P.O. Box 134
Green River, UT 84525

Utah State University | COOPERATIVE extension

UTAH GAME BIRD HEALTH AND MANAGEMENT SYMPOSIUM

Green River, Utah
March 11-12, 2011

SPECIAL ACKNOWLEDGEMENT

We are proud to extend a very special thanks to Cargill for their generous contribution to enhance the quality of this meeting.

To all the folks of Cargill:

THANK YOU!

TABLE OF CONTENTS

UTAH GAME BIRD
HEALTH AND MANAGEMENT SYMPOSIUM

March 11-12, 2011
Green River, Utah

March 11 (Friday)

INTRODUCTION & WELCOME

8:00 – 8:15 a.m. . . . . *Royd Hatt*, Hatt's Ranch
Bruce King, State Veterinarian

HATCHERY MANAGEMENT

8:15 – 9:30 p.m.

Incubation/hatching optimization . . . . . *Vern Christensen*
North Carolina State
University (retired)

HEALTH AND DISEASE

9:30 – 10:30 a.m.

Brooding concepts and chick health . . . . . *David Frame*
Utah State University
Cooperative Extension

10:30 – 11:50 a.m.. . . . . Break

11:50 a.m. – 12:00 p.m.

Necropsy wet lab. . . . . *David Frame*
USU Cooperative Extension
E. Jane Kelly
Central Utah Veterinary
Diagnostic Laboratory

12:30 – 1:00 p.m. . . . . Lunch

1:00 – 1:30 p.m.
Avian influenza update. . . . . *Warren Hess*
Assistant State Veterinarian

MANAGEMENT

1:30 – 2:30 p.m.
Game bird management. . . . . *Keith Hicken*
Pleasant Valley Hunting
Myton, UT

2:30 – 2:50 p.m.. . . . . Break

2:50 – 5:00 p.m.
Game bird management. . . . . *Troy Laudenslager*
Mahantongo Game Farms
Dalmatia, PA

DINNER. . . . . JWP Museum basement
5:30 p.m.

****

March 12 (Saturday)

9:00 a.m. to 12:00 p.m. . . . . Tour of Hatt's Ranch
(breeder farm, hatchery, and
hunt club)

UTAH GAME BIRD
HEALTH AND MANAGEMENT SYMPOSIUM

Participant Biographical Information

Vern L. Christensen
(435) 851-4911
vlcturkey@aol.com

Dr. Vern L. Christensen received his B.A. from Utah State University in 1971, subsequently earning the M.S. degree from Brigham Young University in 1975 and his Ph.D. from University of Missouri in 1978. His areas of professional interest and expertise are in the embryology, physiology, metabolism, and fertility of avian species. Specific interests focus in molecular events that affect the fertilization and embryo viability of domestic turkeys. For nearly 30 years, Dr. Christensen has been a faculty member at North Carolina State University. He has published over 150 refereed journal publications on the physiology and survival of turkey embryos.

David D. Frame
Utah State University
(435) 283-7586
david.frame@usu.edu

A 1980 graduate of Utah State University with a B.S. in Animal Science, Dr. Frame subsequently received his DVM degree from Oregon State/Washington State Universities in 1984. Dr. Frame completed an avian medicine residency with the University of California, Davis specializing in poultry pathology and diagnostics. He is board certified in the American College of Poultry Veterinarians. Dr. Frame was employed as chief veterinarian for Moroni Feed Company for 12 years before joining the faculty of the USU

Animal, Dairy, and Veterinary Sciences Department in 1998 as an Associate Professor. He currently serves as the USU Extension Poultry Specialist with an additional assignment as poultry diagnostician for the Utah Veterinary Diagnostic Laboratory.

Dr. Frame has served on elected and appointed national governing boards and committees, including the National Poultry Improvement Plan General Conference Committee (an advisory committee to the US Secretary of Agriculture), American Association of Avian Pathologists Board of Directors, numerous positions with the Western Poultry Disease Conference Executive Committee, and Subject Editor for the *Journal of Applied Poultry Research*.

Dr. Frame married Lisa Gilbert of Fairview, Idaho in 1979 and they are the parents of two girls and two boys (none of whom are interested in pursuing a career in veterinary medicine!).

Royd Hatt
Hatt's Ranch
(435) 564-3224
royd@etv.net

Royd Hatt is a lifelong resident of Emery County, Utah having been born and raised in Green River. He and his wife, Toni, are the parents of four children. Royd and his family are owners of Hatt's Ranch game bird ranch. Royd has served as president, vice president, and board member of the North American Game Bird Association.

Warren J. Hess
Utah Department of Agriculture and Food
(801) 870-7818
wjhess@utah.gov

Dr. Warren J. Hess and his lovely wife, Lori, reside in Kaysville, Utah. They have five children (three married), 3 1/3 grandchildren, two dogs and three horses. They love anything to do with family and each other.

Dr. and Mrs. Hess both grew up in Bountiful, Utah and graduated from Bountiful High School. Dr. Hess received his Doctor of Veterinary Medicine (DVM) degree from

Colorado State University in 1989. He worked in private practice with a special emphasis in birds and exotic animals until 2004 when he left private practice to work for the Utah Department of Agriculture and Food. He currently serves as Assistant State Veterinarian.

Dr. Hess is a founding member of Utah Emergency Animal Response Coalition, Inc. (UEARC, Inc.), a non-profit 501(c)3 organization that supports efforts statewide to prepare people and communities to address animals in their emergency and disaster response plans. He also serves as a founding board member of the National Alliance of State Animal and Agricultural Emergency Programs (NASAAEP), a national organization that promotes state's interests and best practices in the animals in disasters arena.

Dr. Hess has served as president of the Utah Veterinary Medical Association (UVMA) and currently serves as chairman of the Disaster Committee in that association. He served for many years in the Boy Scouts of America and enjoyed the association with the up and coming generations. He is actively involved in his neighborhood and church community.

Keith Hicken
Pleasant Valley Hunting
Myton, UT
khicken@yahoo.com

I was born in Heber City Utah on a dairy farm. We moved to the Uintah Basin in 1973. We continued in the dairy business for several years trying to make ends meet. In 1982 I got married to the greatest wife a person could have and we wanted to stay on the farm. After nearly starving to death farming in 1987 I decided to make change. My wife , two children and I started to raise pheasants for a supplemental income to the farm. There was only twelve pheasant raisers registered with the Division of Wildlife at that time. Most of them had a pair or two of exotic pheasants. Unfortunately for us there were not too many people to ask how to raise birds.

We proceeded with trial and error for a couple of years. After raising 2000 pheasants with success we felt we could succeed. My father a lifetime farmer then could see the success and became my partner.

Four years ago we sold our successful business so my father could retire but I still manage the business for the new owners. We have built a business with great success. We have produced as many as 42,000 birds a year. This season we have produced 32,000 pheasants. People come from all over the world to hunt with us. (Some for my wife's great cooking).

My wife and I now have three children, two married and an eight year old boy (wow). We love what we do for a living.

E. Jane Kelly
Veterinary Diagnostician, Bacteriology Section Head
Central Utah Veterinary Diagnostic Lab
(435) 623-1402

Dr. Kelly was born in Liverpool, England. She received her B.S. (1985) and DVM (1989) degrees from North Carolina State University. Subsequently, Dr. Kelly earned a M.S. degree from Utah State University in 1992. She and her husband, Paul, are the proud parents of two children (Elaine, age 14 and Michael, age 8). She loves hiking, camping, skiing, running marathons, and everything else related to the out-of-doors. Dr. Kelly has been working in the Utah Veterinary Diagnostic Laboratory (UVDL) system since 1991, and serves as the director of the Central Utah Branch Laboratory in Nephi as well as the Bacteriology Section Head for the UVDL.

Bruce L. King
Utah Department of Agriculture and Food
(801) 520-4309
bking@utah.gov

Dr. Bruce L. King was raised in Antimony, Utah on a cattle ranch. He is the third of ten children. He graduated from Piute High School in 1970 and married Valene Oyler in 1975. They have four children, two girls and two boys. After graduating from Colorado State University in 1981 with a Doctors Degree in Veterinary Medicine, he practiced with Dr. Thomas Anderson in Gunnison, Utah for 16 years in primarily a food animal practice. In 1988 he went to work for the Utah Department of Agriculture and Food as a field veterinarian. Dr. King's current position is the State Veterinarian.

BASIC CONCEPTS OF GOOD INCUBATOR OPERATION: WHAT CAN THE EMBRYO TELL US?

V. L. Christensen, G. S. Davis, and M. J. Wineland
North Carolina State University

EGG HANDLING PRIOR TO INCUBATION.

The main objective of a good egg handling system is to **control/eliminate harmful organisms** that may be on the eggshell surface, prevent the egg from being **contaminated** through handling and provide the **proper humidity** and **temperature control** for maximum hatchability.

SANITIZING EGGS:

The egg comes in contact with many sources of possible contamination before it gets to the hatchery. Organisms such as *Salmonella arizona*, other *Salmonellae***,** coliforms**,** *Pseudomonas*, etc., may be found in fecal material, floor litter, airborne dust and nest litter. When an egg comes in contact with any of these materials, the eggshell surface is instantly contaminated. Organisms get inside the egg through thousands of tiny pores in the shell as a result of the pressure. **The pressure differential that occurs when the temperature of the interior of the egg cools down is necessary to sanitize the egg to kill bacteria on the eggshell surface before the egg cools.**

EGG HANDLING AND SANITATION PROCEDURES.

Egg hatching quality depends upon the rate of carbon dioxide loss from an egg. Any management practice that reduces carbon dioxide loss from eggs, such as decreased temperature, increased humidity or packaging will also improve hatchability.

Management Practices.

1) Collection.

a. Collect eggs hourly with hens being pushed off the nest at each collection. This will minimize shell-surface contamination and discourage broodiness. An egg in the nest may be broken if a second hen enters the nest to lay.
b. Collect nest eggs and floor eggs separately and discard floor eggs.

2) Disinfection.

a. Disinfect settable eggs immediately after collection (within 60 minutes after being laid).
b. Disinfect either by washing with a quaternary ammonia solution or by fumigation. If the washing method is used, take care to avoid removing the cuticle. A fixing agent such as formaldehyde may

be used in the wash solution to ensure cuticle integrity. This will also help reduce bacterial or fungal growth through pores in the shell. Check washing solution for bacterial or fungal contamination twice weekly.

3) Temperature

a. After disinfection, cool eggs immediately.
b. Maintain the temperature in the egg rooms and egg storage room at 60°F. If the eggs are to be stored more than 4 to 5 days, room temperature should be 55°F. The egg storage room should have a relative humidity of 75%.
c. Maintain egg-handling and storage rooms in a sanitary condition in order to prevent contaminating eggs after washing. Immediately remove residue from broken eggs and disinfect the floor. Wash and disinfect floors and walls of the egg-handling room at the end of each day. Clean and disinfect floors and walls of the holding room weekly or following shipment of eggs to the hatchery.

4) Problems

a. Hairline cracks, which are not visible to the eye, will result in embryonic mortality. Avoid this type crack by using an adequate amount of a soft-nesting material. Collecting no more than 40 to 50 eggs per basket will also help reduce cracks. To ensure this number, use baskets, which will hold no more that 40 to 50 eggs.
b. Mold development in hatching eggs is seen frequently as a problem, particularly during warm weather. Check nesting material, change it often, and keep it dry.

5) Transportation

a. When transporting hatching eggs from farm to hatchery considers the distance, temperature and humidity as part of the management practices. Keep the temperature and relative humidity in the transport van nearly the same as in the egg-holding room. Otherwise, if egg temperature rises, "sweating" or moisture condensation on the shell surface will occur. Moisture on the shell surface will lead to bacterial or fungal contamination inside the egg.
b. The most important point to consider is control of embryonic development during transport. The embryos should be maintained in an undeveloped

state. Embryo development should cease immediately after the egg is laid and not start again until the incubation process is begun.

MAINTAINING HATCHING QUALITY:

Embryonic development has already started in an egg at the time of lay. If the egg is cooled too rapidly and embryo growth (cell division) is stopped before the egg is 6 hours old, the embryo has very little chance to develop. It is likely to be weak, and it may be destroyed easily. Embryo growth should continue for another 6-8 hours after being laid to develop a good, strong embryo that will withstand the stress of shipping and storage. **A temperature of 75-80°F during this period is ideal**. Embryo growth must be stopped by the time the egg is 18 hours old. If embryo growth is not stopped, an over-developed embryo will result, and it may die prior to start of incubation. In dry air, the evaporation of moisture through the pores of the egg is faster than it is in moist air. If the egg loses too much moisture, the thick albumen can start to break down, the egg's air cell can become too large and embryonic mortality can be increased. Pouts that do get out of the shell are likely to be of poor quality. **Relative humidity should be maintained at 75-80% in order to slow the loss of moisture due to evaporation.** If eggs are to be shipped or **stored longer than 5-6 days, relative humidity of 85-95% is recommended.**

CONCEPT OF PHYSIOLOGICAL ZERO:

The concept that a temperature exists at which all embryonic development ceases has existed in poultry science since the 1930's. Early data suggested the temperature was between **65 and 70°F** but more recent data suggest **50 to 55°F**. Eggs stored for 2 to 3 days probably hatch best when stored at the higher storage temperature while those stored for longer than 7 days probably hatch better when stored at the lower storage temperature. Most commercial farms operate their egg storage rooms at approximately 65°F. The concept of a physiological zero is still a subject of much research. As new DNA technologies become available; the storage temperature conditions for eggs will undoubtedly be refined.

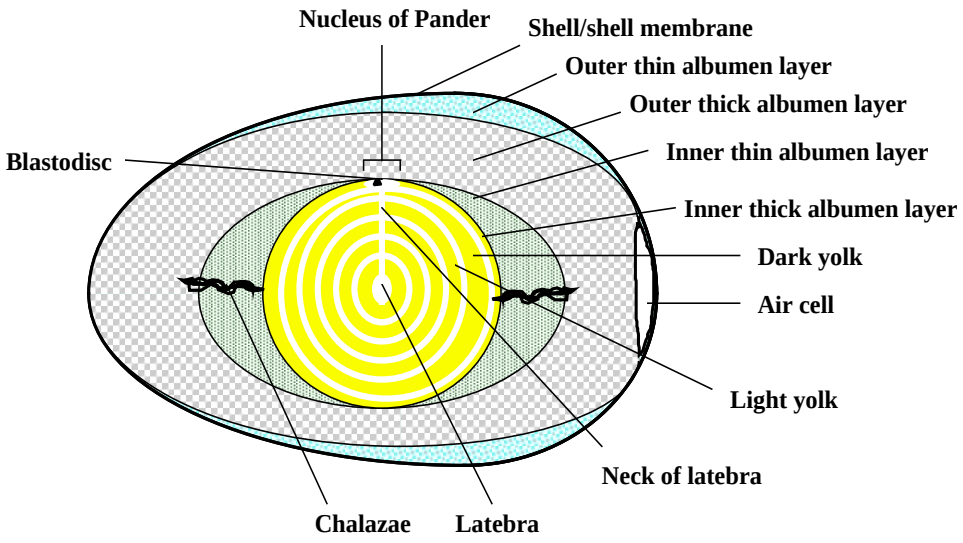
When storage temperatures change, it is important to remember that the relative humidity in the egg storage room must be changed simultaneously. A storage room relative humidity of about **70%** is recommended and is most easily measured using a wet bulb thermometer. For example:

Wet bulb temperature	Dry bulb temperature	Relative Humidity
65-68°F	60-62°F	75%

POSITION OF THE EGG DURING STORAGE:

Hatching eggs are normally stored **with the blunt egg in a vertical position**. In wild species the eggs are stored with the blunt end of the egg in a **horizontal position**. It is not known how the hen accomplishes egg storage of about 12 days in the wild. When similar attempts are made to duplicate horizontal storage in situations of artificial incubation, the eggs do not hatch well. The following examples illustrate some of these physiological concepts involved in egg position during storage.

1) When eggs are stored with **the blunt end in a vertical position**, the yolk will remain next to the air cell. The yolk weighs less than the albumen so it is floating in the egg white. Because of the viscosity of albumen, it requires a long period of time before the yolk will actually float to the top of the egg. This amount of time may be critical to embryo survival during storage because we know that **if the embryo adheres to the membranes**, it dies.
2) When eggs are stored with **the pointed end in the vertical position,** the yolk remains in the center of the egg. It would seem that this would enhance embryonic survival, but **this position does not enhance embryo survival.**
3) When eggs are stored with the **blunt end of the egg in a horizontal position**, the yolk will gravitate toward the top of the egg and eventually will make contact with the eggshell membranes. **This position results in more embryos adhering to eggshell membranes and more embryonic deaths.**



CHALAZAE.**The chalazae are twisted cords of thick albumen that lie at each end of the yolk in the long axis of the egg.** The chalazae at the narrow (pointed) end of the egg consist of two cords while the chalaza at the blunt end of the egg is composed of one cord. At the outer ends of each chalaza the cords merge with the thick

albumen, and serve to stabilize the yolk in the center of the egg; limited rotation of the yolk is possible, however, the chalazae serve to prevent lateral movement. The chalazae stabilize the yolk within the field of gravity.

LATEBRA. **The center of the yolk has a hole which protrudes halfway through called the latebra (see Figure 1)**. The embryo rests on top of the latebra. Because the yolk is not a solid mass, the heavier end of the yolk will always be at the bottom of the egg in the field of gravity. This serves to stabilize the embryo in a vertical direction. The chalazae serve to stabilize the yolk within the albumen laterally. During egg storage it is important to stabilize the yolk with its embryo both vertically and laterally.

It is recommended that eggs be placed with the blunt end in a vertical position during storage. If the eggs are stored in this position for longer periods of time (longer than 7 days), it requires daily turning during storage to prevent embryos from adhering to the eggshell membranes covering the air cell. **Daily turning enhances the survival rates of embryos when eggs are stored for more than 10 days.**

CARBON DIOXIDE AND EGG STORAGE

The loss of carbon dioxide from fertilized eggs results in the loss of embryonic viability eggs during storage. Carbon dioxide is lost by diffusion from eggs from the very moment of oviposition. **Carbonic anhydrase** is an enzyme that is involved in metabolizing carbon dioxide in physiological systems. Carbonic anhydrase is involved in the following reaction:

$$\underset{\text{Bicarbonate}}{HCO_3^-} + H^+ \xleftrightarrow[\text{Dissociation}]{} \underset{\text{Carbonic Acid}}{HCO_3} \xleftrightarrow{\text{Carbonic Anhydrase}} CO_2 + H_20$$

In the egg, carbonic anhydrase is present in the epithelium of the chorioallantoic membrane (CAM). Carbonic anhydrase is responsible for local acidification of the CAM which allows for the solubilizing of the eggshell to release calcium and other minerals that can then be transported to the embryo. The equilibrium of the chemical equation is reversible. When carbon dioxide accumulates within an egg, the contents become acidic. When carbon dioxide is lost from the egg, the egg contents become more basic.

Within the albumen is a protein containing two different protein molecules, ***i.e.,*** ovomucin and lysozyme. Ovomucin is present in small amounts in egg albumen and contributes to the gelatinous properties of the egg white. Lysozyme is an enzyme that scavenges bacteria within the egg. In the egg at oviposition, ovomucin is bound to lysozyme. As pH and temperature increase, the two protein molecules are cleaved and as they separate, the albumen thins. This concept is presented below:

$$\text{Ovomucin-Lysozyme} \xrightarrow[\text{pH}]{\text{Temp}} \text{Ovomucin} + \text{Lysozyme}$$

This thinning allows the yolk to float more freely within the albumen and requires that eggs be turned more often to avoid loss of embryonic viability during storage. **When carbon dioxide loss from eggs is slowed, then the breakdown of ovomucin and lysozyme is slowed and egg storage may be facilitated**.

EGG PROCESSING FACILITY:

A three-stage egg house system is used by most breeder farms and consists of a sanitizing room, a "clean" overnight room and an egg holding room. Floors, ceilings and walls in these rooms should be smooth, cleanable surfaces that can withstand repeated washes with disinfectant solutions.

Sanitizing room. The egg-sanitizing machine used by most of the industry is the Aquamagic. An air intake should be provided for the machine from a clean air source outside of the sanitizing room in order to prevent contamination of the cleaned eggs. An air exhaust system should be provided to remove humidity and fumes from the dryer and from the sanitizing room. The airflow goes from the "overnight" or "clean" room and out the sanitizing room. The machine should be monitored constantly for correct water temperature **(110-130°F)** and disinfectant levels (use manufacturer's recommendations). The machine should be sprayed out after every gathering and should be taken apart and thoroughly cleaned at the end of each day. **Eggs with fecal or muddy material on the shell should not be processed through the machine and must be discarded.** The floor should be kept clean at all times and mopped with disinfectant solution daily.

"Clean" Overnight Room. The Aquamagic egg sanitizing machines are mounted through the wall between the sanitizing room and the sterile overnight room. Sanitized eggs are discharged from the end of the machine directly into the "clean" overnight room. Eggs are placed in flats to cool down overnight and are cased the next morning and moved to the egg holding room.

The "clean" overnight room is totally isolated from the sanitizing room and fully insulated for proper temperature and humidity control. In order to maintain the proper temperatures between 65°F and 75°F, this room must be equipped with a system, which can heat and cool and a thermometer. In order to maintain the proper relative humidity of 75-80%, a humidifier and a humidity indicator are required. A sink for washing hands and a foot dip pan should be placed at the entrance to this room. Access to this room should be limited to the person handling sanitized eggs, and this person should was his hands and put on a clean smock prior to handling eggs. A temperature of 75°F during the day and 65°F during the night should be maintained. The floor must be kept clean at all times and mopped daily with disinfectant solution.

Personnel entering this room must wash and disinfect their hands prior to entering.

Egg Holding Room. This room should be fully insulated with a cooler capable of maintaining a temperature of 58°F and a humidifier capable of maintaining a minimum of 75% relative humidity with accurate thermometer and humidity indicators. There is a connecting door between the holding room and the "clean" overnight room with access limited to the person

operating the "clean" overnight room. This room should have an access door to the outside, with a foot dip pan. For egg pick up, the truck driver picking up the eggs does not enter the room.

Only cased eggs and a three-day supply of cases and flats are stored in this room, so they can absorb moisture. The floor in this room should be mopped daily with disinfectant.

Egg Packing Material Storage Area. Only egg packing materials are kept in this room. No other supplies or trash are permitted. Access to this room is limited to the person operating the "clean" overnight room with all other access doors remaining closed.

ARTIFICIAL INCUBATION OF EGGS

The final destination of the properly managed fertilized egg is the incubator within the hatchery. Modern-day hatcheries generally have egg-setting capacities thousands of eggs. Fertilized eggs have different developmental period depending upon the species so the scheduling of egg settings and removal of hatchlings requires careful planning and monitoring of incubation conditions. Sanitation is imperative in commercial hatcheries as well because conditions for bacterial, mold and viral growth are ideal under incubation conditions. In fact, human vaccine manufacture is often accomplished using fertile poultry eggs. To accomplish successful incubation, an understanding of the basic principles of incubation is essential.

Five principles of artificial incubation are essential for successful hatching of eggs. These factors are valid as well as for the incubation of almost any species of birds. The five principles are **Temperature; Humidity; Turning: Ventilation; and Light/Sound**. Each of these environmental factors must be controlled to successfully develop a blastoderm into a hatchling.

Explanation of each of the five principles

Temperature. When discussing incubation temperature it is important to differentiate the type of incubating machine used. Incubators can be classified based on ventilation and how eggs are set. Ventilation can be by **Still-air** or **Forced-draft. Single-stage** incubators are machines designed to incubate one setting of eggs through to hatching. **Multi- stage incubators** are engineered to contain eggs of multiple ages. Eggs become **exothermic** approximately midway between setting and hatching (approximately 14 days). Energy can be saved if **endothermic** (eggs less than 14 days of setting) are incubated with eggs older than 14 days. Heat from the older eggs is used to provide incubation temperatures for the younger eggs. Temperature requirements differ for each type of incubator.

1) **Still-air Machines.** It is recommended that the incubation temperature for still-air machines be 100.5°F the first week of incubation, 101.5°F the second week, 102.5°F the third and 103°F the fourth week (Insko and Martin, 1936).

   Reducing temperature 2 to 3°F and increasing humidity to a wet bulb temperature of 90°F (70% RH) increased hatchability of eggs (Krueger, 1966).

A suitable alternative may be simply maintaining a constant incubation temperature of 102°F throughout the entire incubation period.

4) **Forced-draft Machines.** Each manufacturer will have specific directions for their machine. It is generally recommended that incubation temperatures be approximately 99.5°F for the initial 25 days of the incubation period.

3) **Critical Range for Incubation Temperatures.** Embryos have either a nonexistent or a very weak thermoregulatory ability. The zone of thermoneutrality is very narrow for an embryo. Therefore, incubation temperatures must be controlled very closely to avoid physiological aberrations and/or death. The **critical temperature for incubating eggs is between 96.0°F and 103.0°F.** Out side of this range is the LD 50(Lethal dose for 50% of the animals). It is important in operating incubators that the temperature of the machine not be less than 96°F nor greater than 103°F. Operating at these temperatures for short periods of time will not harm the embryo, but operation for extended periods may be fatal.

Humidity. The physiological role of humidity in incubation is only partially understood. It is easy to see how **dehydration** may affect embryonic growth because all life must develop in water. The role that **over hydration** plays in incubation and embryonic survival is less easily understood. Experience has proven that a relative **humidity of 54% inside the incubation cabinet is ideal** for embryonic survival. However, incubator humidity must be increased during the final few days of incubation to prevent dehydration during the actual hatching process. If humidity is not increased during the final few hours of hatching, many embryos will stick to the shell because the residual albumen held in the albumen sack will act as glue if desiccated.

1) **Dehydration**. At oviposition a fertilized egg is approximately two/thirds water. In order for optimal growth to occur during incubation, the relative amount of water in an egg must remain at approximately 66%. Water vapor is lost from an egg at incubation temperatures through tiny pores in the shell. Collectively, these pores account for less than 1% of the total surface area of the egg, but they play a very important role in embryonic growth. As development proceeds **water vapor from the embryo diffuses through these pores** into the incubator environment. **Diffusion of gases** is dependent upon a gradient. Water vapor will flow in the direction of the smaller gradient. The rate of flow can be controlled by the size of the gradient (the ratio of the water vapor pressure inside the shell to the water vapor pressure outside of the shell). In hatcheries we deal with water loss as a percentage of weight lost from the egg at the time of setting until hatching begins by breaking the shell. **The ideal percentage water loss for most eggs is 11.5 to 12% of the initial egg mass**. This water loss has been shown to result in an embryo at hatching which is 66% water. Hatchlings with 66% water are not dehydrated.

2) **Over hydration.** It is more difficult to understand the physiology underlying the inability of an embryo to grow when there is too much water in an egg than when there is not enough. The lipids in the yolk provide more than 90% of the energy for embryonic growth. Lipid metabolism creates water as a by-product. If no water were lost from an egg, the relative water content of an egg would increase during development because of the metabolic water formed during energy metabolism. It is thought that the embryo may drown metabolically. It could not drown in the usual sense of the word because the lung of the bird is the shell and its underlying chorioallantoic membrane. For optimal survival rates, water must be lost at a rate that maintains the relative water content of the egg at 66%. **As stated previously, the ideal percentage weight loss for most eggs to fulfill this requirement is again 11.5 to 12.0%.**

Suggestions for Controlling Incubation Humidity:

1) Game bird eggs are more sensitive to water loss than are chicken.

2) 30 to 35 eggs should be marked with a soft-lead pencil and observed throughout an incubation cycle. The following table shows the values that should be seen at different incubation stages.

Day of Incubation	Water loss (%)	Ideal loss (%)	Loss from a 90 g egg
6	**2 to 3**	**2.5**	**2.25 g**
12	**4.1 to 6**	**5.0**	**4.50 g**
18	**6.2 to 9**	**7.5**	**6.75 g**
24	**9.0 to 12**	**10.0**	**9.00 g**

3) Alternative means of monitoring egg weight loss is by observing the air cell of incubating eggs. Excessively large or small air cells indicate problems.

4) **AS A GENERAL RULE, INCUBATE AT 54 PERCENT RELATIVE HUMIDITY UNTIL 24 DAYS, THEN USE 70 PERCENT UNTIL HATCHING.**

5) If additional humidity is needed, wet the incubator floor, place pans of water in the incubators, place burlap wicks in the pans already there. In general, one needs to increase the surface area available for evaporation.

6) **TO REDUCE HUMIDITY, INCREASE THE VENTILATION.**

Ventilation. Proper atmospheric concentrations of oxygen and carbon dioxide are a subject of considerable debate. Basically, the fairest statement is that critical concentrations are unknown. However, it is known that embryos are sensitive to both too little and too much oxygen and carbon dioxide.

1) **Oxygen.** Based on limited research, there are some generalities that can be made about oxygen in the incubator. Normal atmospheric concentrations of oxygen are 20.9% of the environmental air. In scientific terms it makes more sense to discuss oxygen as a partial pressure because barometric pressure can vary from location to location. If we assume that 760 mm of mercury (mm Hg) is the standard condition, then normal oxygen partial pressure will be .209 X 760 = 159 mm Hg. We know that **oxygen toxicity occurs at partial pressure greater than 190 mm Hg and less than 114 mm Hg**. If we assume that most hatcheries operate at about 760 mm Hg then these values **correspond to 25% and 15% of the atmosphere**.

   Oxygen concentrations are maintained in incubators by fans and vents. The fans are controlled by thermostats rather than by an oxygen sensor. Oxygen sensors are expensive and unreliable under incubation conditions. Therefore, it necessitates that the hatchery manager controls the vent openings manually. The proper vent opening may need to be determined by trial and error within each hatchery. Portable oxygen sensors and generators are available and many hatcheries use them to monitor oxygen concentrations -- especially during the actual hatching process. The vent openings can then be adjusted to optimize the oxygen concentrations based on actual atmospheric oxygen measurements.

2) **Carbon dioxide.** We know less about proper carbon dioxide concentrations than we do about oxygen. Carbon dioxide is essential to the development of embryos because normal development does not occur in the absence of carbon dioxide. We also know that carbon dioxide probably has upper and lower limits just as oxygen does. As mentioned above with oxygen, the concentrations of carbon dioxide are also expressed as percentages of the total atmosphere. If we are incubating at 760 mm Hg, then normal atmospheric concentration of carbon dioxide is .0025 X 760 = 2 mm Hg. **The lower toxic limit for carbon dioxide is about .4 mm Hg whereas the upper toxic limit for carbon dioxide is about 4 mm Hg**. Less than 760 mm Hg, these values **correspond to .05% and .5% of the total atmosphere**.

   If carbon dioxide is totally absent from the atmosphere, then normal blood acid/base balance does not occur before hatching and the egg pipping process is delayed. If too much carbon dioxide is found in the incubation environment, then the embryo may die immediately or the shell pipping process may be accelerated.

3) **Oxygen and Carbon Dioxide Concentrations at Different Times during Incubation.** Times of morphologic stages during the embryonic development period are characterized by great sensitivity to carbon dioxide and oxygen whereas others are characterized by almost a totally lack of sensitivity. The most sensitive periods in the development of a embryo are 1 to 6 days of incubation and 21 to 28 days of incubation.

Suggestions for Controlling Respiratory Gases.

1. At both critical times of incubation, less than 15% oxygen (114 mm Hg at 760 mm Hg of barometric pressure) is toxic. Similarly, at both stages 1.5% carbon dioxide (4 mm Hg at 760 mm Hg of barometric pressure) is toxic.

2. At all other times of incubation, embryos can tolerate less than 15% oxygen and up to 7% carbon dioxide.

3. **DO NOT OPEN THE INCUBATOR DOOR MORE THAN NECESSARY WHEN THE DEVELOPING EGGS ARE AT THE CRITICAL STAGES.**

4. Ventilation should be measured carefully when embryos are at the critical stages of development. Newer model incubators now have carbon dioxide and oxygen monitors on them.

5. Ventilation plays and important but undefined role at the final stages of incubation. This effect is probably best demonstrated by the following data depicting survival of embryos in eggs with drilled holes:

Day of Incubation	Hatchability (%)
13	89.0
14	89.5
15	90.4
16	93.5
17	87.6
18	85.1
19	84.9

Turning. Funk (1934) was probably the first to note the beneficial effects of turning eggs during artificial incubation. **Most eggs are generally turned every three hours day and night.** However, if the automatic turning equipment fails, manual turning at least five times a day is a very satisfactory. **Fertilized eggs should not remain in the same position for longer than 8 hours during the critical developmental time periods (1 to 9 days of incubation).**

1) **Physiology of Egg Turning.** It was demonstrated many years ago that if eggs were not turned, **the embryo would actually adhere to the shell membranes**. It is not known if the adherence kills the embryo but it certainly does not do it any good. It is also known that if eggs are not turned, the fluids from the albumen will penetrate the inner and outer shell membranes of the shell and **prevent the formation of chorioallantoic blood vessels** that serve as the lung of the developing embryo. One can easily visualize an unturned egg with an egg candling light by observing the lack of blood vessel development around the shell.

A third suggested cause of death in unturned eggs is that **the nutrients in an egg become stratified** in the absence of turning. That would render nutrients unavailable to the embryos and possibly cause death.

2) **Frequency of Turning.** Most eggs need turning during only the first 30% of incubation period. After that time turning does not seem essential to embryonic survival. **The minimum amount of turning is two times per day** whereas there **does not seem to be a limit to the number of times an egg can be turned before it affects embryonic survival.**

3) **Dimensions of Turning.** Most eggs are set in the vertical position in egg incubators. How far must an egg be turned and in what planes does it need to be turned? Research indicates that **eggs turned between 30 and 60 degrees in a one-dimensional plane hatch best. Most commercial incubators turn eggs about 45 degrees in a one-dimensional plane.**

Light and Sound. The use of light and sound in incubation are relatively new developments. Because they are so new, there aren't many management guidelines available. Lauber (1961) was the first to observe effects of light in incubators. She was observing the effect of light on the formation of the embryonic eye and noted that the **eggs exposed to the light began hatching nearly 24 hours earlier** than those in total darkness. It is now a common observation that light accelerates embryonic development, but there have been no consistent reports on a beneficial effect on hatchability. Transferring incubating eggs from a dark incubator into a lighted incubator at 24 days of incubation resulted in accelerated hatching and an improvement in hatchability, but exposing incubating eggs to light for the entire incubation period did not.

Sound has similar effects on hatching rates (Sandusky, 1994). The effect of **playing music had a synchronizing effect on hatching times.** The hatchlings seemed to emerge from the shell very close to the same time. More research is needed to confirm this very preliminary report.

Both light and sound may be factors that can be used in the future in our artificial incubation of eggs. However, currently most of our concern should be focused on the previously discussed factors of temperature, humidity, ventilation and turning.

PHYSIOLOGY OF THE EGG DURING INCUBATION

Vern L. Christensen

The technical expertise to control incubation equipment has far exceeded our knowledge of the biological requirements for embryonic growth and survival. Hatchery managers should have a rudimentary understanding of biological bases on which to make judgments for optimal incubator operation. The following section describes some of the biological requirements for embryonic development.

Preparation for Embryonic Development

Although we usually think of embryonic development as an accepted phenomenon, there are many events that are unknown to the general public even to many who operate commercial hatcheries. The size and scope of the commercial hatching business has placed less emphasis on the biology of avian embryonic development and more on efficiencies of scale and the engineering of systems to incubate large numbers of eggs using a minimal amount of labor. The purpose of the next few pages is to acquaint the student of incubation with a brief physiological sketch of the components of an egg and their role in embryonic development.

Figure 1 shows each of the structures that will be discussed so the reader is advised to consult the Figure when reading the physiological function of each component. Some of these structures were discussed previously in the Section on Egg Storage.

Latebra

The latebra is a small portion of "white yolk" in the center of the ovum that is the remainder of white yolk formed in the early stages of ovum development prior to deposition of the pigmented yellow yolk (Burley and Vadehra, 1989). This yolk is less viscous and has a greater proportion of protein to lipid (Burley and Vadehra, 1989). The latebra is connected, via the neck of the latebra, to the periphery of the ovum which is in contact with the blastoderm the nucleus of Pander. This white yolk provides the first nutrients for the blastoderm prior to formation of the embryonic membrane structures (Burley and Vadehra, 1989).

Chalazae

The chalazae are twisted chords of thick albumen, which lie at each end of the yolk in the long axis of the egg. The chalaza at the narrow (pointed) end of the egg consists of two chords while the chalaza at the blunt end of the egg is composed of one chord (Burley and Vadehra, 1989). At the outer ends of each chalaza the chords merge with the thick albumen, and serve to stabilize the yolk in the center of the egg; limited rotation of the yolk is possible, however, the chalazae serve to prevent lateral movement (Burley and Vadehra, 1989). The twisted nature of the chalazae is due to the rotation of the ovum as it travels down the reproductive tract; as albumen is deposited the chords are twisted.

Vitelline membrane

Initially this membrane surrounds the yolk and maintains an osmotic gradient to keep the yolk and albumen nutrients separated. As the embryo ages, the membrane begins to disintegrate and allow the protein from the albumen to be intermingled with the lipids from the yolk thus providing a balanced diet for growth for the embryo. Eventually, the yolk sac membrane replaces the vitelline membrane. The yolk sac membrane is not a true biological membrane. It develops from a single layer of cells that extend from the area vasculosa (inner portion of the area opaca). This highly vascularized membrane is fully formed by the ninth day of incubation and encloses the yolk. The inner surface of the yolk sac membrane is highly convoluted which allows maximum contact with the yolk. One yolk sac membrane function is to break down and absorb yolk for the developing embryo.

Egg White (Albumen)

The albumen provides several physiological functions during incubation. It contributes water and solutes, which enter the yolk, and provides albumen protein, which is absorbed via the yolk sac during the last week of incubation. In addition, the early embryo (Blastoderm) uses glucose from the albumen as an energy source. The albumen has an antimicrobial role, which is provided by one of the proteins of which it is composed. Antibacterial proteins inhibit bacterial growth in different ways. Ovotransferrin chelates iron and avidin binds biotin which make these substances unavailable for use by microorganisms. In addition, there are several bacterial protease inhibitors; ovomucoid, ovoinhibitor, cystatin, and ovomacroglobulin. Ovomucin in albumen is a known antiviral agent. Lysozyme, a bacteriophage, is also present in the albumen. This protein will be discussed in detail later.

Inner and Outer Shell Membranes

The outer shell membrane is thicker than the inner shell membrane (Burley and Vadehra, 1989). The outer shell membrane is joined to the shell by fibers that pass into the mammillary cores of the shell, while the inner and outer shell membranes are joined by fibers that pass from the inner to the outer membrane (Burley and Vadehra, 1989). The inner shell membrane also makes contact with the chorioallantoic membrane and assists in calcium movement from the shell to the chorioallantoic membrane. At the large end of the egg the inner and outer shell membranes separate to form the air cell, which provides the embryo with its first breath of oxygen during pipping. The outer shell membrane serves as the lung of the embryo early in development by resisting the diffusion of respiratory gases and water vapor early in embryonic development.

Shell

The shell provides three important functions for the embryo. First, it protects the embryo from the outside environment of the incubator. It has some insulation value and resists the loss of heat when an incubator door is left open or when a hen is away from the nest. It provides a cushion from shock. If an egg is dropped

or tipped unnecessarily the embryo could become damaged if not contained in a shell. It is also a major shield against bacterial invasion of the stored nutrients. Secondly, the shell provides important nutrients to the embryo. It is the major source of calcium and magnesium for the growing tissue mass. Lastly, the shell is the lung of the embryo. Tiny microscopic pores that resist or facilitate the loss of carbon dioxide and water vapor from the embryo and the competing aim of providing oxygen to the developing organism cover the shell. All respiration by the shell is accomplished totally by diffusion, *i.e.*, the embryo is totally dependent upon the number and geometry of pores to supply respiratory gases, it cannot increase its respiration rate.

Yolk

Yolk is actually formed in globules. These globules are so named because they are unaffected by the concentration of salt or urea which dissolve or disrupt other structures in yolk (Burley and Vadehra, 1989). However, as their lipid composition is similar to that of yolk low-density lipoprotein (with the only difference being a higher proportion of phospholipid), it may be that these globules supply energy for the growing embryo. There are two types of yolk based on the amount of yellow pigment they contain. Yellow yolk differs from white yolk in two ways; first, it contains pigments from the diet (carotenoids) which give it the yellow color, and second, it contains small particles (yolk low density lipoprotein) not present in white yolk (Burley and Vadehra, 1989). The function of yellow yolk during incubation is to provide lipids and proteins to the embryo. Both lipids and proteins are absorbed via the yolk-sac membrane then transferred as an energy source to the embryo. Proteins (and carbohydrates) are the main energy source during the first two-thirds of incubation while lipid metabolism is most intense during the last 7 days of incubation of the embryo when growth is rapid. Surface layers of yolk are formed during the final rapid phase of yolk formation while the ovum is still on the ovary. The surface layers consist primarily of yellow yolk so this type of yolk would be available to the embryo before the white yolk would be.

Water

The egg is composed of 83 to 84% water in altricial species (young hatch helpless) and 72 to 75% in precocial species (young are more independent at hatching). Approximately 12 to 15% of water is lost by the egg is via diffusion. Water in the egg influences the egg temperature, the hatching process and the weight of the hatched chick Eggs of small species of birds tend to have proportionally more water in their eggs than other birds. These small birds, which have higher metabolic demands than larger birds are able to leave the eggs unincubated for longer periods of time during trips for food, without the eggs cooling appreciably. Distribution of water in egg components varies through the egg depending on the period of incubation. Water is an important factor involved in osmotic balance of the egg components and the embryo. Water also serves as a solvent for many biochemicals.

Carbonic Anhydrase

Carbonic anhydrase is an enzyme that is involved in the following reaction:

$$\underset{\text{Bicarbonate}}{HCO_3^-} + H^+ \xleftarrow{\text{Dissociation}} \underset{\text{Carbonic Acid}}{HCO_3} \xleftarrow{\text{Carbonic Anhydrase}} CO_2 + H_20$$

In the egg, carbonic anhydrase is present in the epithelium of the chorioallantoic membrane (CAM). Carbonic Anhydrase is also found in the albumen of the egg. Carbonic anhydrase is responsible for local acidification of the CAM which allows solubilizing of the eggshell (Calcium carbonate) to release calcium and other minerals which can then be transported to the embryo (Narbaitz, 1987). In embryos that have developed primitive and definitive red blood cells, carbonic anhydrase also serves to regulate carbon dioxide transport and pH (Tuan, 1987).

Subgerminal fluid

Subgerminal fluid is aptly named, as it is the fluid that is contained in a cavity beneath the early avian embryo (blastoderm). Subgerminal fluid contains glucose, sodium, potassium, protein and water, which bathe the embryo. Later in incubation, amniotic and allantoic fluids replace this fluid.

Extra Embryonic Structures During Embryogenesis

Very early in development, membranes emanating from the embryo grow to surround the embryo and or yolk. Figure 2 depicts these structures. There are four of them and each has a unique physiological function. The student of embryology and incubation should have at least a basic knowledge of these structures. This knowledge will aid in identifying incubation problems.

1. Chorion

The sole function of all of the structures is to protect the embryo and provide for its nutritive, excretory or respiratory needs. The chorion is a layer of cells that fuses with the allantois (the bladder of the embryo) very early in incubation. The structure formed is called the chorioallantoic membrane and forms the circulatory system around the periphery or the egg and also serves as the site of respiratory gas exchange or as the "lung" of the embryo.

2. Amnion

This layer of cells forms a fluid-filled sac that surrounds the embryo proper. It has three functions:

1. Protects the embryo from drying.
2. Forms a fluid cushion for the embryo.
3. Forms an isolated chamber where growth and positional changes can occur easily.

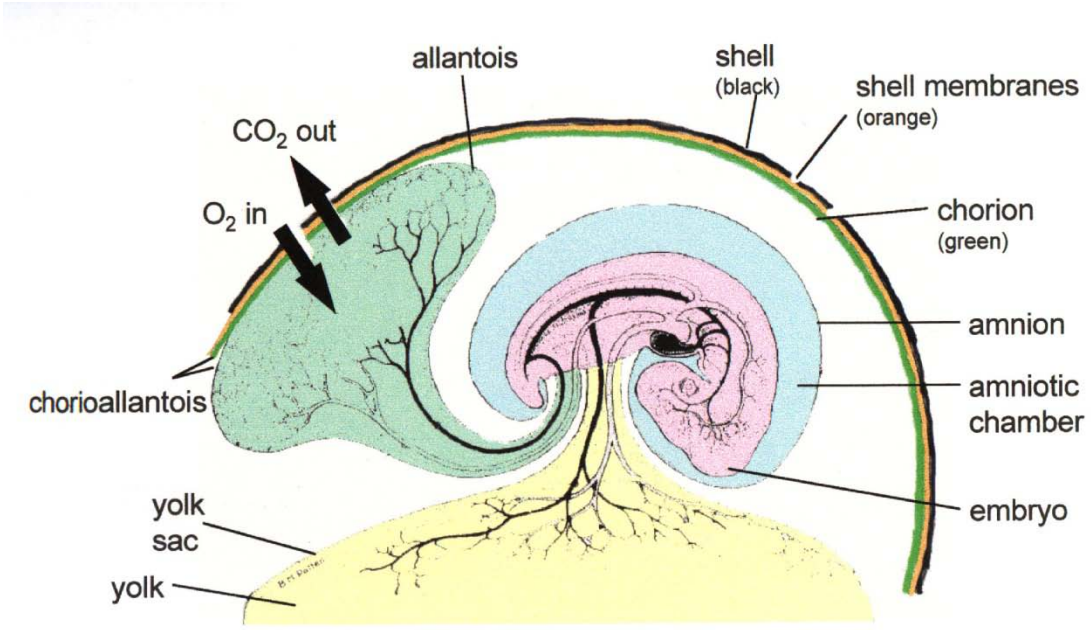
3. Yolk sac

The yolk sac membrane fuses with the chorioallantoic membrane during Embryogenesis. It lies between the food supply, the yolk, and the circulatory system to carry nutrients to the growing tissues. It contains digestive enzymes and possesses the ability to "digest" food.

4. Allantois

The allantois is a membrane growing from the yolkstalk of the embryo. It has two general physiological functions:

1. It participates in the exchange of oxygen and carbon dioxide between outside air and the embryo. It is the embryonic lung.
2. It forms a sac in which nitrogenous wastes (Urea, the main breakdown product of protein) are stored. Urea is formed only during the early development stages and is water-soluble. Later in development the embryo forms uric acid which is an insoluble solid and is deposited near the allantoic sac as a white powdery material.



Adapted from Patten, 1951

HATCHERY RELATED PROBLEMS

Vern L. Christensen

Watch for These Ten Hatchery-Related Problems

Don't blame your hatchery man for excessive early mortality – at least not always. The mortality could be the fault of poor brooder house management.

Having said that, however, there are 10 points for growers to watch for in hatchlings - hatchery related factors that could give producers problems with their poults. They are:

1. **Dehydrated chicks:** They generally result from low humidity during incubation, and early hatch or excessively long holding periods in boxes before delivery. Dehydrated chicks can be identified upon delivery at the farm by **examining the shanks and feeling the chicks**. If a fairly large number of chicks have shriveled legs or shanks and bodies feel hard and look angular, give the birds extra good care the first week. The chicks should have "easy" access to water and feed and they should be kept comfortable. Do not chill or overheat the chicks in the brooder house. **Always check a sample of chicks (50 to 100 at random) upon delivery to determine the state of dehydration and then brood accordingly.**

2. **Weak chicks:** Weak chicks do not have to be dehydrated chicks, and often are not. Weak chicks usually result from higher than recommended temperatures during hatching, inadequate ventilation in the hatchers, over-fumigation at hatching time, infection, rough sexing or setting old eggs. Weak chicks can be identified easily by pressing down on the chicks in the boxes with the palm of the hand. If the chicks are strong, they will offer considerable resistance to the pressure of the hand; if they are weak, they can be pushed down easily. **With a little practice (the touch of the master) you can detect weak chicks upon delivery. Weak chicks need better than average brooder house care.**

3. **Large, soft-bodied chicks:** Large, sluggish chicks usually are the result of high humidity during incubation and hatching. They often have a heavy abdomen and feel soft and full of moisture to the touch. They generally ship better when transported long distances. **These poults usually present no serious brooding problems except that they appear sluggish.**

4. **Rough navels:** The navels of chicks always should be checked upon delivery to the farm. A rough or open navel makes the chick more susceptible to infections. Rough or unhealed navels result when the hatch is late (more than 28 days), incubation temperature has been variable and high, or when excessively high humidity was used during hatching. **Chicks with rough navels upon delivery probably should receive a broad-spectrum antibiotic in the feed or water for the first week to minimize the possibility of infection and morbidity.**

5. **Omphalitis (navel infection):** Omphalitis is the result of filth in the hatchers and/or contaminated chick boxes and chick box pads. *E. coli, Pseudomonas, Proteus*, or occasionally a *Staphylococcus* usually causes it. Sometimes the yolk sac is involved in addition to the navel. Yolk sac contents change from a yellow-green material to a caseous material or to a yellow-brown watery material when contaminated with *E. coli.* The navel opening often has an offensive odor. **Mortality and morbidity will be high with a high percentage of runts among the surviving poults.**

   An omphalitis infection means that the hatchery must change its clean-up and egg and hatchery sanitation programs immediately. **A broad-spectrum antibiotic may help reduce morbidity and the percentage of runts.** The type of organism involved and drug resistance will affect the type of response one gets to treatment.

6. **Chick delivery.** Errors in the chick delivery system can injure potentially strong, healthy chicks. Damage can occur in several ways; namely, overheating in the delivery van, chilling in the van, poor van ventilation resulting in overheating, chilling, or CO_2 poisoning. Assuming good judgment in programming the load, the driver becomes the "key" to a successful delivery of undamaged chicks. Some truck drivers have no feel for the product being delivered. **The salvage process at the brooder house consists of ample feed and water, and a comfortable brooding temperature, along with a tremendous amount of care and attention.** The amount of loss depends on the damage done to the chicks in transit, and the amount of care given them during brooding.

7. **Improper toe trimming**, wing clipping, snood removal, poultry injection and rough handling during sexing: Quality control and sanitation are the greatest problems a hatchery has with these operations - getting the hatchery personnel to do their jobs properly and uniformly. Improper wing clipping or toe trimming can leave a chronic sore. Many years ago poultrymen recommended wing clipping or toe trimming through a joint taking into account the proper angle, and using a modified beak trimming unit to do the job.

   The injection site and injection process should be kept as sterile as possible. Chicks should be injected according to directions - meaning proper equipment and needles, recommended dosage of antibiotic mixture, injection in the upper portion of the neck and subcutaneously. If the antibiotic mixture is of the type that puts the chicks to sleep, delivery should be delayed until **all** chicks have recovered from the injection.

   There is little that farm management can do with chicks that have been improperly processed except to talk to hatching management.

8. **Chick grading.** All malformed, straddle-legged, and weak chicks should be culled at the hatchery before delivery. A high percentage of abnormal chicks will die or be morbid. Most hatcheries do a good job of removing the abnormal chicks.

9. **Nutritional deficiencies.** Breeder rations that are marginal in certain vitamins and/or trace minerals can result in hatched chicks that are weak and marginal in vitamin and/or

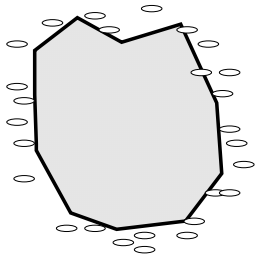
mineral reserves. Those chicks should be fed a prestarter well fortified with vitamins and minerals. Often when young breeder hens have been on a poorly vitamin and mineral-fortified holding ration, the first two or three hatches of chicks will not start and live as well the first week of brooding as later hatches.

Some of the vitamins and minerals which could be deficient in the breeder ration and which could reflect themselves in the young poult are E, K, riboflavin, biotin, folic acid, pantothenic acid and B_{12}. Some of the minerals would be iodine, potassium, manganese and cobalt. Check to see whether the breeder hens are receiving an adequate diet, if not, feed a prestarter. **A prestarter will have more protein, higher vitamin and mineral fortification and higher levels of growth promotant than the regular starter.**

10. **Irregular-sized chicks:** Irregular-sized chicks result from different age of breeder flocks and age size, variations in incubator temperature and humidity. **If the chicks are from a healthy flock, there is little worry since hatching weight is poorly correlated with market weight.**

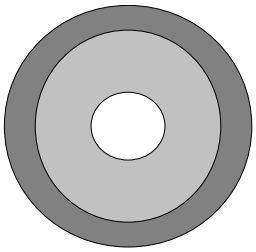
DETERMINING FERTILITY IN AN UNINCUBATED EGG WITH THE UNAIDED EYE

Infertile



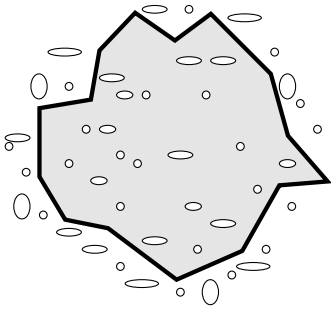
a. The germ spot is a solid white color.
b. The germ spot is relatively small (1/16th")
c. Many vacuoles ("bubbles" or "holes") around the edge of the germ. Sometimes vacuoles are present inside the germ spot.
d. The germ spot is not uniform. It is somewhat circular but has "jagged" or "ruffled" edges.

2. **Fertile**



a. Germ spot is faint. Not a solid white spot. Consists of a faint ring. Germ spot may have a faint or solid white disk in the center of the ring.
b. Germ spot is about 2 times larger than the infertile germ (1/8th").
c. Usually no vacuoles visible in the center of the ring. May be a few on the edge of the ring.
d. Germ spot is very uniform. Is circular with no "jagged" edges.

3. **Early Dead Embryo**



a. Germ spot is a mixture of solid and faint white areas.
b. Germ spot is about the same size as the fertile germ.
c. Usually many vacuoles visible on the edges and in the center of the germ.
d. Germ spot is not uniform. Has irregular edges and is usually not circular in shape.

****<u>NOTE</u>: It is very difficult to distinguish between infertile and very early dead embryos; thus, it is not truly reliable.**

BROODING CONCEPTS AND CHICK HEALTH

David D. Frame, DVM, DACPV
Utah State University Extension Poultry Specialist

Even precocial avian species, such as pheasants, quail, and partridge, cannot fully regulate body temperature at hatch. Time between hatching and juvenile feathering is considered the brooding period, and it is during this stage that supplemental heat must be provided. After about three to four weeks the young birds are able to regulate internal body temperature and require little additional heat.

Artificial brooding is most commonly provided using gas brooder stoves or electric infrared heaters. Other methods, such as hot water pipes, etc. have also been successfully used.

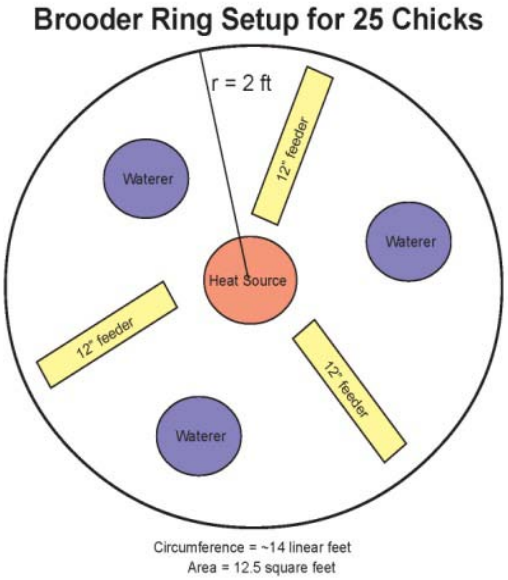
Reasons for brooding

- Provide heat
- Provide confinement
- Provide protection

General brooding guidelines

- Set up brooder rings at least 48 hours in advance of chick arrival
- Pre-heat brooder so litter is warm 24 hours before the chicks arrive.
- Get chicks under heat as soon as possible.
- Provide immediate access to drinking water.
- Establish a temperature gradient: temperature immediately under heat source should be 100°F to 110°F; edge of brooder ring should be ~85°F. Decrease ~5°F per week.
- Make sure feeders and waterers are placed at different temperature areas of the ring so birds will have access to them in their preferred comfort zone.

Figure 1. Brooder ring setup.



The success or failure of the brood occurs within the first 72 hours after arrival. Pay attention to even minute details, such as position of waterers and feeders, attitude of the chicks (are they acting hot or cold?), and environmental conditions ("stuffy" air, too cold, too hot?).

Ventilation control

Perhaps next to suboptimal heat regulation, lack of appropriate ventilation is the greatest cause of non-infectious disease losses. Careful attention to the details of brooder ventilation will more than pay for the time and money invested by yielding greater chick liveability. The minimum provisions for consistent ventilation control is to

1) provide adequate exhaust fans,
2) control incoming air using vent boxes,
3) have a computerized controller, and
4) utilize a method of measuring/monitoring static pressure.

Purposes of ventilation

1) Provide oxygen (O_2) and remove carbon dioxide (CO_2) and other noxious gases, such as carbon monoxide (CO) that can form via incomplete combustion;
2) Remove moisture;
3) Remove dust; and
4) Remove ammonia (NH_3) – usually not a problem during early brooding.

Static pressure

In order to control air flow within a building, the concept of *static pressure* must be understood and used. Static pressure is the slight vacuum caused when fans pull air. It is measured in inches of water column. Static pressure controls the velocity (not quantity!) of air entering a building. Static pressure must be controlled using appropriate inlet space for the amount of fan capacity.

Ventilation concepts

- Static pressure controls air velocity and direction.
- Fan capacity controls air volume.
- Fan efficiency is dependent on inlet space.

Figure 2. Insufficient static pressure.

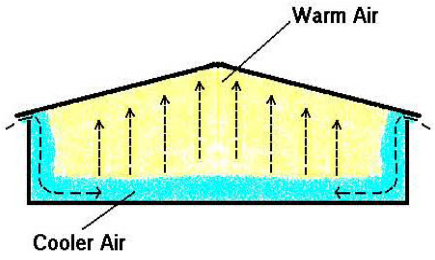


Figure 3. Excessive static pressure.

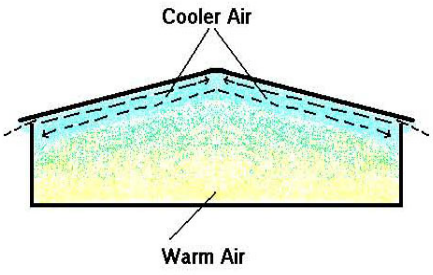


Figure 4. Optimal static pressure.

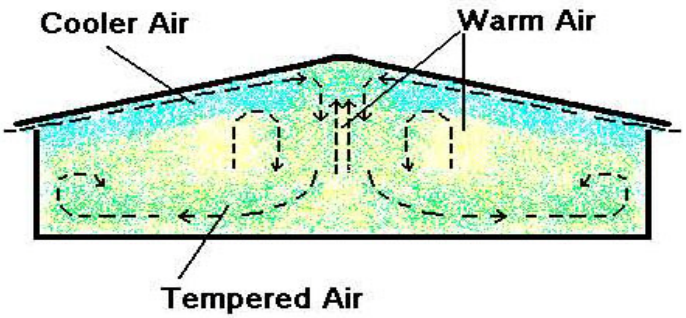


Table 1. General fan capacity rating in cubic feet per minute (cfm).

Fan diameter	cfm rating
18”	1,500 to 2,000
24”	3,000 to 5,000
36”	8,000 to 10,000
48”	18,000 to 20,000

Ventilation rules of thumb (ROTs)

ROT #1: Insulate before you ventilate
Ceiling: R-21
Walls: R-11 to 19

ROT #2: Match inlet space to fan capacity to achieve optimal fan efficiency, directional air movement, air velocity, and air exchange rate.
- 200 in^2 of opening required for each 1,000 cfm
- A typical commercial vent box (~2.40 ft2) will accommodate 1500 cfm

ROT #3: Control incoming air where *you* want it. Seal cracks and crevices, close doors tightly, etc. Force air to come in through the inlets. Place inlets high on wall so cooler air mixes with warm air.

ROT #4: For each 20°F rise in air temperature its water-holding capacity doubles.

ROT #5: Minimum ventilation = 0.1 to 0.2 cfm/chick at placement. Increase accordingly as chicks grow.

ROT #6: Maintain optimal static pressure (0.05” to 0.08” water column).

ROT #7: Control ventilation on a 5 minute cycle – reduces variation.

ROT #8: Understand and apply the differences between *air exchange* and *air movement*
Air exchange: air entering (through inlets) and leaving (through exhaust fans).
Air circulation: movement of air *within* the building.

ROT #9: NEVER put a draft on chicks – even in warm weather. If circulation fans are used, make sure they are not moving air directly over the birds. (Should not need circulation fans for first few days anyway.)

Example calculation (using minimum air approach)

Building = 100 ft x 40 ft
Placement = 5,000 chicks (0.8 ft^2/chick)
Air needs: 0.2 cfm @ placement
1.5 cfm @ moveout

1) Compute fan need
   a) Maximum = 1.5 cfm/chick x 5,000 chicks = 7500 cfm
   b) Decide amount of fans necessary: Two 24" fans (always install an extra fan if computed ventilation need is marginal). In this case, each fan is rated at 5,000 cfm, giving a theoretical capacity of 10,000 cfm.

2) Compute inlet need
   a) Total cfm capacity = 10,000
   b) Vent box size = 2.40 ft^2
   c) Each vent box accommodates 1500 cfm
   d) Total vent boxes needed = 10,000 cfm/1500 cfm = 6.6 (that is, 7 or 8) vent boxes

3) Compute run time on fans for minimum ventilation
   a) At placement:
      i. Minimum requirement = 0.02 cfm/chick x 5,000 chicks = 100 cfm
      ii. This obviously will require only one fan (vent box opening would have to be adjusted). 100 cfm/5000 cfm = 0.02 (or fan running 2% of time)
      iii. 2% of 5 minutes (300 sec) = 6 sec. Notice this is not an efficient amount of time for a fan to work, so I recommend running a minimum of 30 sec/5 minutes as long as this doesn't cool the building. It may take a little more heat cost to do this, but it saves wear and tear on fans and increases efficiency. If the building is excessively cooled by this approach, try backing off to a temporary10 minute cycle (fan on 30 sec/10 minutes)

   b) At moveout:
      i. Minimum requirement = 1.5 cfm/bird x 5,000 birds = 7,500 cfm
      ii. This will require the operation of both fans = 75% capacity
      iii. 75% of 5 minute cycle = 225 sec (3.75 minutes); therefore, both fans would be operating for 3.75 minutes on and 1.75 minutes off.

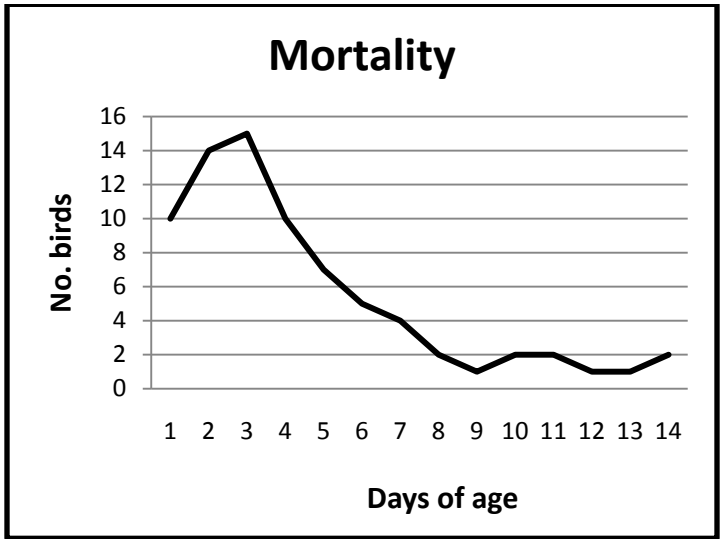
Keep in mind this example is for minimum air need. **Be sure to always have a temperature override on your fans**.

As birds get older *moisture removal* becomes the main controlling issue of power ventilation. If building gets stuffy and litter condition begins to deteriorate (i.e., get wet), fan time will need to be increased. This also applies for dust removal. Build in enough fan capacity and inlet space to accommodate this extra potential need. I have a computer program that can recommend fan capacity based on estimated moisture removal. If interested, contact me directly at david.frame@usu.edu or (435) 283-7586.

Common brooder health issues

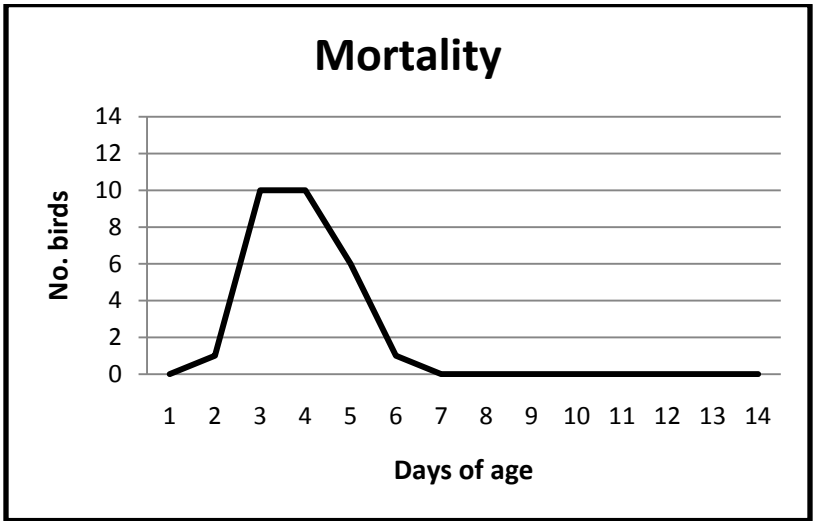
1. Retained yolk sac
    a. Sign of suboptimal metabolism, either late hatch stage or early brooding.
    b. Yolk considered "retained" if present in significant quantity after 3 days of age.
    c. Contributor to starveout mortality
    d. Solution = If chicks appear very docile and seek heat immediately after delivery, temperature may need to be temporarily increased about 5°F under the heat source, but provide additional easily accessible water sources also.

Figure 5. Possible mortality associated with pre-delivery.



2. Starveout
    a. Losses at 3-5 days of age
    b. Small, light, dry feeling
    c. Cause = suboptimal brooding temperature/range, or inaccessibility of water.
    d. Solution = make sure there is a proper heat gradient from underneath heat source to edge of circle. If chicks appear very docile and seek heat immediately after delivery, temperature may need to be temporarily increased about 5°F under the heat source, but provide additional easily accessible water sources also.

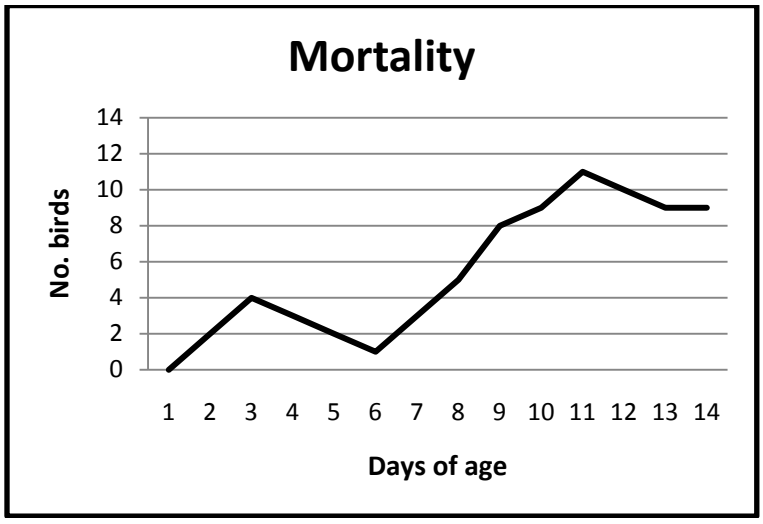
Figure 6. Typical starveout mortality pattern.



3. Bacterial infections
    a. Most common bacteria are *E. coli*, *Salmonella*, *Pseudomonas*, and *Staphylococcus*.
    b. Sources are hatchery and brooder environment.
    c. Suspicious mortality patterns: 1) heavy death loss within first two days after delivery (likely hatchery origin) or 2) increasing mortality during second or third week (likely brooder origin).

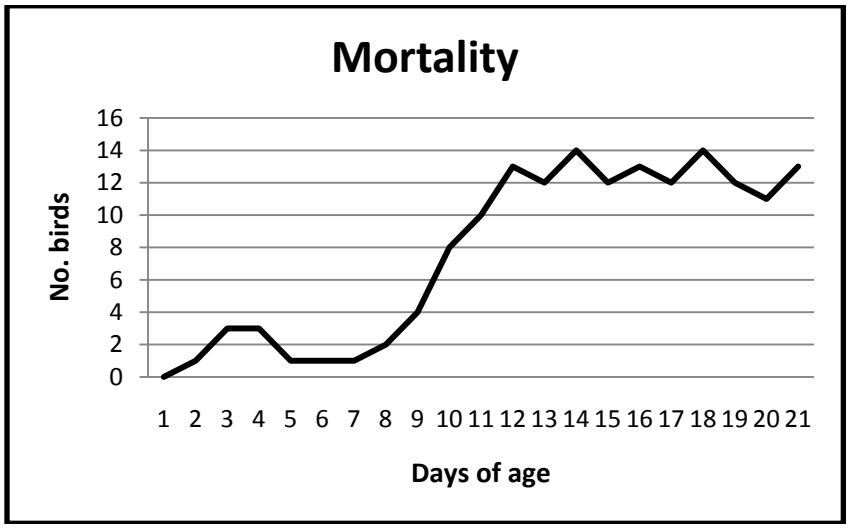
4. Fungal infection (aspergillosis)
    a. Pre-delivery related: mortality starts early ("nodular pneumonia").
    b. Post-delivery related: most common source is litter – especially if it gets wet and dries out again.

Figure 7. Typical enteritis mortality pattern.



4. Nutritional insufficiencies can take on various mortality patterns depending on the cause of the deficiency. Often, there is a combination of deficiencies involving multiple vitamins and/or minerals caused either by lack of proper concentrations in the feed or by inability of the birds to absorb and assimilate (i.e. enteritis) a perfectly normal and balanced feed. General characteristics of nutritional deficiency include slow growth; poor feathering; poor feather quality; lameness or difficulty in moving; "wing-walking"; abnormal neck posture, such as "star-gazing"; or loss of balance, such as walking backwards, tumbling over, or paddling on side.

Figure 8. Mortality pattern that could be related with a nutritional deficiency – especially if birds are small, poorly feathered, and show abnormal behavior.



It is emphasized that the above graphs depict "typical" patterns. Causes cannot definitively be determined by pattern. If unusually high mortality is experienced, representative dead birds should be submitted to a qualified poultry diagnostic laboratory.

PROCEDURE FOR THE EXAMINATION OF CULL AND DEAD GAME BIRDS (POSTMORTEM EXAMINATION OR NECROPSY)

David D. Frame, DVM, DACPV
Utah State University Extension Poultry Specialist

1. Examine outside of birds for parasites, scratches, animal bites, and other signs of injury.
2. Using heavy scissors or tin snips, cut off upper beak and look at sinuses. Gently squeeze sides of beak and check for excess mucus.
3. Using the snips, cut along side of mouth and open the throat to level of where neck enters the body cavity. Observe esophagus for lumps, bumps, atypically colored or textured areas, ulcers, or severe reddening.
4. Cut open the windpipe (trachea) lengthwise and look for excess bloody content, yellowish cheesy material, or excess mucus.
5. Cut open the crop and look at contents. Is it the normal feed? Is it sour-smelling or dry and impacted? Remove contents and look at the crop lining. Is it thickened? Are there reddened or raised areas present?
6. Peel back the skin and feathers from the breast and check for areas of injury, paucity of meat (i.e. starvation), uniformly dry and dark muscles (i.e. dehydration), or presence of tumors.
7. Using a knife, cut down the inner side of each leg until the hip joint is reached. Pull the legs away from body and twist sideways to expose the hip joint. Break one of the leg bones to test the bone strength. Is it soft and rubbery? Does it feel brittle and break too easily?
8. Using the snips, cut away skin and muscle along the rear underside of breast bone to expose the internal organs. Continue cutting along each side of the body cavity until the ribs have been cut in two. Gently raise the breast bone away from the internal organs. Remove the breast by snipping through the bones near the shoulder area, thus exposing the internal organs.
9. Look for cloudy air sacs or cheesy material in the body cavity.
10. Examine heart, liver, lungs, and spleen. Is the heart or liver covered with white or yellowish granular or cheesy material? Is the spleen larger than normal? Are the lungs bright orange-red and spongy, or are they dark red-brown, hard, or compacted?
11. Look at the outer surface of the intestines. Are nodules or areas of hemorrhage present? Slit open the intestines lengthwise and look for worms, bloody content, excess mucus, thickened lining, or other abnormalities.
12. Open up the proventriculus (stomach) and look for pinpoint red lesions, thickening, or enlargement.
13. Slit open the gizzard. Examine contents. Peel away the inner lining and look for reddened or hemorrhagic areas underneath.
14. Examine other areas of the body cavity for abnormalities.
15. Make notes of any abnormalities encountered. If you think your game birds have a problem, contact your area diagnostic laboratory or the USU Extension Poultry Specialist, Dr. David Frame at (435) 283-7586.

Figure 1. External examination of mortality. Examine for parasites, scratches, animal bites, and other signs of injury.

Figure 2. External examination of mortality. Examine eyes, beak, nostrils for unusual growths (i.e. nodules or crusty material) or excess mucus.

Figure 3. External examination of mortality. The application of soapy water helps mat the feathers, keeping them from interfering with the subsequent postmortem examination. Wetting the feathers in this manner also reduces the likelihood of aerosolizing disease-causing agents.

Figure 4. Breast exposed after pulling away skin and feathers. Notice that cuts have been made on the inside of the thighs and the left hip joint has been dislocated by slightly twisting the leg in order to expose the femoral head.

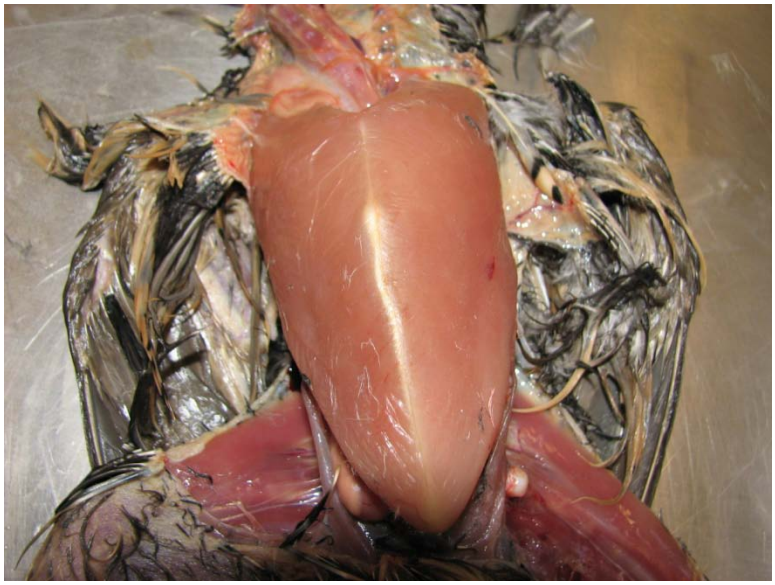


Figure 5. Internal organs in situ. (After removal of the breast.)

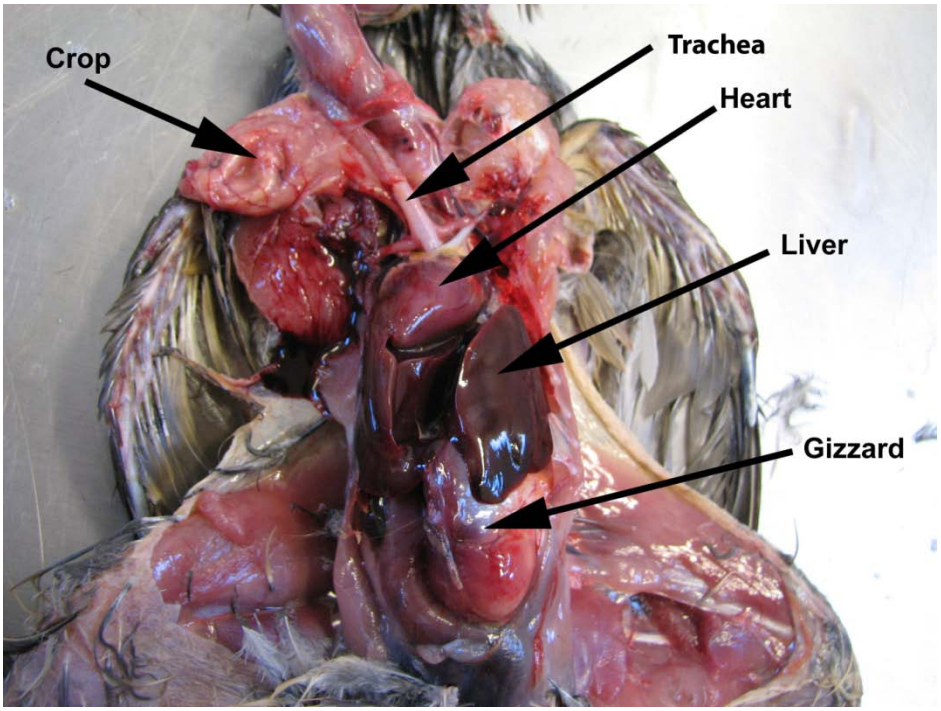
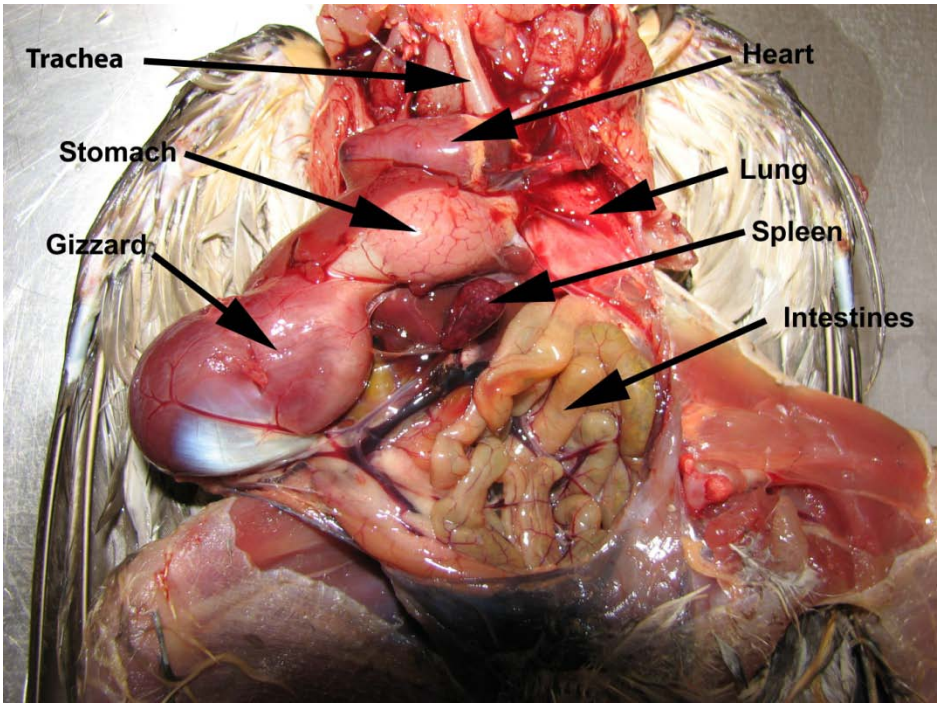


Figure 6. Internal organs in situ. (After lifting away the gizzard and liver.)



AVIAN INFLUENZA IN GAME BIRDS

Warren J. Hess, DVM

Epidemic

In epidemiology, an **epidemic** (επι (epi)- meaning "upon or above" and δεμος (demos)- meaning "people"), occurs when new cases of a certain disease …. and during a given period, substantially exceed what is expected based on recent experience. The disease is not required to be communicable. Examples of epidemics are cancer, heart disease and avian influenza. An epidemic may be restricted to one locale, a region, a country, a continent, or may become global (the latter cases are generally called a **pandemic**). A few cases of a very rare disease may be classified as an epidemic, while many cases of a common disease (such as the common cold) would not.

Pandemic

A **pandemic** (from Greek πᾶν *pan* "all" + δῆμος *demos* "people") is an **epidemic** of infectious disease that is spreading through …. populations across a large region; for instance a continent, or even worldwide. A widespread endemic disease that is stable in terms of how many people are getting sick from it is not a pandemic. Further, flu pandemics exclude seasonal flu, unless the flu of the season is a pandemic. Throughout history there have been a number of pandemics, such as smallpox and tuberculosis. More recent pandemics include the HIV pandemic and the 2009 H1N1 flu pandemic.

Influenza is a viral infection that has three main types; types A, B, and C.

Influenza Type A

Influenza type A viruses can infect people, birds, pigs, horses, and other animals, but wild birds are the natural hosts for these viruses. Influenza type A (think A=Avian) viruses are divided into **subtypes** and named on the basis of two proteins on the surface of the virus: hemagglutinin (HA) and neuraminidase (NA). Only influenza A viruses infect birds, and all known subtypes of influenza A viruses can infect birds. However, there are substantial genetic differences between the influenza A subtypes that typically infect birds and those that infect both people and birds.

Influenza Type B

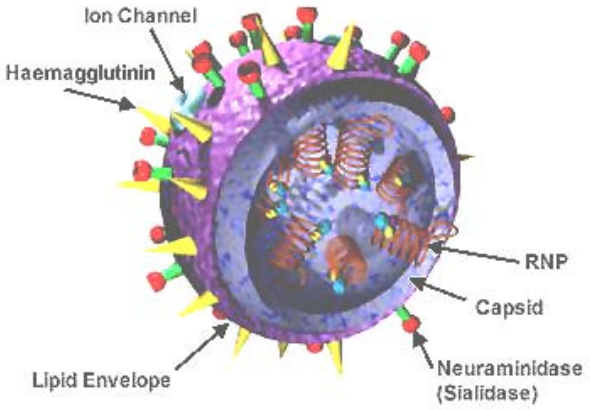
Influenza B viruses are usually found only in humans. Unlike influenza A viruses, these viruses are not classified according to subtype. Influenza B viruses can cause morbidity and mortality among humans, but in general are associated with less severe epidemics than influenza A viruses. Although influenza type B viruses can cause human epidemics, they have not caused pandemics.

Influenza Type C

Influenza type C viruses cause mild illness in humans and do not cause epidemics or pandemics. These viruses are not classified according to subtype.

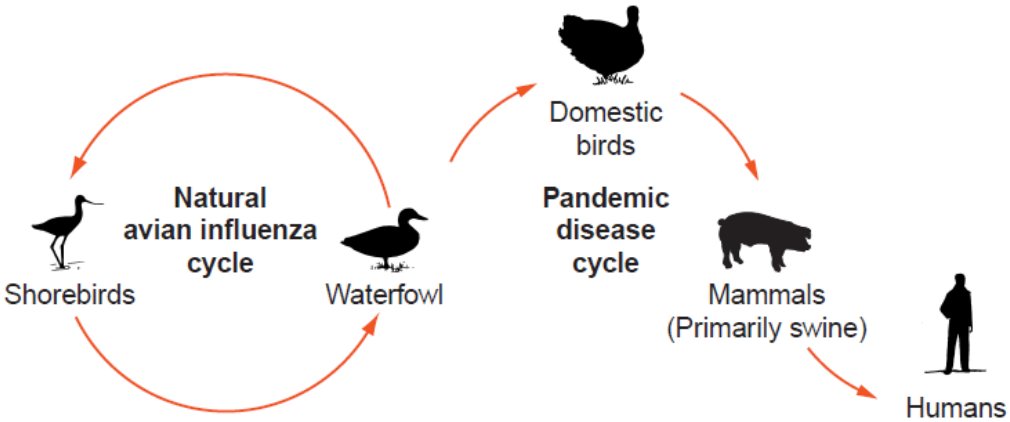
Avian influenza (AI) is only caused by influenza type A viruses and are classified according to their subtypes.

Influenza A Virus Subtypes



Hemagglutinin – 16 unique proteins (H1-H16)
Neuraminidase – 9 unique proteins (N1-N9)
16 X 9 = 144 potential subtypes of Influenza A viruses
Many different **strains** within each **subtype**

Influenza A Transmission Cycle



Avian influenza virus strains are further classified as low pathogenicity (LPAI) or highly pathogenic (HPAI) on the basis of specific molecular genetic and pathogenesis criteria that require specific testing.

Low path avian influenza (LPAI)

LPAI typically causes high morbidity but low mortality in one or more avian species and is generally similar in humans.

High path avian influenza (HPAI)

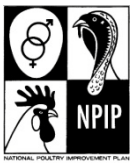
HPAI generally causes high morbidity and high mortality in one or more avian species, and may cause low or high morbidity and mortality in humans.

LPAI vs. HPAI

- Most cases of AI in birds is LPAI
- LPAI in birds can mutate to HPAI
- LPAI in humans: examples are H7N7, H9N2, and H7N2
- HPAI in humans can be mild or severe and the same subtype can cause either extreme
    - Mild – H7N3, H7N7
    - Severe/Fatal – H5N1, H7N7

Bio-security is the most effective device a breeder has to protect themselves from AI exposure. The entire concept behind bio-security is to limit contact with unnecessary items that could potentially carry the AI (or any other) virus. Waterfowl are the most common carriers of AI and therefore should never be allowed on or near a breeding facility. The better protected the game birds are from migrating waterfowl, the better protected they will be. Other common errors made with bio-security are allowing other breeders on your property without proper personal protective equipment (PPE) so that they don't accidentally carry something onto your place, sharing equipment with other breeders, and allowing employees to have contact with other birds (pet birds, raising their own birds, contact with live bird markets, etc.).

National Poultry Improvement Plan (NPIP)



The NPIP program allows for national certification of flocks. This certification indicates that a flock has either tested negative or is being monitored for specific diseases. For game bird flocks, the type of certification is different for breeding flocks vs. birds raise for release. Any poults or eggs being sent out of state (even if they are only to be raised there for release) need to be NPIP certified as a breeding flock.

- Game Bird Breeding Flocks
  - Part 145 Subparts A&E
    - Designations
      - U.S. Pullorum-Typhoid (PT) Clean
      - U.S. Mycoplasma Gallisepticum (MG) Clean
      - U.S. Mycoplasma Synovia (MS) Clean
      - U.S. H5/H7 Avian Influenza Clean
- Game Birds Raised-for-Release
  - Part 146 Subparts A&E
    - Designations
      - U.S. H5/H7 Avian Influenza Clean

9 CFR 147 Subpart C

Subpart C—Sanitation Procedures

§ 147.21 Flock sanitation.

To aid in the maintenance of healthy flocks, the following procedures should be practiced:

(a) Baby poultry should be started in a clean brooder house and maintained in constant isolation from older birds and other animals. Personnel that are in contact with older birds and other animals should take precautions, including disinfection of footwear and change of outer clothing, to prevent the introduction of infection through droppings that may adhere to the shoes, clothing, or hands (see § 147.24(a)).

(b) Range used for growing young stock should not have been used for poultry the preceding year. Where broods of different ages must be kept on the same farm, there should be complete depopulation of brooder houses and other premises following infection of such premises by any contagious disease.

(c) Poultry houses should be screened and proofed against free-flying birds. An active rodent eradication campaign is an essential part of the general sanitation program. The area adjacent to the poultry house should be kept free from accumulated manure, rubbish, and unnecessary equipment. Dogs, cats, sheep, cattle, horses, and swine should never have access to poultry operations. Visitors should not be admitted to poultry areas, and authorized personnel should take the necessary precautions to prevent the introduction of disease.

(d) Poultry houses and equipment should be thoroughly cleaned and disinfected prior to use for a new lot of birds (see § 147.24(a)). Feed and water containers should be situated where they

cannot be contaminated by droppings and should be frequently cleaned and disinfected. Dropping boards or pits should be constructed so birds do not have access to the droppings.
(e) Replacement breeders shall be housed at the proper density consistent with the type of building and locality and which will allow the litter to be maintained in a dry condition. Frequent stirring of the litter may be necessary to reduce excess moisture and prevent surface accumulation of droppings. Slat or wire floors should be constructed so as to permit free passage of droppings and to prevent the birds from coming in contact with the droppings. Nesting areas should be kept clean and, where appropriate, filled with clean nesting material.
(f) When an outbreak of disease occurs in a flock, dead or sick birds should be taken, by private carrier, to a diagnostic laboratory for complete examination. All *Salmonella* cultures isolated should be typed serologically, and complete records maintained by the laboratory as to types recovered from each flock within an area. Records on isolations and serological types should be made available to Official State Agencies or other animal disease control regulatory agencies in the respective States for follow up of foci of infection. Such information is necessary for the development of an effective *Salmonella* control program.
(g) Introduction of started or mature birds should be avoided to reduce the possible hazard of introducing infectious diseases. If birds are to be introduced, the health status of both the flock and introduced birds should be evaluated.
(h) In rearing broiler or replacement stock, a sound and adequate immunization program should be adopted. Since different geographic areas may require certain specific recommendations, the program recommended by the State experiment station or other State agencies should be followed.
(i) Feed, pelleted by heat process, should be fed to all age groups. Proper feed pelleting procedures can destroy many disease producing organisms contaminating feedstuffs.
(Approved by the Office of Management and Budget under control number 0579-0007)

§ 147.22 Hatching egg sanitation.

Hatching eggs should be collected from the nests at frequent intervals and, to aid in the prevention of contamination with disease-causing organisms, the following practices should be observed:
(a) Cleaned and disinfected containers, such as egg flats should be used in collecting the nest eggs for hatching. Egg handlers should thoroughly wash their hands with soap and water prior to and after egg collection. Clean outer garments should be worn.
(b) Dirty eggs should not be used for hatching purposes and should be collected in a separate container from the nest eggs. Slightly soiled eggs may be gently dry cleaned by hand.
(c) Hatching eggs should be stored in a designated egg room under conditions that will minimize egg sweating. The egg room walls, ceiling, floor, door, heater, and humidifier should be cleaned and disinfected after every egg pickup. Cleaning and disinfection procedures should be as outlined in § 147.24.
(d) The egg processing area should be cleaned and disinfected daily.
(e) Effective rodent and insect control programs should be implemented.
(f) The egg processing building or area should be designed, located, and constructed of such materials as to assure that proper egg sanitation procedures can be carried out, and that the building itself can be easily, effectively, and routinely sanitized.
(g) All vehicles used for transporting eggs or chicks/poults should be cleaned and disinfected

after use. Cleaning and disinfection procedures should be as outlined in § 147.24.133

An effective program for the prevention and control of Salmonella and other infections should include the following measures:
(a) An effective hatchery sanitation program should be designed and implemented.
(b) The hatchery building should be arranged so that separate rooms are provided for each of the four operations: Egg receiving, incubation and hatching, chick/poult processing, and egg tray and hatching basket washing. Traffic and airflow patterns in the hatchery should be from clean areas to dirty areas (i.e., from egg room to chick/poult processing rooms) and should avoid tracking from dirty areas back into clean areas.
(c) The hatchery rooms, and tables, racks, and other equipment in them should be thoroughly cleaned and disinfected frequently. All hatchery wastes and offal should be burned or otherwise properly disposed of, and the containers used to remove such materials should be cleaned and sanitized after each use.
(d) The hatching compartments of incubators, including the hatching trays, should be thoroughly cleaned and disinfected after each hatch.
(e) Only clean eggs should be used for hatching purposes.
(f) Only new or cleaned and disinfected egg cases should be used for transportation of hatching eggs. Soiled egg case fillers should be destroyed.
(g) Day-old chicks, poults, or other newly hatched poultry should be distributed in clean, new boxes and new chick papers. All crates and vehicles used for transporting birds should be cleaned and disinfected after each use.

§ 147.24 Cleaning and disinfecting.
(a) In the poultry houses

The following procedures are recommended:

§ 147.23 Hatchery sanitation.

(1) Remove all live "escaped" and dead birds from the building. Blow dust from equipment and other exposed surfaces. Empty the residual feed from the feed system and feed pans and remove it from the building. Disassemble feeding equipment and dump and scrape as needed to remove any and all feed cake and residue. Clean up spilled feed around the tank and clean out the tank. Rinse down and wash out the inside of the feed tank to decontaminate the surfaces and allow to dry.
(2) Remove all litter and droppings to an isolated area where there is no opportunity for dissemination of any infectious disease organisms that may be present. Housing where poultry infected with a mycoplasmal disease were kept should remain closed for 7 days before removal of the litter.
(3) Wash down the entire inside surfaces of the building and all the installed equipment such as curtains, ventilation ducts and openings, fans, fan housings and shutters, feeding equipment, watering equipment, etc. Use high pressure and high volume water spray (for example 200 pounds per square inch and 10 gallons per minute or more) to soak into and remove the dirt to decontaminate the building. Scrub the walls, floors, and equipment with a hot soapy water

solution. Rinse to remove soap.
(4) Spray with a disinfectant which is registered by the Environmental Protection Agency as germicidal, fungicidal, pseudomonocidal, and tuberculocidal, in accordance with the specifications for use, as shown on the label of such disinfectant.

(b) In the hatchers and hatchery rooms:

(1) Use cleaning agents and sanitizers that are registered by the U.S. Environmental Protection Agency as germicidal, fungicidal, pseudomonocidal, and tuberculocidal. Use manufacturer's recommended dilution. Remove loose organic debris by sweeping, scraping, vacuuming, brushing, or scrubbing, or by hosing surface with high pressure water (for example 200 pounds per square inch and 10 gallons per minute or more). Remove trays and all controls and fans for separate cleaning. Use hot water (minimum water temperature of 140^{o}F) for cleaning hatching trays and chick separator equipment. Thoroughly wet the ceiling, walls, and floors with a stream of water, then scrub with a hard bristle brush. Use a cleaner/sanitizer that can penetrate protein and fatty deposits. Allow the chemical to cling to treated surfaces at least 10 minutes before rinsing off. Manually scrub any remaining deposits of organic material until they are removed. Rinse until there is no longer any deposit on the walls, particularly near the fan opening, and apply disinfectant. Use a clean and sanitized squeegee to remove excess water, working down from ceilings to walls to floors and being careful not to recontaminate cleaned areas.
(2) Replace the cleaned fans and controls. Replace the trays, preferably still wet from cleaning, and bring the incubator to normal operating temperature.
(3) The hatcher should be fumigated (see § 147.25) or otherwise disinfected prior to the transfer of the eggs.
(4) If the same machine is used for incubating and hatching, the entire machine should be cleaned after each hatch. A vacuum cleaner should be used to remove dust and down from the egg trays; then the entire machine should be vacuumed, mopped, and fumigated (see § 147.25) or otherwise sanitized.

(c) The egg and chick/poult delivery truck drivers and helpers should use the following good biosecurity practices while picking up eggs or delivering chicks/poults

(1) Spray truck tires thoroughly with disinfectant before leaving the main road and entering the farm driveway.
(2) Put on sturdy, disposable plastic boots or clean rubber boots before getting out of the truck cab. Put on a clean smock or coveralls and a hairnet before entering the poultry house.
(3) After loading eggs or unloading chicks/poults, remove the dirty smock/coveralls and place into plastic garbage bag before loading in the truck. Be sure to keep clean coveralls separate from dirty ones.
(4) Reenter the cab of the truck and remove boots before placing feet onto floorboards. Remove hairnet and leave with disposable boots on farm.
(5) Sanitize hands using appropriate hand sanitizer.
(6) Return to the hatchery or go to the next farm and repeat the process.

§ 147.25 Fumigation.

Fumigation may be used for sanitizing eggs and hatchery equipment or rooms as a part of a sanitation program. APHIS disclaims any liability in the use of formaldehyde for failure on the part of the user to adhere to the Occupational Safety and Health Administration (OSHA) standards for formaldehyde fumigation, published in the Dec. 4, 1987, Federal Register (52 FR 46168, Docket Nos. H-225, 225A, and 225B).