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Incubating and Hatching Eggs

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Eggs of exotic birds and common chickens require a standard measure of care in storage and incubation to ensure a successful hatch. Environmental conditions, handling, sanitation and record keeping can impact the success of incubating and hatching eggs.

Fertile Egg Quality

From the smallest canary eggs to the largest ostrich eggs, high quality fertile eggs should always be considered rare and fragile. To successfully hatch eggs, begin with fresh, clean, fertile eggs.

Eggs can be produced "on site" or purchased from many sources. Commercial hatcheries will ensure good fertility, but often will not ship small quantities of eggs.

Eggs easily transmit contagious diseases between flocks. Therefore, to ensure protection from such diseases, purchase eggs from only National Poultry Improvement Plan (NPIP) or equivalent surveyed facilities. Every egg producer should be NPIP tested; further information can be obtained from Texas A&M University NPIP at (979) 845-4186.

If eggs are purchased by mail order, it is important to ensure that the eggs receive proper care in transit. Extremes of temperature and poor handling can destroy prospects for a good hatch.

If fertile eggs are produced "on site" at the business location, the breeding stock must be maintained and supported for maximum health and fertility. Basic egg production is severely affected by day length and lighting control. Egg quality and embryo livability are affected by hen and sire age, health, nutrition, cock/hen ratio, breeder genetics, and other factors that can stress birds such as the weather. Keeping more than four females per male can reduce fertility in some settings. Inbreeding, the mating of closely related males and females, might decrease fertility of eggs and increase embryo mortality. Hatchability of eggs is severely harmed by inbreeding, age and poor health.

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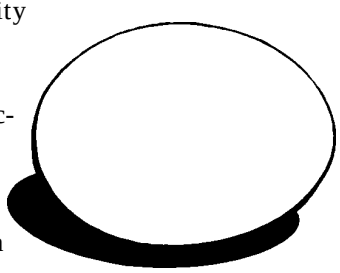
Most eggs are laid by mid-morning. Eggs should be collected several times a day to reduce the amount of time eggs remain in the nest. This practice decreases the number of cracked and soiled eggs and also prevents premature incubation. Embryos begin to prematurely develop at temperatures above 72 degrees F. Starting and stopping embryo development by repeatedly changing temperatures increases embryo death. Frequent collection and proper storage delays embryo development until egg incubation can begin.

Storing Fertile Eggs

Fertile eggs are alive. Each egg contains a living cell mass that develops into an embryo, and finally into a chick. Each incidence of improper handling reduces the probability of a successful hatch. Fertile eggs usually are gathered over a period of time before an adequate number of eggs can accumulate for incubation, or until the incubator is available for a new set of eggs. These normal situations require that, before incubation, eggs must be stored properly to ensure hatchability.

Cleaning and culling—Cracked, poorly shaped, soiled and unusually large or small eggs should not be incubated. These eggs rarely hatch and they increase the probability of introducing infection into the incubator.



Eggs should not be washed. Washing or wiping with a damp cloth removes a protective layer that coats the egg. Soiled eggs should be cleaned by gently buffing the soiled area with fine sandpaper. Washing eggs transfers disease infection agents from the surface to the inside of the eggs.

If an egg is washed, it should be washed briefly in 110-degree F water that contains a commercial egg sanitizer. Washing an egg in water that is cooler than the egg itself causes egg contents to contract. Contraction of egg contents draws water into the egg through pores in the shell. This water carries infecting microorganisms into the egg.

General care—After clean and undamaged eggs have been selected for incubation, use great care to prevent damage or contamination of the eggshells. This includes using frequent hand washing as a barrier to microbial contamination.

Storage time—Ideally, eggs should be set in the incubator as soon after gathering as possible to maintain egg quality. If eggs are to be stored before incubation, the best hatchability occurs when eggs are stored for less than 7 days from the time they were laid. However, some species are more sensitive to storage than other species. Hatchability decreases rapidly in eggs held in storage for more than 10 days. Storing eggs longer than 2 weeks also can extend the normal incubation time as much as 1 day.

Temperature and humidity during storage—Fertile eggs should be stored at a dry bulb, normal temperature between 55 degrees F and 65 degrees F, or 13 degrees C and 18 degrees C. Embryos will begin to develop abnormally, weaken and die if the temperature is too high. A low temperature also causes high embryo mortality. Storage temperature should never exceed 72 degrees F (22 degrees C) and never go below 46 degrees F (8 degrees C). Egg storage at room temperature or at normal refrigerator temperatures (32 degrees F to 40 degrees F) is not acceptable because hatchability decreases.

A refrigerator can be used to store eggs if the temperature is properly adjusted to the recommended temperatures. Eggs should be stored in a refrigerator dedicated to egg storage because these temperatures are not low enough to safely store food. Storage temperature should be reduced to 50 degrees F or 55 degrees F if eggs must be stored more than 2 weeks.

Holding eggs for more than 10 days reduces hatchability. However, chukar and turkey eggs are an exception. Chukar eggs have been stored 3 weeks to 4 weeks without appreciable loss in hatchability.

A good storage area also requires stable humidity. Two methods, wet bulb temperature and relative humidity, are measures of humidity. These two methods should not be confused; whenever humidity measures are discussed, know which method is referenced.

Relative humidity is the water vapor in the air expressed as a percentage of the greatest amount of water vapor possible at that temperature. The amounts of water vapor that air can contain are different at different temperatures. To measure relative humidity, expensive equipment or a complicated procedure is required. However, the wet bulb temperature is easily measured and is the method usually used to measure humidity in an incubator. Relative humidity is expressed as a percentage while wet bulb temperature is expressed as degrees.

A wet bulb thermometer can be purchased or made from a common dry thermometer. Knowing how to make a wet bulb thermometer helps to understand how it works. A thermometer, a shoelace (approximately a 6-inch long piece) and a short piece of dental floss are needed. First, stick the bulb end of the thermometer about 1 inch into the hollow of the shoelace. Next, tie a piece of dental floss around both the shoelace and thermometer directly above the bulb. This is to keep the shoelace from sliding off. Place the opposite end of the shoelace directly in a pan of water. If the water is the same temperature as the air temperature, the reading on the thermometer is the wet bulb temperature. The temperature reading of the wet bulb will be less than a dry thermometer because evaporation of water cools the thermometer.

However, the reading also will be influenced by the relative humidity of the air. The wet bulb reading is used as an index of relative humidity but is not numerically equal to the relative humidity value. The wet bulb temperature will change at different dry bulb temperatures even as the relative humidity remains constant. So, the appropriate wet bulb temperature that is to be maintained must be known for each dry bulb temperature that occurs during storage.

Relative humidity in the storage room should be approximately 70 percent to 80 percent (wet bulb temperature of 50 degrees F to 60 degrees F). Condensation forms on eggshells exposed to excessive humidity. Condensation on the eggshell can clog pores and, like washing eggs, provides a vehicle for contamination. Suffocation or contamination of the embryo can result. Excessive amounts of water evaporate from the egg if humidity is too low, which also causes embryo death. To increase the humidity, a pan of water can be placed in the storage room. If the incubator temperature is correct, the only factor governing humidity is the surface area of water inside the incubator or storage unit. Avoid drafts during storage that can dry eggs even when humidity levels are within appropriate levels.

Hatchability is best maintained by storing eggs with the small end down in sealed, airtight plastic bags. The bags help keep the eggs clean and prevent moisture loss.

Positioning and turning eggs during storage—Eggs that will be stored for less than 10 days before incubation should be placed on egg flats or in egg cartons with the large end up. Eggs do not need to be turned from side to side during storage if they are incubated within the week the eggs are laid. If the eggs are not sealed in a plastic bag, cover them with a loose fitting material to prevent debris or dust from soiling the eggs.

Eggs stored for more than 10 days should be tilted from side to side over a 90-degree angle once or twice a day to assure optimal hatching success rates. To turn eggs during the holding period, place a 6-inch block under one end of the carton (or flat) holding the eggs to produce a 45-degree angle against the floor. The next day, remove the block and place it under the opposite end of the carton. Turning eggs prevents some hatchability loss that can occur during long-term storage.

Incubation

When an adequate number of eggs are collected, move eggs from storage to incubation.

Incubators—Incubators of several types and capacities with adapters for eggs from different species are available. Basically, an incubator is a box that holds and rotates eggs while maintaining appropriate temperature, humidity and oxygen levels. A well-designed incubator should maintain temperature within 1/4 degree F and humidity within 1 degree F wet bulb temperature.

Several features are standard in popular or larger incubator models. Automatic turners that turn eggs at least once every 2 hours to 4 hours are recommended. Humidifiers are of several types. Some are actuated by wet bulb systems while others are designed to maintain humidity by a simple water reservoir surface area system. Either of these systems can be used effectively. Temperature can be controlled by the older wafer system or by newer microprocessor systems. Whatever the system chosen, an incubator with a backup controller set at less than 102 degrees F can save the hatch if the primary temperature controller ever malfunctions. Remember that temperature, humidity, ventilation and turning are the important factors during incubation.

Egg Storage Reminders

- ☆ Store less than 10 days.
- ☆ Maintain temperature between 55 degrees to 65 degrees F.
- ☆ Keep relative humidity at 75 percent (50 to 60 degrees F wet bulb temperature).
- ☆ Turn eggs stored more than a week.
- ☆ Handle the eggs with care!

Consider the differences between forced-draft and still air incubators before choosing a system to use. Forced-draft incubators maintain more consistent temperature and humidity levels throughout the incubator, and recover temperature and humidity to regulated levels faster when doors are opened during the incubation period. In still air incubators, wet bulb readings are misleading and a water reservoir with a large surface area is needed. Temperatures in still air incubators must be monitored at the level of the eggs since temperature can vary considerably between locations within a still air incubator. Forced-draft incubators are preferred.

The temperature and humidity of the room housing the incubator should be controlled and stable. Place the incubator in a stable environment, free of drafts and away from direct sunlight.

Locate the incubator and hatcher away from growing facilities. The equipment and newly hatched chicks can be contaminated by older birds, and the dust that accompanies growing birds. Keep foot traffic to a minimum; personnel should limit trips between the growing area and the incubation area as much as possible. Do this by attending to the incubator and hatchlings before maintaining other areas.

Chicks can be hatched in the same unit in which they were incubated. However, hatching creates large amounts of dust and down. Hatching in a separate unit prevents contaminating and soiling the incubator. Temperature and humidity also can be managed more effectively if separate units are used for incubation and hatching. It is best to keep hatchers in a separate room from the incubator. The incubator and the hatchers should be constructed and coated with material that is easily sanitized. The incubation and hatcher rooms should also be constructed or coated with impermeable material that can be easily washed and sanitized.

Two days before incubation—Prepare and adjust the incubator 2 days or 3 days before setting the eggs. Ensure that the incubator is clean and sanitized. Make proper adjustments to the temperature and humidity at this time. Adjustments made while eggs are set can either lengthen or shorten the time of hatch, or kill or damage the embryos. If the incubator has an automatic turner, make sure the turner functions properly. The temperature in the room where the incubator is located should also be controlled during this time. Do not set the eggs until temperature and humidity are correct and stable.

Cleaning and fumigation—Microbial infection in an incubator can significantly reduce hatchability of eggs. Cleaning procedures and disinfecting equipment should be part of standard operating procedures. Incubators, hatchers and the racks should be disinfected with quaternary ammonia or commercial disinfectant after each hatch.

Some larger businesses fumigate incubators before setting eggs. Occasionally the incubators are fumigated briefly with lower concentrations of the fumigant while eggs are in the incubator. Do not fumigate eggs after the first day of incubation. Embryos are sensitive to fumigation between 2 days and 5 days of incubation. When eggs are fumigated at set, exposure of the eggs should be limited. Only trained individuals should use these techniques.

The day eggs are set—Remove eggs from storage and allow them to warm to room temperature for 4 hours to 8 hours before setting in the incubator. Cold eggs placed into a warm, humid incubator will become covered in condensation that will increase the possibility of egg contamination. Ensure that proper records are maintained so that eggs are turned a minimum of three to five times in a 24-hour period. Failure to turn eggs adequately results in embryo death. Use of an automatic turner considerably simplifies the work and decreases human error during the incubation process.

Once eggs are in the incubator, do not adjust the temperature or humidity for a few hours unless the temperature exceeds 102 degrees F. After 4 hours, make proper adjustments. The final temperature should vary only 1/2 degree above or below 99.5 degrees F. The temperature of incubators without circulating fans fluctuates more than incubators with circulating fans. If the temperature does not exceed 102 degrees F, the hatch should not be harmed.

The small end of the egg should be lower than the large end of the egg when set in the incubator. An embryo orients during incubation so that the head develops toward the large end of the egg where the air cell is located. A chick's head can orient away from the air cell of the egg if the small end is higher than the large end during incubation. An embryo oriented in the wrong direction will not hatch.

Set stage—The 'set stage' refers to the days of incubation prior to the final 2 days or 3 days before a hatch. Different species have different incubation periods (Table 1). Incubating different species at the same time in the same incubator is not recommended, especially if the incubator is also used as a hatcher.

Birds in the wild frequently turn their eggs in the nest. Similarly, turning eggs during incubation prevents embryo death and unhealthy hatches. Eggs must be turned at least five times within a 24-hour period. Turning more frequently is better; once per hour is best. This turning schedule must be maintained even through weekends. An automatic turner is recommended. If the incubator is equipped with an automatic turner, eggs will be turned at least every few hours.

Temperature, humidity and ventilation of incubator (set stage)—Temperature in the incubator should be 99.5 degrees F to 100 degrees F (37.5 degrees C). If the temperature deviates more than 1/2 degree from 100 degrees F, a poor hatch is likely. Temperature should be checked at least twice a day.

Relative humidity should be set at 86 degrees F to 88 degrees F (30 degrees C) wet bulb temperature. Humidity should not fluctuate more than 1 wet bulb degree. If the incubator uses a passive humidity control system, water should be added daily to the water pan or trough to ensure correct humidity levels.

If the humidity in the incubator is too low or too high, the hatch will fail. When humidity is too low during incubation, the air cell will be too large at the time of hatch. The contents of the egg will be too thick and sticky for the chick to turn. The membranes will be too tough to break. The navel will not close properly.

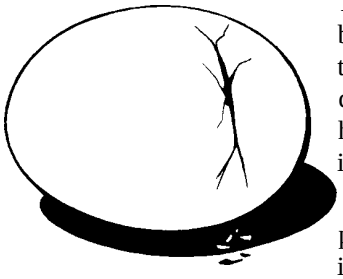
Table 1. Total incubation time to hatch, time for transfer to hatcher, and dry and wet bulb temperatures for common birds.

Common Name	Incubation Conditions			Hatcher Conditions		
	Period (days)	Dry Bulb (° F)	Wet Bulb (° F)	Transfer at day	Dry Bulb (° F)	Wet Bulb (° F)
Canary	13-14	100.5	86-88	11	99	90-94
Chicken	21	99.5	86	18	98.5	90-94
Cockatiel	18-20	99.5	86-88	15-18	99	90-94
Cockatoo (various)	22-30	99.5	86-88	20-27	99	90-94
Conure (Sun)	28	99.5	86-88	25	99	90-94
Conure (various)	21-30	99.5	86-88	18-27	99	90-94
Dove	14	99.5	86	12	98.5	90-94
Duck (common)	28	99.5	86-88	25	98.5	90-94
Muscovy Duck	35-37	99.5	86-88	31-33	98.5	90-94
Finch (Zebra)	14	99.5	86-88	12	99	90-94
Domestic Goose	30	99.5	88	27	98.5	90-94
Geese (various)	22-30	99.5	88	20-27	98.5	90-94
Grouse	24-25	99.5	84-86	22	99	90-94
Guinea	28	99.5	84-86	25	98.5	90-94
Lovebird (various)	22-25	99.5	86-88	20-22	99	90-94
Macaw (various)	26-28	99.5	86-88	23-25	99	90-94
Mynah	14	100.5	86-88	12	99	90-94
Parakeet (various)	18-26	99.5	86-88	15-23	99	90-94
Budgerigar	18	99.5	86-88	15	99	90-94
Parrot (various)	18-28	99.5	86-88	15-25	99	90-94
Parrot (African Grey)	28	99.5	86-88	25	99	90-94
Chukar Partridge	23-24	99.5	88	20	99	90-94
Peafowl	28-29	99.5	86-88	25-26	98.5	90-94
Ptarmigan	21-23	99.5	86-88	18-20	99	90-94
Raven	20-21	99.5	86-88	17-18	99	90-94
Ring-neck Pheasant	24-25	99.5	86-88	21	99	92-95
Pheasant (various)	22-28	99.5	86-88	20-25	99	92-95
Pigeon	17-19	100.5	88	14	99	92-95
Bobwhite Quail	23	99.5	84-86	21	99	90-94
Japanese Quail	17-18	99.5	86-88	15	99	90-94
Swan (various)	33-37	99.5	86-88	30-33	99	90-94
Turkey	28	99.5	84-86	25	98.5	90-94
Emu	49-50	97.5	70-75	47	97.5	90
Ostrich	42	97.5	70-75	39	97.5	90
Rhea	36-42	97.5	80		97.5	90

[1] This period is the entire incubation time until hatch that includes 3 days in the hatcher. Ventilation should be increased half way through the incubation period.

If the humidity in the incubator is too high during incubation, too little water will evaporate from the egg. The air cell will be too small for the chick to reach during the hatching process. The chick will either drown or the chick will be too swollen with water to turn itself within the egg. The yolk sac will also be too large for the navel to completely close. These problems will cause the hatch to fail.

The air cell of the egg should become larger as incubation progresses. Chicken eggs will lose 12 percent to 14 percent of their total weight by evaporation during incubation. The growth of this air cell is a balance between temperature and humidity during the incubation. Racks of eggs can be weighed during incubation to detect problems with humidity and evaporative loss before a hatch is destroyed.



The chick embryo uses oxygen and produces carbon dioxide. This gas exchange is insignificant during the early period of incubation or when a small number of eggs are incubated. However, recommendations of the incubator manufacturer should be followed to assure that adequate oxygen is available to the developing chicks. Near the end of the incubation period, the eggs are nearly filled with the embryo. An incubator filled with eggs contains a large animal mass that requires large amounts of oxygen. Adequate ventilation is needed during the end of the incubation period. Particular attention should be focused on air vent settings, and wet and dry bulb temperatures during the last third of incubation.

Record keeping—Keep a daily record of the incubator environment (Appendix A). This sample record is designed for use with eggs that hatch after 21 days of incubation. Record keeping can be used to detect malfunctions before a disaster develops. Also, records of fertility and embryo deaths alert the hatchery manager to production, storage, or incubator problems so that adjustments can be corrected before major losses occur.

Proper records call attention to deviations that could destroy a producer's profits. A 5 percent loss of hatchability can go unnoticed. **However, a 5 percent loss is 100 percent profit, and conditions that cause a 5 percent reduction in hatchability also contribute to health problems in successfully hatched chicks.**

Candling

All incubated eggs will not hatch. It is probable that only 90 percent or less of incubated eggs are fertile. Removal of eggs that can be identified as infertile or dead eliminates possible sources of contamination from the incubator. Candling can be used to identify some of these eggs.

Shining a light through the egg to observe embryo development is called "candling." White or pale eggs are more easily candled than dark or speckled eggs. Many people use small flashlights with lenses the size of a nickel that can be focused to candle eggs. Excellent candlers also can be purchased at a reasonable cost. Simple candling devices can be made by inserting a light into a container and cutting a small hole to emit light, or by taping a cone formed from several thicknesses of paper over the lens of a bright light projector. The hole that allows light to pass from the tip of the cone should be the size of a dime or quarter (depending upon the size of the egg).

In a dark room, hold the egg to the light of the candler to observe the contents of the egg. Cooling that occurs for short periods (less than 10 minutes) during careful examination of eggs does not harm the development of the embryo. However, limit the exposure of the egg to the hot light source. Even a brief period at 104 degrees F kills all embryos.

The presence of embryos can be confirmed easily after 8 days to 12 days of incubation. The embryo is located in the large end of the egg, where blood vessels radiate under the surface of the shell. The embryo appears as a dark spot that becomes larger as incubation progresses. Eventually only a dark mass and the air cell are seen. An infertile or unincubated egg brightly transmits light in comparison. Remove infertile or nongrowing eggs from the incubator. If questions arise about candling, contact someone with experience for advice.

Dead embryos will sometimes appear as a ring or smear of blood in the egg or a dark spot dried to the inside of the shell. The living embryo will appear as a dark spot in the large end of the egg surrounded by a faint outline of blood vessels. The blood vessels will appear firm and distinct. After embryo death, the embryo no longer grows and the blood system fades.

Retain records of egg infertility or embryo death. Some mortality can be expected, however, unusual occurrences of mortality or certain characteristics of the mortality can be indicators of practices that can be corrected to improve hatchability.

Hatch Stage

The hatch stage refers to the final 2 days to 3 days of incubation. Chicks hatch out of the shell during this stage. Do not turn the eggs during the last 3 days to 4 days of incubation. Transfer eggs to a dedicated hatcher at this time. If a hatcher is unavailable, remove the eggs from the turner and lay the eggs in the hatching basket or place on cloth or rough paper (not newspaper) in the incubator. Make sure that the paper does not obstruct airflow, contact the water, or contact the heating element. Temperature should remain at 99.5 degrees F and increase the humidity to at least 90 degrees F wet bulb. Humidity can be increased by adding either a wet sponge or wet paper towels to increase the evaporative surface in the incubator. The chicks should start to pip within a day of the incubation period listed for the species in Table 1.

Incubation Reminders

- ☆ Locate the incubator in a room with a constant temperature, away from drafts and direct sunlight.
- ☆ Sanitize the incubator.
- ☆ Ensure that the humidifier and wet bulb wick are in working order.
- ☆ Wash hands before touching eggs. Keep germs, dirt and oil away from incubating eggs.
- ☆ Only incubate egg species with similar incubation lengths at the same time in one incubator.
- ☆ The small end of the egg should not be higher than the large end.
- ☆ Keep a daily record of incubator data.
- ☆ Check temperature daily and keep it at 99.5 degrees F to 100 degrees F.
- ☆ Verify that the water trough is full and humidity measures 86 degrees F to 88 degrees F wet bulb.
- ☆ Turn eggs at least five times a day until the last 3 days before hatch.
- ☆ Increase ventilation during the last one-third of the incubation period.
- ☆ Do not turn for the final 3 days. Provide a cloth or rough paper surface upon which chicks can walk.
- ☆ Increase wet bulb to 90 degrees F in the hatcher.

When Chicks Hatch

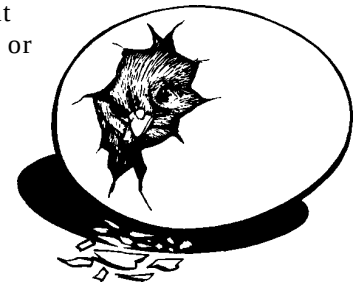
The hatching process requires great exertion by the chick. The chick progresses through periods of activity followed by lengthy periods of rest. The entire hatching process requires 10 hours to 20 hours. Do not be concerned about the time a specific chick requires to hatch unless the process exceeds 20 hours.

Once chicks successfully leave the shell they should remain in the incubator until their feathers are dry. Ventilation should be increased. When more than 90 percent of the chicks are dry they should be removed from the hatcher. Excessive time in the incubator can dehydrate chicks. Remove chicks to a warm brooder and provide them with water and feed.

Eggs that remain unhatched for 1 day beyond the predicted incubation period should be discarded. Attempts to help a chick free itself from the shell often are unsuccessful. Chicks too weak to hatch themselves usually do not live. If they live, they usually will not thrive. Dispose of weak or deformed chicks humanely. These chicks should never be used for breeding purposes because these traits could be transmitted genetically to their young.

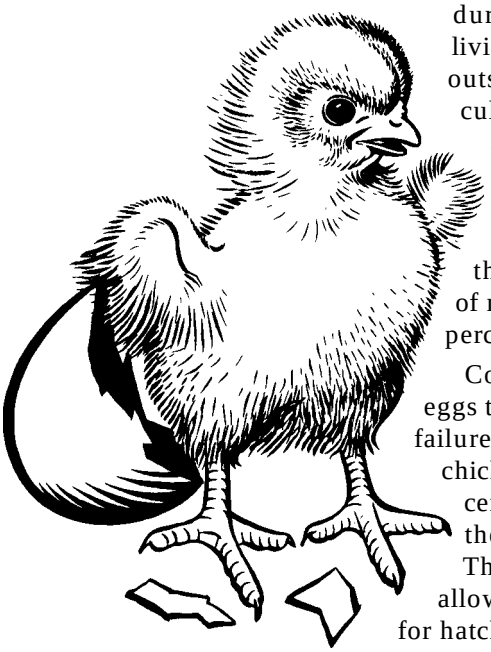
Embryo Mortality (Death)

Unsuccessful hatches can be caused by infertile eggs or embryo mortality. Each of these conditions can be diagnosed after candling and after hatch. Examine eggs that do not hatch to estimate whether infertility or embryo death is the basis for hatch failure. Keep records of the time of embryo death; such records can suggest changes in husbandry that can increase profitability. A sample record form for hatch and fertility failures is in Appendix B.



Embryo death predominately occurs at two periods during incubation: within the first 3 days of incubation and within the last 3 days immediately before a hatch.

Early embryo death occurs during formation of embryonic organs. Of all the eggs determined to be fertile by candling at one-third of incubation, 88 percent to 93 percent should continue to develop.



Death immediately before a hatch occurs during the transition between living in an egg to living on the outside. The chick can have difficulty positioning for pipping, absorbing the yolk sac, or changing to breathing air. Sometimes humidity control can be implicated in some of these problems. An overall hatch of more than 85 percent to 90 percent can be achieved.

Collect and examine all unhatched eggs to determine the cause of hatch failure. An appropriately developed chick within the egg will show certain characteristics. Normally the head is under the right wing. The air cell will be large enough to allow the chick to position correctly for hatching. The shell membranes should not dry to the chick during hatch. Note any dryness. Note the condition of the beak, wings and legs for proper form. All abnormalities should be recorded and analyzed to determine if hatch failure resulted from fertility or environmental problems that can be corrected by changing management procedures. Nutrition can be a factor in fertility and hatchability problems, as recognized by the National Research Council (Appendix C).

Examine the eggs that fail to hatch by removing the top of the egg at the large end. Carefully examine the contents and classify infertile or dead embryos using the designations listed in Table 2.

Use the "Hatchability and Mortality Record" (Appendix B) to calculate the percentage fertility, percentage hatchability and percentage of total eggs hatched. These numbers will help in evaluating hatch efficiency. Any change in these figures, or a change in the distribution in mortality records are early warnings to correct small problems before they become serious.

Table 2. Incubating and Hatching Egg and Chick Classification.

Culled eggs	Cracked, misshapen or otherwise not likely to hatch.
Infertile eggs	Determined to have no germ. Originally infertile. These eggs are clear during candling and show no evidence of blood or embryo development.
Early dead	Embryos died during the first quarter of incubation. Some of these can be detected and removed during candling. These eggs would be fertile and could show a dead early embryo, show no development, development but no blood, or a blood ring.
Middle dead	Embryos died after the "early" period but before transfer.
Late dead	Embryos died during the hatch phase of incubation.
Malformed	Embryos that have an obvious deformity.
Malpositioned	Embryos not positioned correctly for hatching.
Live pips	Chicks that have pipped and are living, but not hatched.
Dead pips	Pipped chicks that died but are not malformed or malpositioned.
Rots	Infected or contaminated eggs.
Culled chicks	Chicks that hatched but are unsound.
Good chicks	Good quality, healthy normal chicks.

Table 3. Possible Causes of Hatching Problems

Observation	Possible Causes
Eggs Exploding	Dirty eggs Improperly cleaned eggs Dirty incubator
No embryonic development	Infertile egg Rough handling of eggs Incubation temperature too high Incubation temperature too low Eggs stored too long

Table 3. Possible Causes of Hatching Problems (continued)

Observation	Possible Causes
No embryonic development	Eggs stored improperly Breeders stressed Too many hens per rooster Old or unhealthy hens or males Inbreeding Disease
Bloodring	Old eggs
Early dead	Incubation temperature too high Incubation temperature too low
Dead embryos, second week	Incubation temperature too high Incubation temperature too low Electric power failure Eggs not turned Inbreeding Infection Poor nutrition of breeders
Air cell too small	Humidity too high
Air cell too large	Humidity too low
Chicks hatch early Dry chicks Bloody navels Chicks too small	Small eggs Temperature too high Humidity too low
Chicks hatch late	Large eggs Old eggs Temperature too low Humidity too high
Chicks dead after pipping shell	Eggs not turned first 2 weeks Thin-shelled eggs Incorrect temperature during incubation Temperature too high during incubation Humidity too high during incubation Humidity too low during incubation Infection, disease
Unhealed navel Mushy or water-logged chicks	Temperature too low during incubation Wide temperature variation in incubator Humidity too high during incubation Poor ventilation
Malformed legs and toes	Improper temperature during incubation Improper humidity during incubation Legs also may be harmed by hatching or holding chicks on a smooth surface
Weak chicks	Temperature too high or low Old eggs Poor ventilation
Gasping chicks	Disease Bronchitis Newcastle disease
Malpositions	Temperature too high or low Turning inadequate Large end of egg not up when set Old or poorly handled eggs Poor breeder nutrition

APPENDIX A: INCUBATOR DATA CHART

Day #	Date	Turner Works[1]			Temperature		Wet Bulb	Water Checked	Candling	Remarks
		1	2	3	Room	Incubator				
1										
2										
3										
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21		XXX	XXX	XXX						

This record is important. Keeping data will help prevent problems from developing during incubation.

[1] Check the turner three times each day except days 19 through 21. Eggs are not turned on these days.

APPENDIX B: Hatchability and Mortality Record

ID #	Set Date	Candling Date	Eggs		Dead			Malformed/ Malposition	Pips Live/Dead	Rots	Chicks		Percentage		
			Culled	Infertile	Early	Middle	Late				Cull	Good	Fertility[1]	Hatch[2]	Total[3]
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This record is important. Keeping data will help identify problems with bird husbandry and incubation.

[1] Fertility (%) = (Fertile Eggs/Eggs Set) x 100%.

[2] Hatchability (%) = (Good Chicks Hatched/Fertile Eggs) x 100%.

[3] Total Eggs Hatched (%) = (Good Chicks Hatched/Eggs Set) x 100%.

Appendix C: Signs of Deficiency in the Embryo

Nutrient:	Deficiency Signs:
Vitamin A	Death at about 48 hours of incubation from failure to develop the circulatory system; abnormalities of kidneys, eyes and skeleton
Vitamin D	Death at about 18 or 19 days of incubation, with malpositions, soft bones, and with a defective upper mandible prominent.
Vitamin E	Early death at about 84 to 96 hours of incubation, with hemorrhaging and circulatory failure (implicated with selenium).
Vitamin K	No physical deformities from a simple deficiency, nor can they be provoked by antivitamins, but mortality occurs between 18 days and hatching, with variable hemorrhaging.
Thiamin	High embryonic mortality during emergence but no obvious symptoms other than polyneuritis in those that survive.
Riboflavin (Vitamin B_2)	Mortality peaks at 60 hours, 14 days, and 20 days of incubation, with peaks prominent early as deficiency becomes severe. Altered limb and mandible development, dwarfism and clubbing of down are defects expressed by embryo.
Niacin	Embryo readily synthesizes sufficient niacin from tryptophan. Various bone and beak malformations occur when certain antagonists are administered during incubation.
Biotin	High death rate at 19 days to 21 days of incubation, parrot beak, chondrodystrophy, several skeletal deformities and webbing between the toes. Perosis.
Pantothenic acid	Deaths appear around 14 days of incubation, although marginal levels may delay problems until emergence. Variable subcutaneous hemorrhaging and edema; wirey down in poults.
Pyridoxine	Early embryonic mortality based on antivitamin use.
Folic acid	Mortality at about 20 days of incubation. The dead generally appear normal, but many have bent tibiotarsus, syndactyly and mandible malformations. In poults, mortality at 26 days to 28 days of incubation with abnormalities of extremities and circulatory system.
Vitamin B_{12}	Mortality at about 20 days of incubation, with atrophy of legs, edema, hemorrhaging, fatty organs, and head between thighs malposition.
Manganese	Deaths peak prior to emergence. Chondrodystrophy, dwarfism, long bone shortening, head malformations, edema, and abnormal feathering are prominent. Perosis.
Zinc	Deaths prior to emergence, and the appearance of rumplessness, depletion of vertebral column, eyes underdeveloped and limbs missing.
Copper	Deaths at early blood stage with no malformations.
Iodine	Prolongation of hatching time, reduced thyroid size, and incomplete abdominal closure.
Iron	Low hematocrit; low blood hemoglobin; poor extra-embryonic circulation in candled eggs.
Selenium	High incidence of dead embryos early in incubation.

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Poster 21559, "The Australian Emu: Embryonic Development," ANR Communication Services, University of California. http://anrcatalog.ucdavis.edu.

Poster 3321, "Development of the Pheasant Embryo," ANR Communication Services, University of California. http://anrcatalog.ucdavis.edu.

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For more information about sources and suppliers of incubators and supplemental equipment, contact the local office of the Texas Agricultural Extension Service or contact Lee Cartwright in the Poultry Science Department, 107 Kleberg Center, 2472 TAMU, College Station, TX 77843-2472, telephone (979) 845-4319, fax (979) 845-1921, e-mail a-cartwright@.tamu.edu

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