold climates.

Floor Requirements for Caged Layers

Much controversy arises on cage floor space requirements. This is because various factors come into consideration, such as cage size, feeder space, colony size, chicken strain, housing type, number of cage decks, lighting programs, etc. Research indicates that available feeder space per bird is a "better criterion" for cage density than is available floor space per bird.

Transferring Pullets to Laying Cages

Pullets normally are transferred to laying facilities at 18 weeks of age, but bird weight plays a major role in scheduling the move. First egg production is initiated between 19 and 20 weeks of age. Growing facilities may have inadequate space to allow birds to remain longer than 18 weeks, or the laying house may not be available until the pullets are older.

Water Consumption by Layers

Beginning at 20 weeks, daily water consumption ranges from 2.5 to 5.5 gallons per 100 hens, depending on environmental temperature and housing method. Caged layers drink more water than do floor hens. As egg production increases, water consumption increases. Water consumption is highest in mid-afternoon.

Water restriction reduces moisture content of droppings, but water should not be restricted prior to peak egg production or during hot weather. Water restriction is not practical in cup or nipple systems because of leakage problems.

One cup or one nipple shared between two cages of hens is adequate, except when several hens are housed in one cage. A trough waterer across the front of a cage is more than adequate to meet the needs of caged hens. Troughs for continuous running water have a 3-inch slope per 100 linear feet.

FEEDING LAYING HENS

Egg Production Rate and Feed Intake

For best performance laying hens need to be fed carefully and kept in a house at 21-28°C. This means that hen houses are designed to keep as near as possible to this temperature year round. The hens are checked regularly to monitor their health and medicines may be administered as needed. Tinted egg strains usually require less feed (105g feed/hen/day) than brown egg strains (120g feed/hen/day). A common feed blend for laying hens based on a mixture of 67% corn, 22% soybean meal, 8% limestone and 3% other ingredients.

The quality of feed provided to hens may be varied for the level of production. Hens can need more nutrients just before and during their peak production than at other times. This is called phase feeding. It can be economical to adjust rations for such high demand periods.

An egg contains between 65 and 100 kilocalories of energy, depending on its size. Because the energy efficiency during digestion and metabolism is approximately 70%, each average size egg will require about 121 kilocalories of dietary energy.

-Rule of Thumb. If egg size is constant; each 10% change in hen-day egg production will alter the feed requirement by 4%.

Egg Size Management

Egg size, to a large extent, is genetically determined, but it can be managed within certain limits to meet specific market needs for different egg sizes. Particular attention is given to:

Body weight at maturity -The larger the pullet's body weight at first egg, the larger the eggs will be throughout the laying period. Thus, delaying light stimulation will increase egg size, and vice versa

Rate of maturity - In general, the earlier the age at which a flock begins egg production, the smaller the egg size, and vice versa.

Nutrition - Egg size is influenced by intake of protein, methionine, dietary energy, linoleic acid, and possibly isoleucine and threonine. An increase in one or more of those nutrients above recommendations will enhance early egg size, assuming other nutrient levels remain constant. Because a large egg contains more calories of energy than does a small egg, the dietary energy required to produce large eggs is greater.

-Rule of Thumb: A hen needs 1.2% more feed as egg size increases one ounce per dozen eggs or 2.4 grams per egg.

Layers are generally reared on full feed *(ad libitum)* as it is assumed that layers, unlike birds raised specifically for meat, regulate their feed intake. The feed is offered to birds via a chain or auger system. The chain system transports feed into the metal feeder at precise times during the day. In general, 2 inches of feeder space is allotted per pullet and 2.5 inches or more for each adult laying hen (Animal Care Series, California Poultry Workshop, 1998).

Young replacement pullets are fed a high protein diet (20 percent) during the first few weeks of life. This level continuously decreases until it reaches approximately 12 to 15 percent protein during egg production. During the laying phase, lysine, methionine, calcium, and phosphorus are precisely monitored to support maximum egg production.

Most laying hen rations are of the all-mash type. They are made of sorghum grains, corn, cottonseed meal or soybean oil meal depending upon the part of the country in which the ration is produced and which ingredient is most available. The feed is carefully balanced so that the hen gets just the right amounts of protein, fat, carbohydrates, vitamins and minerals. An additive is not approved for use in poultry feed unless adequate research has been undertaken to determine its pharmacological properties and possible toxicity and to discover any potentially harmful effects on animals. Hormones are not fed to poultry in the United States.

How much a hen eats depends upon the hen's size, the rate of egg production, temperature in the laying house and the energy level of the feed. In general, about 4 pounds of feed are required to produce a dozen eggs. A Leghorn chicken eats about 1/4 pound of feed per day. Brown-egg layers are slightly larger and require more feed.

Egg quality is affected by the type feed. Shell strength, for example, is determined by the presence and amounts of vitamin D, calcium and other minerals in the feed. Too little vitamin A can result in blood spots. Yolk color is influenced by pigments in the feed. Maximum egg size requires an adequate amount of protein and essential fatty acids.

Effect of Bird Weight on Feed Consumption

Caged layers are heavier than hens raised in floor houses. The larger the hen, the more feed required for body maintenance. The net result is increased feed consumption during egg production. Brown egg layers are also heavier than the white leghorn which lays white shelled eggs.

-Rule of Thumb: For each 0.1 pound (45.4 grams) increase in body weight, a laying hen requires 1.3% more feed

Protein Requirements for Egg Production

Protein requirements of laying birds are closely associated with egg production rates. The amount of protein in an egg layer ration is lower than the 20% required for early pullet growth. The essential portion of protein is actually the amino acids, which are part of the protein.
In general, 15.5% of the pullet's diet is protein; but when egg production reaches its peak, the requirement is at least 17.5%. Near the end of the production cycle, protein needs may drop to 14%.

Calcium, Phosphorus, and Sodium Requirements for Layers

The calcium requirement for laying hens is over 4 gram per day with amounts increasing as the hens proceed through the laying cycle. Available phosphorus requirements actually decrease through the laying cycle. Calcium levels in laying diets are high enough that these diets are not appropriate for younger birds.

Feed Wastage

Feed "beaked out" of a cage feeder is complete waste. As bird density per cage increases, feed wastage increases. In addition, the deeper the feed level of the trough, the more the feed wastage. Beak trimming has been shown to reduce feed wastage. Beak trimmed birds have less feed wastage than non-trimmed hens in most management systems.

PRODUCTION INDICES

Hen-day egg production=

$$\frac{\text{Number of eggs produced today}}{\text{Number of live hens}} \times 100 = \text{\% hen-day egg production for today}$$

$$\frac{\text{Number of eggs produced during period}}{\text{Number of hen days in the period}} \times 100 = \text{\% hen-day egg production for the period}$$

Hen-housed egg production =

$$\frac{\text{Number of eggs produced today}}{\text{Number of hens housed}} \times 100 = \text{\% hen-housed egg production for today}$$

$$\frac{\text{Average daily number of eggs produced}}{\text{Number of hens housed}} \times 100 = \text{average \% hen-housed egg production}$$

LIGHTING - BASIC RULES FOR LIGHTING PROGRAMS

Guidelines for growing period

Start pullets with 20 to 22 hours of continuous and bright (20 to 30 lux, 2 to 3 foot-candles) light during the first week of age. Alternatively, an intermittent lighting program (4 hours of light followed by 2 hours of darkness) can be used during the first week of age. The dark period (or periods) serves as 'resting time' and helps strong chicks to show the weak chicks how to find feed and water.

The light intensity should be 30 lux (3 foot-candles) during the first week of age, after which it can be reduced to 5 to 10 lux (0.5 to 1.0 foot-candles) in cages or to 15 lux (1.5 foot-candles) when grown on the floor. The higher light intensity for floor-grown birds will allow the birds enough light to navigate their environment. In cages, there should be 10 lux (1.0 foot-candles) at the feed through and 5 lux (0.5 foot-candles) inside the cage.

Reduce the day length weekly to reach 9 to 10 hours at 10 weeks of age or, if longer, the day length dictated by greatest natural day length in open or brownout houses. In Hy-Line Brown and W - 98 lines, a constant day length of 9 hours may be used to control excessive body weight after 10 weeks of age.

The light intensity in the growing and lay houses should be similar, because pullets can be stimulated to start egg production by an increase in light intensity even if the day length is unchanged. Therefore, the light intensity in the grow house should be gradually increased in increments of 5 lux (0.5 foot-candles) per week to the intensity used in the lay house, starting 2 to 3 weeks before the pullets are moved.

Guidelines for laying period

Onset of sexual maturity (egg production) generally depends on 4 requirements:

- a minimum chronological age which is genetically determined (17 weeks),
- a minimum body weight
- a nutrient and energy consumption to support production
- a constant or increasing day length of at least 12 hours

Light stimulation should not be provided until flocks reach the optimum body weight. Flocks which are light-stimulated into production at lower body weights will likely produce below normal egg weight and suffer from reduced peak production and post-peak dips in production.
Timing of light stimulation can be used as a tool to help attain desired egg size. In general, earlier light stimulation will result in a few more eggs per hen, but at a tradeoff for slightly reduced egg weight. Later light stimulation will result in a few less total eggs, but a slightly larger egg weight earlier in production. In this way, lighting programs can be customized to best meet the egg size demand of a particular market.

The initial light increase should be no less than 1 hour (especially in open or brown-out houses). Increase the day length by 15 to 30 minutes per week or once every 2 weeks until 16 hours of light is reached. Preferably, the period of increasing day length stimulation should last until peak production (i.e., until about 30 weeks of age). The light intensity at housing should be 15 to 30 lux (1.5 to 3.0 foot-candles) in light-controlled houses and 30 to 40 lux (3 to 4 foot-candles) in open-sided houses.

Two Rules of Lighting

- *Never increase light duration during the growing phase.*
  During the first week of brooding, provide 20 to 22 hours of light daily at 3 fc (30lux) intensity. For the next week, reduce light duration to 20 hours daily and lower intensity to 1/2 fc (5lux). During the following weeks and up to 7 to 9 weeks, gradually reduce light duration until reaching 8 to 9 hours of daily lighting.
- *Never decrease light duration or light intensity during the laying phase.*
  Provide light stimulation only when pullet weight reaches 2.8 pounds. Increase light intensity from 1 to 3 fc (from 10 to 30 lux) in the laying house.

Lighting Terminology

- Candela - A candela is the unit of luminous intensity of a light source in a specified direction. As distance from the light source is doubled, luminous intensity is reduced by one-fourth.
- Lumen - A lumen is the amount of light emitted by a light source. A lumen is the rate at which light falls on a square foot area surface which is equally distant one foot from a source whose intensity is one candela.
- Watt -A watt is the amount of electric energy consumed (or the amount of light emitted by a light source). One watt equals 12.56 lumens.
- Foot-candle (fc) -A foot-candle is a United States measure of illumination (amount of light reaching a subject). One fc equals one lumen per square foot. One fc equals 10.76lux.
- Lux –A lux is an international measure of illumination. One lux equals one lumen per square meter. One lux equals 0.0929 fc.
- Available lumens-About 30% of the light from poultry house lighting is absorbed by the walls, ceiling, equipment, etc. In fact, only 49% of the rated lumens of the lighting system are available to the chickens in the house. [For example, if one 60-watt incandescent bulb produces 753.6lumens (60 watts X 12.56 lumens/watt), only 369.3 lumens (753.6 lumens X 49%) are actually available to the chickens.]

Artificial Lighting Sources

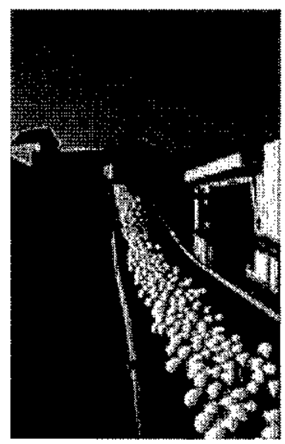
- Incandescent bulbs
  Most economical, but shorter bulb life (750 to 1,000 hours) and lower light efficiency, flat or saucer type reflectors increase light intensity at bird level by 50%. Dusty bulbs emit one-third less light than do clean bulbs. Incandescent bulbs are being phased out and will become unavailable.
- Fluorescent tubes
  More efficient than incandescent bulbs, provides more light relative to operating costs. Although higher priced, fluorescent tubes last longer.
- Compact Fluorescent Lamps (CFL)
  These lamps are modified fluorescent tubes spun into a compact arrangement. These lamps may fit the standard light sockets and may replace the incandescent bulbs. These fluorescent lamps currently contain mercury and disposal of spent bulbs may need special

consideration. Some lighting systems experience flickering with these lamps and care should be taken in selecting matching lamps and lighting system such as dimmers etc.

- Light Emitting Diodes (LEDs)
  The newest offerings for poultry house lighting are the agricultural LEDs which are very efficient and are declining in price and increasing in features and functionality. LEDs are very specific and narrow in wavelength of light emitted.
- Mercury vapor and metal halide lighting
  Classified as high intensity discharge (IDD) lighting mercury vapor lighting is almost as efficient as incandescent bulbs, but cannot be used in a low ceiling house. Requires several minutes to warm up, but has long life (24,000 hours).

EGG COLLECTION, GRADING, PROCESSING AND HANDLING

In laying operations, most of the eggs are laid within five hours of the first light in the morning. Collection should be more frequent in very hot or cold weather. Eggs should be held at 60 degrees Fahrenheit and 70 percent relative humidity before cleaning. Eggs stored at room temperature, about 75 degrees, can drop as much as one grade per day. Embryos can start to develop in fertile eggs held at a temperature above 85 degrees for more than a few hours. Keep egg temperature relatively constant until the eggs are washed to avoid sweating. Sweating occurs when eggs are moved from cold storage to a warm environment. Condensation on the surface of the egg facilitates the movement of microbes inside the shell due to moisture. In the past, eggs were held in plastic-coated wire baskets so that the air could circulate freely among the eggs and cool them. Now, eggs are also held in fiberboard flats that hold 30 eggs per flat. Misshapen, cracked, broken or extremely dirty eggs should be separated from clean eggs.



Egg collection is either a manual or a semi-automatic process. During daily hand gathering, an efficient worker riding a motorized cart can collect all the eggs from 30,000 caged layers. Automated egg gathering devices installed in cage operations allow eggs to roll from the cage's sloping floor onto a movable belt, which carries the eggs to the service room. Uncollectable eggs are those broken prior to gathering and which pass through the floor of the cages. Many are soft-shelled, body checks, and misshapen eggs. On the average, one-half of the uncollectable eggs are shell-less. Up to 7% of all eggs laid are uncollectable, and the hen's egg production is not credited.

Egg collection

In layer facilities, there are two primary methods of egg collection, a) in-line facilities, and b) off-line facilities. In either case, hens lay eggs onto an angled wire floor which rolls the egg toward the front of the cage (floor angle is generally eight to ten degrees) onto a nylon belt. The belt transports eggs out of the house either to the egg processing facility or a storage cooler. Since the processing facility and cooler remove eggs from the house, based on hourly demand, eggs may reside on the belt for as long as 12 to 14 hours, but most are collected within a few hours post-lay.

The first type of egg processing is the in-line facility. In this facility, eggs move directly from the layer house to the egg processing facility. Once the eggs enter the egg processing center, they are washed, visual inspected, and then graded for packaging. Following packaging, eggs are moved to a cooler room (40-45° F), where they await shipment to retail outlets. Egg producers commonly deliver eggs to retail outlets within one week of lay.

The second type egg processing is the off-line facility. This facility functions nearly identical to the in-line facility except that the eggs are transported out of the house directly to an egg cooling room. In this method, the eggs remain in the cool room for approximately two to three days, and then they are transported to an egg processing facility via a refrigerated truck. These eggs are treated identically as those from the in-line operations.

Manual egg gathering is labor intensive. Eggs will be needed to be collected often, twice in the morning and once in the afternoon to decrease the number of dirty and broken eggs and to start cooling eggs as soon as practical. An egg cart, filler flats and a nearby storage site will help reduce labor. In floor operations, roll-away nests simplify egg collection because the eggs can roll from the sloped floor of the nest to a collection area or belt. Ideally, eggs are packed within 24 hours after they are laid. U.S. Department of Agriculture (USDA) rules require that eggs be packed within 30 days of lay. In programs that assure high quality, eggs are usually packed within 3 to 7 days of lay. Egg storage in coolers with items that give off odors, such as onions and citrus, may cause the eggs can pick up the odor through the shell's pores.

Dust, mud, feces, feathers and contents from broken eggs may soil as many as 30 percent of eggs in free-range systems (Parkhurst and Mountney, 1988). Free-range systems should minimize mud on pastures and make provisions such as pallets, straw or gravel at the entrance of the bird doorways to clean the feet of hens entering the poultry house. It is also important to maintain clean nesting material. If eggs are broken in the nest the other eggs will get dirty. Methods to prevent broken eggs include collecting eggs often, using a nest with a sloping floor (roll away nest) so that eggs roll to a separate collection area and allowing access to the nests only during the morning when most birds lay.

Hens should not sleep in nest boxes because the hens will defecate and dirty the eggs and block the eggs from rolling out of the roll-out nests. Provide a sufficient nest area to prevent hens from laying eggs on the floor where the eggs are easily soiled. If individual nest boxes are used, allow no more than 5 hens per nest box. If communal nest boxes are used, follow the manufacturer's recommendations. Nests should be designed or oriented to allow birds to avoid brightly lit areas during lay; some nests use curtains for darkening. In alternative production systems, egg washing is an important issue because eggs often become dirtier in free-range systems than in cages.

Government Regulations and Grading

United States Department of Agriculture

In December, 1970, the Egg Products Inspection Law was enacted. It requires that plants processing eggs for interstate, intrastate, and foreign commerce operate under mandatory, continuous inspection of the United States Department of Agriculture.

In 1972, quarterly on-site inspections of all shell egg processors became required. A producer with a flock of fewer than 3,000 hens is exempt from complying with the Egg Products Inspection Act. The Shell Egg Surveillance program ensures that shell eggs are as good as or better than grade B. The USDA AMS has a voluntary egg grading service for shell eggs that is paid for by plants. Under the grading service, USDA graders continuously monitor the grading and packing of eggs to ensure that the eggs meet quality and size standards. In addition, plant processing equipment, facilities, sanitation and operating procedures are verified according to regulation requirements. By meeting these requirements, eggs packed at official plants are eligible to carry the USDA grade shield. The Egg Grading Manual is an excellent resource and is available online at the USDA, AMS web site.

With more emphasis on Hazard Analysis and Critical Control Points (HACCP) and high quality, the Plant Sanitation and Good Manufacturing Practices Program (PSGMP) designation is also available under voluntary grading. Although small-scale egg producers do not have to comply with federal programs, they need to follow state egg laws. Although states have exemptions for small producers, some states are quite rigorous in terms of washing, candling and temperature requirements during storage and sale. Many eggs are sold ungraded at farmers' markets.

Environmental Protections Agency

Poultry litter and the associated disposal is also regulated by the Environmental Protection Agency as is the waste stream from egg processing operations. Groundwater protection issues are important considerations, as are odor and nuisance of poultry production facilities. State and local agencies are also involved with the enforcement of these regulations.

U.S. Food and Drug Administration

The Egg Safety Rule went into effect July 9, 2010 for egg producers with 50,000 or more laying hens. Under the requirements of this rule, egg producers are required to implement safety standards to control risks associated with pests, rodents, and other hazards; to purchase chicks and hens from suppliers who control for *Salmonella* in their flocks; and to satisfy testing, cleaning, and refrigeration provisions to prevent SE. These facilities must register with FDA and are required to maintain written plans summarizing their safety practices. Under this new rule, FDA was to inspect more than 600 farms over a period of14 months (through 2011) to ensure that producers are complying with the new provisions of the Egg Safety Rule.

EGG GRADING AND LABELING REQUIREMENTS

The requirements for selling eggs can vary depending on the point of sale. Eggs sold from a person's farm and directly to the ultimate consumer have very few regulatory requirements. Nevertheless, it is always good to follow food safety guidelines such as only selling clean eggs and to refrigerate eggs at 45°F or less. Once eggs are sold off of the farm to a grocery store, restaurant or at a farmer's market, the producer must meet all of the egg grading and labeling requirements. These include:

1) All eggs must be clean.
2) All eggs must be candled and meet State egg grading standards.

3) Cartons or boxes of eggs must be labeled with the grade and size of the eggs, the name address and zip code of the packer a pack date following the Julian calendar (day of the year) and a freshness date not to exceed 30 days from the date of packing
4) A safe Handling statement that says "Safe Handling Instructions. To prevent illness from bacteria, keep eggs refrigerated, cook eggs until yolks are firm, and cook foods containing eggs thoroughly." In addition, the statement "Perishable, keep Refrigerated" must be on all cartons. In addition to the required labeling, other claims can be used on the cartons.

Claims made on labels are expected to be substantiated. For example, if you state on the label that your eggs are from cage free chickens, they must be cage free at all times. There is no requirement for what size the area must be and cage free does not mean they have access to the outdoors. Some of the claims that are more difficult to verify are terms like "Natural." The term natural is one that is used as a claim but has little definition to it. What is a natural egg? The United States Department of Agriculture (USDA) currently defines the term natural as "minimally processed" which means that no additives have been used with the products, but has nothing to do with production practice.

EGG CLEANING

General Rules for Washing Eggs

Eggs should be washed in water that is at least 20 degrees warmer than the warmest eggs, and the water should be at least 90 degrees. This is to prevent water that is cooler than the egg from forcing the egg contents to contract and pull water and microbes through the shell into the egg and cause contamination. Also, the wash water should not be more than 40 degrees above the temperature of the eggs or the eggs may experience thermal cracking. Cleaners can be helpful in the washing process. According to the Food and Drug Administration (FDA) the ingredients in the material used to clean eggs must be Generally Recognized as Safe (GRAS).

The ingredients must also be a substance that is regulated as a food additive (USDA FSIS, 2008). Ingredients in compliance with FDA guidelines can be found in the Code of Federal Regulations. Detergents help remove dirt and kill microbes during wet cleaning. Methods that use spraying, pouring or dipping reduce the time of contact between water and egg. Soaking eggs is generally not appropriate. Eggs are cleaned to remove debris and stains and reduce the microbial load. Excessively dirty eggs should not be cleaned, but rather discarded. Reasonably clean eggs requiring only slight cleaning for home use might be dry cleaned with an egg brush or rubbed with a sanding sponge and sandpaper to remove slight stains.

To best understand egg washing, consider that the unwashed shell is covered by a waxy layer (the cuticle) that helps prevent microbes from entering the pores that allow the passage of gases. The cuticle is not impenetrable and water on the surface of the egg shell can undermine these defenses because water helps bacteria pass through the shell pores into the egg. If the period of contact between egg and water is short, there will be little microbial penetration into the egg. Therefore it is important to limit the amount of time that the shell is wet. Soaking eggs in water for as little as 1 to 3 minutes can allow microbes to penetrate the shell. Although the USDA does not allow immersion washing (allowing eggs to stand or soak in water), most small producers are not operating under USDA requirements. Most operate under exemptions to state egg laws and washing methods are usually not specified. Small-scale egg washing should take place with a continuous flow of water, such as dipping, spraying or pouring, that allows the water to drain away from the eggs. Only potable water should be used for cleaning.

In some states, small-scale producers may be required to candle eggs to ensure interior quality of the eggs in terms of blood spots, cracks and more. Even if an egg producer is exempt, candling is still important to ensure their customers do not receive fertile eggs with developing embryos, eggs with blood spots or cracked eggs. If you gather frequently and use cold storage, embryos will not have the chance to develop in fertile eggs. Brown eggs are more difficult to candle than white eggs due to the darker shell which can generally lead to a higher percentage of blood and meat spots. Eggs should be refrigerated. If eggs are stored in a standard refrigerator, where the humidity is lower, washed eggs only keep for five weeks.

Manual washing small quantizes of eggs:

If cleaning just a few eggs, use a brush and wash them in a sink with hot running water and then dip them in a sanitizer. The water should be warmer than the egg. Pre-wetting and using a detergent will help. Brushes that can be sanitized are helpful. The sanitizer may be obtained by using tablespoon of household chlorine bleach, usually 5.25 percent sodium hypochlorite, per gallon of water will result in a solution of 200 ppm chlorine.

Manual washing larger quantizes of eggs:

To wash several dozen eggs, make up three separate basins, one for washing containing a detergent, on basin with rinse water and one basin containing a sanitizer solution. Wash each egg separately and do not soak. Dip the egg in rinse water, and then dip it in sanitizer. Using an egg basket or colander to rinse and sanitize many eggs at once will save time. Then, set eggs aside to dry. To keep the wash water clean, change the detergent and rinse water after every 3 to 4 dozen eggs. Use gloves to protect hands from hot water, detergent and sanitizer.

Some small producers may use a solution of distilled white vinegar diluted in half with water to wipe their eggs. Vinegar can aid in removing stains from the shell and is known to have antibacterial properties due to its acidity. Continuous or excessive use of detergent could be harmful to septic system and a gentler soap or other material should be used.

Organic Operations

In certified organic processing under the National Organic Program, §205.605 of the National List lists nonagricultural (nonorganic) substances that may be used in processed products labeled as organic or made with organic ingredients. Check before selecting detergents, sanitizers or other cleaners.

Commercial Operations

Washing: The USDA requires that wash water be changed every four hours in commercial production. Replacement water is added continuously. Defoamers are used with egg-washing machines to help reduce foaming. Excessive foaming causes water to spill over the sides of the tank and this affects water temperature and pH.
Rinsing: Eggs are rinsed to remove adhering dirt, detergents, and foam (Zeidler, 2002). Rinse water should be a few degrees higher than the wash water to prevent drawing water into the egg.
Sanitizing: After washing, eggs are sanitized to reduce microbial load. Chlorine-based sanitizers should be from 50 to 200 ppm. However, using less than 100 ppm chlorine may help protect the cuticle. Free chlorine level must be frequently checked because chlorine is inactivated by organic material such as dirt. Chlorine test strips are available in restaurant supply stores.
Drying: Eggs should be dried after washing and before packing and storing to prevent fungal and microbial growth. Eggs can be dried by evaporation, with fan assistance.
Storage and distribution: After processing, grading and packing, eggs should be stored at 45 degrees to prevent microbial growth. Humidity should be kept at 70 to 85 percent. Clean eggs stored at these conditions will keep for three months. In large-scale commercial production; eggs usually reach the packing plant only a few days after hens lay them. Eggs packed under federal regulations require the pack date to be displayed on the carton. It is a three-digit Julian date that represents the consecutive day of the year. The carton is also dated with the sell-by or expiration date (Exp.), depending on the state. Eggs with a federal grade must be sold within 30 days from day of pack (USDAD FSIS, 2007a). The USDA recommends that consumers buy eggs before the expiration date and use them within 3 to 5 weeks.

DISEASE CONTROL

Cleanness, sanitation, and strict traffic control are the most effective and least expensive tools in a disease prevention program. The following management principles are guidelines for disease control.

- *Cleanness of the Poultry Farm* - Physical removal and disposal of all litter, manure, dust, feathers, and other poultry debris is the first step in an efficient clean-up program.
- *Sanitation of Poultry Houses and Equipment* - This second step includes removing, dismantling, and disinfecting all equipment. Use high pressure sprayers and effective disinfectants to eliminate disease carryover. Maintain continuous rodent and fly control.
- *Traffic Control* - Foot and vehicle traffic is a constant threat to a flock's health because of the potential for introducing harmful pathogens. The policy should be "no visitors" and locked doors. Provide clean and disinfected footwear and outer garments when it is necessary to permit entrance of visitors. Isolate feed and egg trucks as much as possible from the bird area.
- *Portable Equipment Control* - Portable equipment is a necessity but should be confined to as few houses as possible. Clean and disinfect equipment before moving it to a different house.
- *Disease Monitoring* - Maintain mortality records for each flock. If mortality exceeds 0.5% in one month, perform postmortem examinations on mortalities and a sample of live birds to deter- mine if a disease problem exists. Determine if production practices, nutrition, and other factors are causes of mortality.

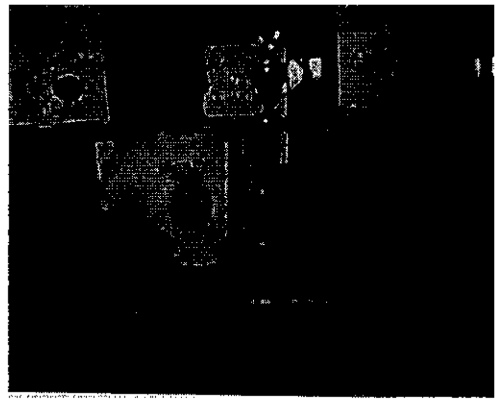
•*Medication; Worming, and Vaccination* - Water-soluble vitamins and electrolytes help relieve the stress of delivery. Floor grown birds should be wormed before and after housing if postmortem examination reveals presence of worms.

Disinfectants Commonly Used in Poultry House Sanitation

Halogen	Iodine	Most effective on clean surfaces
	Chlorine	Can be used as drinking water sanitizer
Quaternary Ammonium Compound	Ammonia	For sanitizing eggs, drinking water, and clean surfaces

ADDITIONAL POULTRY ENTERPRISES AND PRODUCTS *

INTRODUCTION



Not all chickens raised in the United States are White Rock x Cornish Cross broilers or Leghorn laying hens. Long before poultry breeders developed commercial chicken varieties, hundreds of breeds of chickens were raised. Today, many people raise purebred chickens for hobby or exhibition. Pictured here is a successful bantam show exhibitor.

Some breeds have advantages or characteristics that make them attractive to youth for projects. Many FFA and 4-H members have successfully developed markets for purebred birds for meat or eggs. Others have marketed fertile eggs to hatcheries that specialize in purebred chicks (and turkey poults).

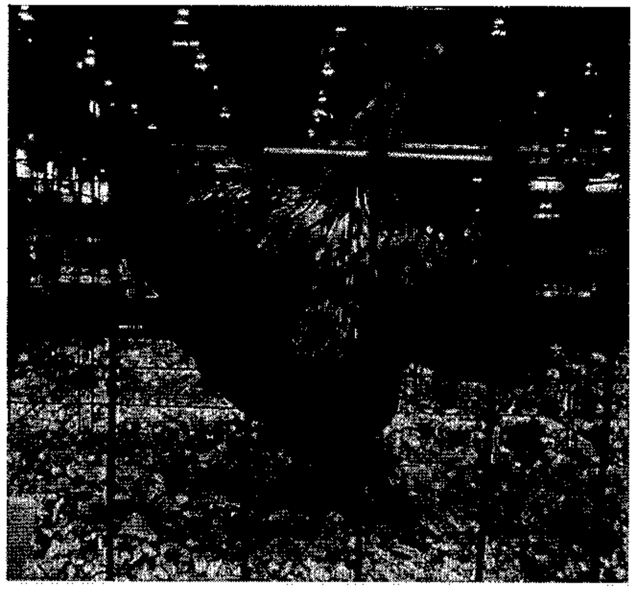
Poultry shows are held in virtually every state. They typically are held in the fall or spring, with fair shows occurring more commonly in late summer. Such shows are a good place to learn about the various breeds and varieties, even if you do not intend to show birds yourself.

STANDARD PUREBRED CHICKENS

Large Fowl and Bantams are the two basic types of purebred chickens. Large Fowl refers to full size chickens. Bantams are purebred miniatures, being about one-fifth the size of Large Fowl. Typically, a Bantam counterpart occurs for each breed of Large Fowl (for example, large Rhode Island Reds and Bantam Rhode Island Reds). However, some Bantam breeds have no Large Fowl counterparts (for example, Japanese Bantams and Sebright Bantams).

Two organizations promote purebred poultry with literature and exhibitions. The oldest is the American Poultry Association (APA), which sponsors shows for purebred chickens, bantams, ducks, turkeys, and geese. The American Bantam Association (ABA) sponsors shows for purebred bantams and bantam ducks only. Both offer junior memberships. Numerous breeds have their own clubs which allow people who are interested in each breed to interact with others sharing that interest.

* *Written, revised and edited by Dr. Lyndon N. Irwin, Emeritus Professor, Missouri State University. Reviewed by Kirk C. Edney, Ph.D., Texas A&M University*



Both the APA and the ABA publish a book, *The Standard of Perfection.* If you plan to raise poultry to show, first look at the Standard. It describes exactly what each breed of bird should look like, down to the individual feather. Poultry judges use the Standard to evaluate and place birds shown at exhibitions. Many schools and public libraries have copies of the Standard. Even an old copy is useful because the descriptions of what the "ideal bird" should look like have not changed significantly over the years. This is a bantam Silver Laced Wyandotte. Three poultry terms are of importance for purebred poultry.

- Breed refers to groups of poultry having the same general shape.
- Variety, a subdivision of a breed, identifies poultry by color or comb type.
- Class refers to groups of breeds having common characteristics.

SELECTED PURBRED CHICKEN CLASSES, CHARACTERISTICS, AND BREEDS

Large Fowl Categories

CLASS	CHARACTERISTICS	BREEDS
American	Yellow skin, red ear lobes, and brown eggs	Rhode Island Red, Plymouth Rock, and New Hampshire
English	White skin (With exceptions), red ear lobes, and brown eggs	Orpington, Sussex, and Cornish
Asiatic	Feathered shanks, red ear lobes, and brown eggs	Brahma, Cochin, and Langshan
Mediterranean	White ear lobes, white eggs, and unfeathered shanks	Leghorn, Minorca, and Ancona
Continental	White ear lobes; from continental Europe	Houdan and Hamburg
All Other Standard Breed	Those that do not fit in the above classes	Sumatra, Aseel, Araucana, Phoenix, and Frizzle

Bantam Categories

CLASS	CHARACTERISTICS	BREEDS
Single comb, clean leg	Single comb and unfeathered shanks	Plymouth Rock. Leghorn, Rhode Island Red, and Japanese
Rose comb, clean leg	Rosen comb and unfeathered shanks	Wyandotte, Sebright, and Belgium D'Anvers
All other combs, clean leg	Any other type of comb and unfeathered shanks	Cornish and Polish
Feather leg	Any kind of comb and feathered shanks	Cochin, Brahma, and Silkies
Old English	All varieties of Old English games. Males must be dubbed	More than 20 color patterns of Old English
Modern Game	All varieties of Modern Game bantams. Males must be dubbed	More than 12 color patterns of Modern Games.

FEEDING PUREBRED CHICKENS

Each breed is fed according to its purpose. When purchasing breeding stock, request the seller to provide you with information on what and how to feed the breed you selected.

Large fowl are fed for maximum growth rate, although feather quality is important if they are to be exhibited. A good quality commercial chicken feed is generally suitable for large fowl.

Bantams are small birds, thus maximum rate of gain is not important. However, feather quality and beauty are important characteristics. Bantams are usually fed a high protein ration that is not too high in calories.

Health of Purebred Poultry

Purebred chickens are susceptible to many of the diseases described elsewhere in this manual. However, you will usually not vaccinate your small flock for many diseases. Before you obtain your birds, request a listing of diseases prevalent in the area to determine if and when you need to vaccinate. The problem often faced is vaccines typically sold in large amounts. Thus, if you want to vaccinate just a few birds, you may have to purchase enough vaccine for 1,000 chicks.

External parasites must be controlled as they are uncomfortable to your birds. At a show, the judge checks birds for lice and mites. If the judge finds them, your bird will probably be. Routinely dust your birds to keep them free of parasites, even if you do not plan to exhibit birds.

Internal parasites may also be a problem. Roundworms and other parasites in the digestive tract can reduce health and vigor of the bird. Therefore, occasionally deworm adult poultry.

If you intend to participate in poultry shows or sell breeding stock, you should participate in the National Poultry Improvement Plan (NPIP). The purpose of the NPIP is to reduce the threat of egg-transmitted diseases. The state veterinarian can help enroll your flock. Most shows require health papers stating that your birds were blood tested for pullorum (a *Salmonella* disease) or, that they came from a pullorum-free flock. Your local veterinarian is usually not able to provide such health papers. More commonly, a state agency in your area does the blood testing. When you purchase breeding stock, it is wise to ask the seller for a pullorum test certificate.

Purchasing Purebred Birds

You have several choices when the time comes to purchase poultry.

- Buying adult birds at a show or from a reputable breeder is a good way to obtain birds of known quality. However, this may be one of the more expensive options.
- Using hatching eggs is another way to get started, and it is a less expensive option. However, you must have a reliable way to incubate eggs. Most hatching eggs are sold with no guarantee.
- Purchasing day-old chicks from a hatchery is an option used for most breeds of large fowl. Day-old chicks can be purchased from distant hatcheries; they can be shipped via courier, nearly always arriving a day or two after shipment. Buy at least 25 chicks so they can keep each other warm during the trip. Purchasing day-old chicks is usually not a good way to obtain the best show quality birds. However, if you want to raise purebred poultry for meat or eggs, then purchasing your chicks from a reputable hatchery is an economical option.
- "Swap meets" are held in many states and are a fun place to see lots of interesting birds. Unfortunately, many birds bought at swap meets are someone's culls. The birds may also have come in contact with disease organisms, so be very cautious with this risky purchase option.

Getting Ready to Show

Preparing to successfully exhibit show birds takes many months of planning. Only fully mature birds should be shown, so your chickens should be at least six months old. It is difficult for judges to evaluate immature birds.

Prior to the show, you will need to send in the entry form with the proper fee. Be sure to identify your entries correctly according to breed, variety, and sex. Most shows also require that each bird have a leg band for identification purposes. Read and follow the show rules.

When you have selected the best birds to show, provide them special care. This may mean placing them in a pen where their feathers will stay clean and where you can give them some extra attention so that they will not be too wild.

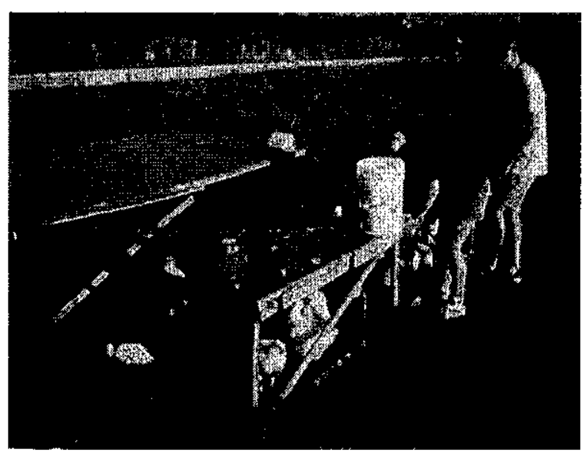
Immediately prior to the show, it may be necessary to wash your bird. However, this recommendation varies with the breed. Some breeds should never be washed. Washing is relatively simple and usually done at least one day before the show. Use a tub of warm water and a gentle shampoo. Do not scrub the bird or in any way damage the feather structure. Then rinse the bird with one or two other tubs of water. If the weather is warm, allow the bird to dry naturally. If the weather is cold, towel dry gently or use a hair dryer.

During the Show

At the show, you may want to place baby oil on the bird's legs and comb to soften and brighten them. Commercial products are also available for that purpose.

Each bird at the show is individually penned in a cage. Typically, the bedding of wood shavings is provided by the show as is the feed and water. The aisle where the judging takes place is usually closed so the judge will not be disturbed. Good luck at the show!

FREE-RANGE OR PASTURE POULTRY PRODUCTION



In some areas of the United States, markets are growing for eggs or meat from birds that have been raised outdoors. You can use your entrepreneurial skills to produce eggs or birds for these niche markets. The terms "Free-Range" and "Pasture" Poultry are sometimes used interchangeably but they are not necessarily the same. Here are two young entrepreneurs checking on their free-range broiler growing unit. Interest in free-range or pasture produced food items is often from those who do not like the confinement methods used to produce most of our commercial eggs and poultry meat. Other consumers simply have the opinion that free-range or pasture eggs and poultry meat taste better or are healthier for them. It makes little difference whether one agrees or disagrees with this because some locations have significant market potential for marketing such specialty products. Furthermore, those who prefer free-range or poultry products are usually willing to pay more for them.

Free-Range production of meat and eggs is just what the name implies – birds being allowed to range freely over an area. They will generally be on a pasture type area but that is not always the case. If the birds do not have access to larger areas, they may consume all of the green forage, leading to bare ground.

Raising poultry as a free-range project will still involve using some form of confinement (good fences at least) to protect the birds from predators (mink, coyotes, foxes, hawks, skunks, raccoons, or more commonly - dogs) and to keep the birds from straying. A well trained guard dog may be helpful in protecting birds from predators – but the dog will have to have extensive training.

Some free-range operations are very similar to pasture operations. By definition, Pasture Poultry production refers to birds that are raised on pastures consisting of various grasses and legumes. The birds will obtain a significant part of their nutritional needs from lush plant material. However, they will need access to regular chicken feeds since they seldom can meet all of their nutrient needs from plants and insects. Most of the more successful pasture poultry operations make use of modular units that are moved easily and are secure enough to prevent predators from going over, under, or through them. Typical units have wheels at the rear so they can be easily moved by one person. Larger units are sometimes constructed on skids for ease of moving.

Advantages of the Movable Pasture Unit

- Birds make use of growing plants (grasses, legumes, and even weeds).
- By moving the unit often, birds do not kill forage.
- Birds meet a part of their nutrient requirements from forage (and from consuming a few insects).
- Birds stay cleaner because they are on fresh forage nearly every day.
- Breast blisters are not an issue because birds are on fresh, soft forage daily.
- Birds have access to fresh air, resulting in fewer respiratory problems.
- Internal and external parasites are not a big problem if the unit is sanitary, birds are parasite-free, and free flying birds are controlled.
- Egg yolk and skin color are more yellow because of the consumption of green pigments.
- Birds scratch (till) the soil and spread their natural fertilizer.
- Construction cost of a free-range unit is lower than the price of a permanent building.

Disadvantages of the Movable Pasture Unit

- Cost of a movable unit may be a significant expense.
- Labor requirements are high, especially for moving the unit daily.
- Cost per pound of bird produced is high. Birds require a longer grow-out.
- Chiggers may leave red marks on the bird's skin.
- Land area needs to be smooth so predators cannot burrow under the unit.
- Land area must be well-drained to keep surface water away from the birds.
- Winterization is a problem if a pasture unit is used for laying hens.
- It is more difficult to use artificial lights and movable electric water heaters.
- Access to fans is more difficult if they are needed on hot, humid days.

Marketing Free-Range Poultry

Unless you are raising birds and eggs for your own use, you should have a marketing plan. The possibility of marketing your product in neighborhood stores sometimes exists. Consider various means of advertising your "niche market" product. Because of the higher cost per unit of production of home-grown poultry, you should charge a higher price for your product.

Some who raise free-range birds also raise them "organically." The term "organic eggs and meat" generally refers to products from birds that have been fed rations without chemical feed additives. Also, no chemicals were applied to the birds or placed in their drinking water. Since 2002, producers meeting USDA standards for organic eggs and meat are permitted to display the USDA-Organic seal on their packaging.

USDA ORGANIC

MYTHS, QUESTIONS, AND CONTROVERSIES ABOUT POULTRY AND EGGS

- *Brown and white shells.* Some consumers have the opinion that brown eggs are more nutritious than white-shelled eggs. Research indicates no difference between brown or white eggs when the chickens that produced them were fed the same feed and kept under the same conditions. The only difference between brown and white eggs is that brown eggs have a thin layer of pigment in the outermost layer of the shell. In fact, the inside of a brown egg shell is white!
- *Green shells.* Araucanas are a South American breed of chickens. They are unique in that they lay eggs with unusual shell colors – usually green or blue. It has been claimed that green or blue shelled eggs are lower in cholesterol. Research has proven that Araucana eggs contain at least as much cholesterol as do chicken eggs of other breeds.

- *Saturated fat content.* Eggs do contain some saturated fat, but not as much as many consumers suppose. The fat deposited in eggs is similar to the fat that the hen consumes. Because a hen's diet is generally based on corn, and corn oil is high in unsaturated fat, then that fat will be deposited in her eggs.
- *Yolk color intensity.* Some consumers prefer eggs with very orange yolks; others prefer a lighter yellow yolk. Yolk color has little to do with the nutritional value of eggs. Yolk color is caused by the presence of the pigment xanthophyll. Xanthophyll is found in bright green and yellow colored plant products. When a bird consumes xanthophyll, it is deposited in the egg yolk and the skin. Thus, the more xanthophyll the bird consumes, the more orange the yolk will be and the brighter yellow the skin and shanks will be. However, when we eat those eggs, we cannot utilize the xanthophyll for vitamins or anything else useful. Therefore, yolk color is not very important. But since consumers have preferences, you can adjust the yolk color by changing the bird's diet.
- *Cloudy whites.* When you break an egg into a skillet, sometimes the white appears to be cloudy. The cloudy color indicates egg freshness. Carbon dioxide is responsible for that cloudiness. The fresher the egg, the more carbon dioxide there is in the white. If the egg white is clear when you break the egg, the egg is not as fresh.
- *Greenish whites.* When an egg is broken into a white bowl, the white sometimes appears to have a greenish tint to it. This is normal and demonstrates presence of the vitamin riboflavin.
- *Green yolks.* Another complaint of consumers is that when they hard boil eggs, an olive green color develops around the surface of the yolk. This means the egg was boiled too long. If you boil an egg just long enough to cause all of its contents to coagulate, the yolk will remain yellow without the green coloration. The green color is not harmful. It is merely a reaction that occurs between sulfur and iron in hot conditions.
- *Fertile versus infertile eggs.* Most retail eggs are produced by hens that have been raised separate from cockerels. Therefore, the eggs are infertile. It is not necessary for a hen to mate in order to lay eggs. Nutritionally, it makes no difference whether an egg is fertile or infertile. No difference exists in their nutritional content.
- *Double-yolked eggs.* A hen may lay an egg with two yolks rather than just one. This usually occurs when she ovulates two yolks at once. Double-yolked eggs are more common in young hens whose hormonal systems are changing. Can a fertile double-yolked egg result in twins (two chicks in one egg)? Fertile embryos sometimes develop for a few days, but the chicks will not develop full term. For that reason, double-yolked eggs are not incubated because it is a waste of incubator space.
- *Difficult peeling.* Sometimes when you hard boil an egg, it is difficult to remove the shell from the white. This means that the egg is very fresh (the carbon dioxide content is high). If you want to have a nicely peeled hard-boiled egg, use an older egg – one week to two weeks of age.

- *Chemicals.* Some consumers fear that eggs contain harmful chemicals and are therefore interested in purchasing organically-produced eggs. The USDA regulates additives that are added to poultry rations. All additives must be thoroughly tested before they can be fed to birds to ensure no harmful residues are in the eggs. However, if consumers in your area prefer to purchase eggs from hens that have not been fed feed additives, you may have a good opportunity to "niche market" such eggs. Organic eggs nearly always sell better than do traditional eggs but they are more expensive to produce.
- *Hormones.* Sometimes consumers claim that commercial eggs and poultry meat are laden with hormones fed to the birds. This is erroneous information. No hormonal implants or feed additives are approved for either laying hens or meat birds in the United States under any circumstances.
- *Cholesterol.* All eggs contain cholesterol. If your physician has recommended that you reduce cholesterol consumption, then you should follow those recommendations. However, for the average person who does not have a problem with cholesterol, research studies have shown that moderate egg consumption does not lead to increased blood cholesterol. It also should be noted that all cholesterol in an egg is in the yolk. Therefore, you can consume all of the egg white that you desire because it contains no cholesterol or fat.
- *Food safety.* Poultry meat and eggs occasionally contain bacteria, such as Salmonella. This has been true as long as domesticated chickens have been around. For this reason, it is important to use proper food handling methods and proper cooking temperatures. Poultry meat should be cooked to an internal temperature of 170°F. Eggs should be cooked to an internal temperature of 160°F or until the yolk and white are firm and not "runny."

WATERFOWL

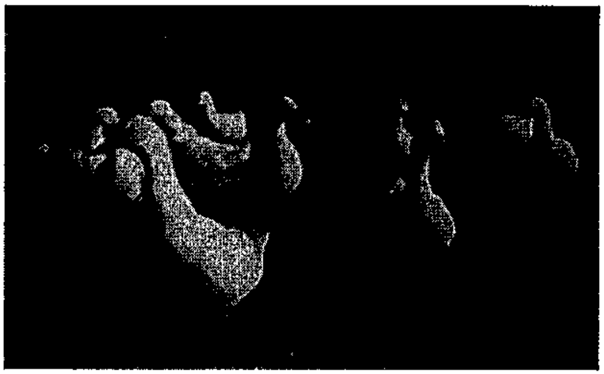
The duck and goose industries are small in comparison to the chicken and turkey industries. A few large commercial duck and goose operations exist in the United States. However, most duck and goose flocks are small enterprises.

Breeds of Ducks

The majority of ducks raised commercially are White Pekins. These ducks are fast growing birds. A White Pekin duck reaches 7 pounds in weight at 7 weeks of age.

The American Poultry Association (APA) categorizes duck breeds into four classes.

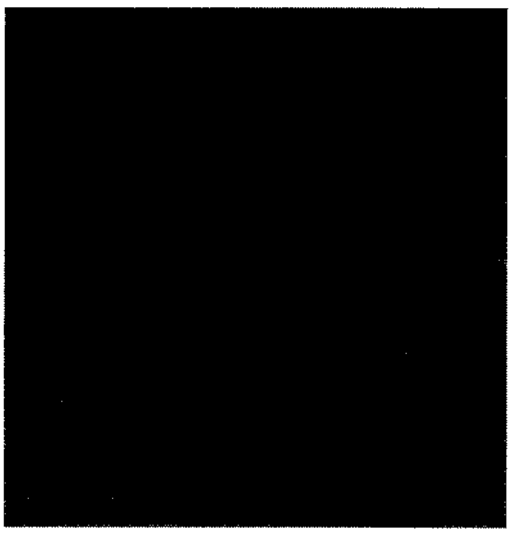
- The heavy-weight and medium-weight ducks are primarily raised for meat.
- The light-weight ducks are better known for their egg producing abilities.
- Bantam ducks are popular but are primarily raised for exhibition purposes.



White Pekin ducks

Fancy Crested Duck

A high demand for duck eggs for human consumption has not developed in the United States.



a Pair of Runner Ducks

CLASSES & BREEDS OF DUCKS

HEAVY-WEIGHT CLASS
Pekin, Aylesbury, Rouen, Muscovy

MEDIUM-WEIGHT CLASS
Cayuga, Crested, Swedish, Buff

LIGHT-WEIGHT CLASS
Runner, Campbell, Magpie

BANTAM DUCK CLASS
Call, East Indies, Mallard

Breeds of Geese

The APA places breeds of geese in three categories. The three heavy breeds – Toulouse, Emden, and African - are the main breeds raised in the United States, with the Emden being most popular. The other breeds are mainly used for hobby and exhibition purposes. It is a challenge to differentiate the sexes in geese because the ganders and females are identically marked and of similar size. It is usually necessary to "vent sex" geese to differentiate the sexes.

CLASSES & BREEDS of GEESE

HEAVY-WEIGHT CLASS	MEDIUM-WEIGHT CLASS	LIGHT-WEIGHT CLASS
Toulouse	Sebastopol	Chinese
Emden	Pilgrim	Tufted
African	Buff	Roman
	Pomeranian	Canada
		Egyptian

Waterfowl Management

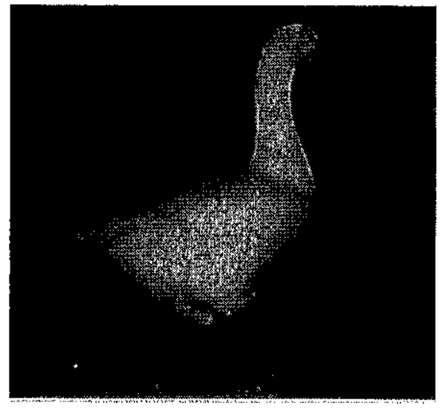
Management of waterfowl presents some interesting challenges in comparison to other poultry. Waterfowl do best in a clean environment, but they do little to keep it that way. Their droppings are very moist, and they tend to spill much of their water. It becomes a constant challenge to maintain dry bedding. This is a picture of African geese.

Although it is obvious that ducks and geese enjoy being around a body of water, it is not necessary to have a pond or stream for them. If given a small pool, waterfowl will pollute it rather quickly. A clean source of drinking water is all that is required.

Most commercial ducks and geese are raised in confinement or, in some cases, semi-confinement. In the past, geese were used as "weeders" because they consumed the weed seedlings that grew in cotton or berry fields without bothering the crop itself. This "weeding" practice is uncommon today.

Waterfowl Incubation

The incubation period for duck eggs is 28 days. An exception is the Muscovy; it has an incubation period of 35 days. Compared to other breeds of ducks, the Muscovy is least related genetically. Goose eggs require 28-30 days to hatch.



You should follow the directions that apply to a particular brand of incubator for setting eggs. However, in general, the incubation temperature is slightly lower and the incubation humidity is higher for waterfowl eggs compared to other poultry eggs. This image depicts a White Emden duck.

For small waterfowl flocks, it is common to allow the female to incubate her own nest of eggs. Another option is to have a broody chicken hen incubate waterfowl eggs. If the latter option is chosen, it is a good idea to sprinkle the eggs with water daily to increase the humidity. When a waterfowl female leaves the nest, she often takes a swim and comes back to the nest with a wet body, thus resulting in increased moisture on the eggs.

Waterfowl Brooding

Ducklings and goslings are brooded similarly to chickens and turkeys. However, the brooder temperature may be about 5 ^{0}F lower. This picture is of a Toulouse goose.

Ducklings are sometimes started on a plastic or vinyl coated wire floor because they tend to spill much of their drinking water. They will play in the water and get into the waterers. If the waterers sit on the litter, it is nearly impossible to keep the litter dry. Wet litter then leads to rapid growth and accumulation of disease organisms.

Waterfowl Nutrition

Nutritional requirements for waterfowl are similar to those for chickens. The starter ration should contain about 22% crude protein (CP); the grower ration should be 15% to 16% CP. Breeder birds require about 15% CP. The starter and grower rations should be pelleted. Young waterfowl will consume more pelleted feed than mash (ground feed).

Geese consume large amounts of high-fiber diets if kept on pasture. They do not digest significant amounts of fiber, but they do utilize the protein, vitamins, minerals, and sugars in plants. Geese also consume large amounts of roughage. However, they are not highly productive on roughages alone.

Processing Waterfowl for Food

Processing waterfowl is similar to chicken and turkey processing. The primary difference is that waterfowl feathers are more difficult to remove. Therefore, hotter water is required for waterfowl processing. Hard scalding occurs at a temperature of 160 ^{0}F to 180 ^{0}F for 30 seconds to one minute. Extremely hot scald water does damage the bird's skin to some extent. Therefore, a lower scald temperature for a longer time may be preferred.

GAME BIRD PRODUCTION

Raising game birds as a poultry enterprise is gaining popularity. You may want to raise game birds for markets (meat, eggs, taxidermy, and live birds for hunting preserves) or simply for exhibition.

Most conservation groups do not recommend raising game birds in captivity for later release. Research has shown that pen raised birds do not survive well in the wild. Therefore, natural propagation methods are preferred if you desire to increase the wild game bird population.

Species of Game Birds

Although a wide variety of game birds exist, four species are most common.

Coturnix (Japanese) Quail are raised for either eggs or meat, but mainly for the quail egg market. Their eggs are often hard boiled and then pickled, thus being featured as hors d'oerves. Coturnix quail grow rapidly, reaching full size at eight weeks of age. They start laying eggs at the amazingly young age of six weeks. They are not among the most attractive quail and do not fly particularly well, so they are seldom used for hunting purposes. Coturnix quail can not survive in the wild, thus a few states require permits to own them. Some zoos and wild animal parks are interested in obtaining Coturnix quail to feed to birds of prey and other animals requiring an animal-based diet. This creates a unique niche market in some areas.

Bobwhite Quail are the most commonly raised game bird in the United States, being native to most states. Bobwhites are raised for meat and hunting; a relatively large demand exists for hunting preserve purposes. Bobwhites for hunting preserves must have nearly perfect feathers and fly well.

Chukar Partridge, a medium-sized game bird, is grown in most states. A few western states have wild populations for hunting. Chukars are commonly raised for hunting preserves. A limited meat market exists for chukars, but that market could be further developed in many areas.

Ring necks Pheasants originated in China but were imported by early American settlers from Europe where royalty raised them for hunting. Pheasants adapt to most northern areas in the United States, particularly the Upper Midwest and Northwest. Pheasants do not do well in southern, humid climates. Good markets exist for meat and hunting preserve pheasants.

Game Bird Permits

Before purchasing game birds, you must determine if a permit is required in your state. Most often, a permit is required if the game bird you plan to raise is one that lives in the wild. Each state has different rules for raising game birds, so contact the Department of Wildlife for permit requirements.

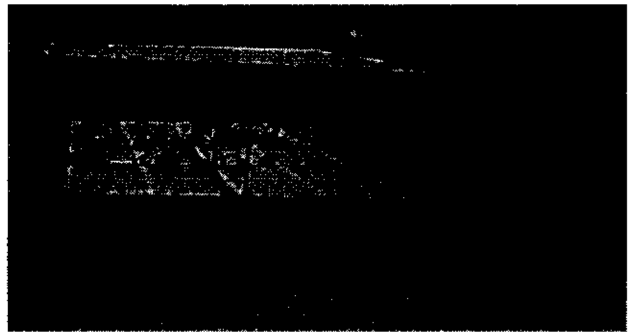
Game Bird Meat Production

Game birds raised for the meat market are managed for maximum gains with little concern for the feathers. They are typically fed a ration high in energy and with adequate levels of all other nutrients to enable them to reach market size quickly.

Hunting Bird Production

If game birds are raised for hunting, they typically receive a diet that is less fattening but one more likely to produce nearly perfect feathers. Hunting birds should be sleek with strong flight abilities. Hunting birds are raised with minimal human contact to maintain a wild disposition. Large flight pens are used for flying practice and allow the birds to experience different weather conditions.

Game Bird Pens



Mature pheasants are usually raised in ground pens. Intestinal disease organisms, such as coccidia, tend to accumulate in soil when quail or chukars are kept on the ground for extended periods. Thus, pheasant, quail and chukars are often raised in well-built wire cages such as this well-constructed raised pen.

Game Bird Incubation

With the exception of some pheasants, the game bird female cannot be relied upon to incubate her own eggs. Most commercially available incubators are used to incubate game bird eggs. Incubation procedures recommended for other poultry will apply to most game birds. Some breeds of bantam hens can be an inexpensive means of incubating game bird eggs.

The incubation period for a common game bird varies according to species. Some example incubation periods include:

- Coturnix quail – 16-18 days
- Bobwhite quail – 22-23 days
- Chukar partridge – 23 days
- Ring neck pheasants – 24-25 days

Cannibalism and Feather Picking

Cannibalism and feather picking are a significant problem when raising game birds. This is because game birds are high strung and occasionally aggressive in confinement. The problem can be prevented by proper management. This involves avoiding excessive light, not overcrowding, providing cover, and providing hay or brush in which the birds can scratch.

If cannibalism cannot be controlled by management, then physical prevention may be necessary. Beak trimming is an obvious option for birds raised for meat production because appearance is not as important as it is for birds raised for hunting. Trimmed beaks are discriminated against by hunters. A plastic or metal blinder can be inserted on the base of the bird's beak, and do a good job of keeping birds from pecking.

Game Bird Marketing

Marketing game birds is a special challenge. Only a few markets exist for game birds, so it is necessary to develop your own market. It is best to have a market developed for birds before purchasing the game bird eggs or hatchlings.

SUMMARY

Young and older people raise poultry for many reasons: hobby, exhibition, meat, eggs, and hunting. Purebred chickens (large fowl and bantams) are raised for fun and shows. Waterfowl (ducks and geese) can be raised for the same purposes. Game bird (quail, partridge, and pheasant) production is growing in popularity. Many bird types are being raised under free-range conditions.

Management information is available from various sources for anyone interested in raising non-commercial species of poultry on a small scale and for niche markets.