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Small Flock Series: Incubation of Poultry

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Hatching eggs — watching an egg turn into a baby chick — is a learning experience for students of all ages as well as a practical way for you to start a small poultry flock. The incubation process is relatively simple, though it may not seem so at first, once you learn the procedures and techniques involved. Incubation procedures for other common farm poultry species such as turkeys and waterfowl are similar to those for chickens; however, there are differences in incubation times and optimum conditions. This publication focuses on care of incubating chicken eggs.

A successful hatch depends on many factors. Good-quality, fresh, fertile eggs and vigorous embryos maintained in a nurturing environment are all elements. Eggs are available from many sources; however, not all sources supply top-quality eggs, and many commercial hatcheries ship only large orders. This publication covers the basics of incubating a small number of eggs, primarily for small flocks or for classroom teaching projects.

Egg handling and storage

The embryo of a fertile egg starts the cell-division process as the egg passes through the warm oviduct of the hen that lays it. The embryo is alive. See Table 1 for the sequence of development of the chick embryo. This development is suspended when the egg cools. For this reason it is important to cool hatching eggs to a temperature between 45 and 55 degrees Fahrenheit as soon as possible after they are laid. Humidity should be about 70 to 75 percent. Common household refrigerators are far too cold for storing fertile eggs. Refrigerators are usually set at between 40 and 45 degrees, and eggs will hatch poorly if placed in these conditions.

Table 1
Events in embryonic development of the chicken egg.

Before egg laying	**Fertilization** **Division and growth of living cells. Segregation of cells into groups of special function (tissues).**
Between laying and incubation	**No-growth stage of inactive embryonic life. (50,000 to 80,000 cells)**
During incubation	
Day 1	

16 hours	First sign of resemblance to a chick embryo
18 hours	Appearance of alimentary tract
20 hours	Appearance of vertebral column
21 hours	Beginning of formation of nervous system
22 hours	Beginning of formation of head
24 hours	Beginning of formation of the eye
Day 2	
25 hours	Beginning of formation of heart
35 hours	Beginning of formation of ear
42 hours	Heart begins to beat
Day 3	
60 hours	Beginning of formation of nose
62 hours	Beginning of formation of legs
64 hours	Beginning of formation of wings
Day 4	
Beginning of formation of tongue	
Day 5	
Beginning of formation of permanent organs and differentiation of sex; Aortic structure begins forming and thickening	
Day 6	
Beginning of formation of beak	
Day 8	
Beginning of formation of feathers	
Day 10	
Beginning of hardening of beak	
Day 13	
Appearance of scales and claws	

Day 14
Embryo gets into position to break the shell
Day 16
Scales, claws, and beak become firm
Day 17
Beak turns toward air cell
Day 19
Yolk begins to enter body cavity
Day 20
Yolk sac completely drawn into body cavity. Embryo occupies practically all the space within the egg except the air cell
Day 21
Hatching of chick

Event listing adapted from Cornell Extension Bulletin 205

Select eggs for hatching that are normal in size, shape, color and shell texture. Excessively large or small eggs are often infertile; do not set these eggs. Remove eggs with obvious defects, dirt and cracks. Pack hatching eggs large end up. Keep them cool. For best hatching results, never store fertile eggs more than two weeks. Eggs hatch best if set within three to four days after laying. Older fertile eggs will hatch satisfactorily if properly stored.

Avoid subjecting hatching eggs to rapid temperature changes or fluctuating temperatures. Place eggs in a suitable storage environment and remove them only before setting. If eggs are kept in cool storage for more than one week, the eggs should be rocked or propped for a period of time leaning to one side and then rocked to lean toward the other side for a period of time to allow the egg contents to move about and not become stuck to the shell.

Sweating occurs when cool eggs are exposed to a sudden increase in environmental temperature or relative humidity. This moisture promotes growth of microorganisms on the shell surface and should be avoided. Microorganisms can be drawn into the egg through shell pores if the egg cools and the contents contract, causing a decrease in internal pressure. Table 2 lists temperatures and relative humidities at which eggs will sweat if they have an internal temperature of 55 or 65 degrees. Microorganisms may cause a poor hatch and even egg spoilage.

Table 2
Effect of temperature and humidity on eggs sweating.

	Relative humidity (percent)	
Environmental temperature	Egg temperature (degrees Fahrenheit)	
	55 degrees F	65 degrees F
60 degrees F	82 percent	
70 degrees F	58 percent	83 percent
80 degrees F	42 percent	60 percent
90 degrees F	30 percent	43 percent
100 degrees F	22 percent	32 percent

The table shows, for example, that if an egg is removed from a cool storage environment (55 degrees Fahrenheit) and placed in a room at 70 degrees, then that egg would sweat when the relative humidity is 58 percent or higher — typical conditions for Missouri.

The cleanliness, soundness and integrity of the egg shell influence the hatch. Do not set cracked or dirty eggs or eggs with thin areas where inadequate calcification has occurred. Cracked or thin shells allow microbial contamination and excessive evaporation from the egg during storage and incubation. Eggs with loose or movable air cells should not be set, because their hatchability also tends to be low.

Sometimes slightly soiled eggs can be cleaned by lightly sanding the soiled area. However, this removes not only the soil but also the cuticle from the egg shell surface. This cuticle is a dried waxlike coating that is deposited on the egg as it is laid. Washing also removes this protective cuticle, making the egg more susceptible to contamination.

Incubation

An egg must be fertile to hatch. Most market eggs found in grocery stores are not fertile. A fertile rooster is essential for the production of fertile eggs. Studies indicate that the egg a hen lays as soon as one day after breeding can be fertile. The fertility and hatchability of eggs produced by a flock and the vigor of the chicks depend on both genetic potential and the environment. The parents' age, nutrition, health, physiological condition and environment will affect the setting egg and hatching chick.

In a small flock, good fertility may be expected within four days following introduction of vigorous males into a flock of females. If the males are removed from the flock, the eggs will show a decline in fertility within four or five days yet may remain at a satisfactory level for up to one week. The semen storage ability of the female fowl may allow fertile eggs to be laid for more than three weeks after removal of the males. The female domestic turkey can store semen for even longer periods and lay fertile eggs as long as 200 days after mating. Hatchability and fertility of eggs tend to decline yearly as a flock ages. The pullet year is the most fertile for the fowl.

Brood hen method

You can let the hens incubate the eggs and rear the chicks, or you can collect the eggs and incubate them artificially. The natural brood hen method will be less expensive but will produce fewer chicks. If you allow several hens to brood a clutch at the same time, you may need additional nests to accommodate the hens of the flock that are still laying.

A hen must be broody (a physiological state in which the hen desires to sit on eggs) before she is used for incubating eggs. Some strains of birds such as the Leghorns seldom become broody. Broody hens may be identified by their tendency to sit on the nest even when not laying an egg; they also cease laying, develop a "clucking" voice and become protective and possessive of the eggs.

Incubator method

The incubator method allows the hens to resume egg production but involves the added expense of an incubator. Thermostatically controlled electric incubators of all sizes are available commercially, or you can build your own incubator.

Getting started

You need to become acquainted with the incubator before starting incubation. Incubators may or may not have internal fans to circulate the air, and the two types operate at slightly different temperatures. (See "Calibration" below.) A small wood and glass incubator, such as those used in Missouri classroom hatching projects, works fine for the later periods of the incubation and hatching process so long as reasonable care is provided in tending the incubator and eggs. Polystyrene and metal desktop incubators work reasonably well if manufacturer's instructions are followed.

Location
Choose a location for the incubator that is free from drafts, out of direct sunlight and not too close to heating ducts and radiators. You will need a sturdy table on which to place the incubator as well as access to an electrical outlet.

Sanitation
Sanitation is very important. Before setting any eggs, clean the incubator. It is essential that the incubator and related equipment be cleaned thoroughly between hatches. This may be done by wiping, sweeping or vacuuming. Heavily soiled areas such as the wire rack on which the eggs were placed may require thorough washing and scrubbing to remove heavy soil.

Before working inside the incubator, be certain to disconnect its electrical cord from the outlet to avoid possible electrical shock. A dilute solution of household bleach and water (20 drops of bleach per quart of water) makes an inexpensive cleaning and disinfecting agent. Take care not to introduce moisture or water into the electrical system of the incubator and allow all surfaces to dry before again reconnecting the electrical cord to the outlet.

Calibration.
It is important that an incubator be calibrated for temperature and humidity control. Allow several hours — preferably overnight — for temperature and humidity inside the incubator to reach equilibrium.

Temperature
With a properly functioning unit, there will be a regular cycle of temperature fluctuations. You should try to maintain an average within the recommended range. If the average temperature is too high or too low, adjust the thermostat accordingly. In the still-air incubator — one without a circulating fan — adjust the wafer thermostat to maintain an average incubation temperature of 100 to 102 degrees Fahrenheit dry-bulb temperature, with an acceptable range from 97 to 102 degrees Fahrenheit. The target for forced-air incubators is usually 99.5 F. The temperature control wafer expands with increasing temperature and shrinks as it cools. A defective snap switch or a leaky wafer will make the temperature control malfunction. New very precise temperature control designs are becoming available, but these also need checking for accuracy.

Humidity
Relative humidity is calculated by using a wet-bulb thermometer to measure the temperature inside the incubator. A web bulb thermometer has a dampened wick covering the bulb. A wet-bulb temperature of 88 degrees Fahrenheit and a dry-bulb temperature of 101 degrees Fahrenheit converts to 60 percent relative humidity. This is a good starting humidity. If the humidity is too low (high wet-bulb temperature) then the size of the evaporation pan must be increased. This can be done either by increasing the size of the pan or by placing a small sponge in the water so that at least half of its surface is still exposed to the air. If the humidity is too high (low wet-bulb temperature), then the size of the pan must be decreased or water surface area reduced.

After a chick has hatched, the effectiveness of humidity control can be assessed by examining the location in which the chick pips — pecks through — the shell. Ideally about one-third of the shell is removed as the chick hatches.

Incubator setup

Operate the incubator for several hours before receiving the eggs so that the temperature and humidity are stabilized. Place a record sheet near the incubator for daily note taking. Records are helpful to keep track of the days of incubation, time eggs are turned, incubator temperature, weight of eggs set, and other notes.

Before handling the eggs, you should also wash your hands and anything the eggs will come into contact with. Incubators are a great environment for growth of harmful bacteria and other germs. Good sanitation is important in obtaining a good hatch.

To avoid excessive thermal shock to the eggs, allow them to warm to room temperature before placing them in the incubator. In incubators without turning devices, place incubating eggs either on their side or with the small end down.

Never cool eggs again after starting incubation. Cooling can occur at temperatures below 80 degrees. In case of a power outage, small incubators may be covered with a blanket to conserve heat for short periods.

For hatches of small groups of eggs, use a pencil to mark on the side of each egg the date on which the eggs are set. Then holding the pencil against the shell at the date mark, rotate the egg half a turn, drawing a line to the opposite side. Mark an X on the shell at the end of the line opposite the date mark. By marking the egg in this way, you will be able to keep track of the direction and rate of turning.

When placing the eggs in incubators without egg-turning devices, lay eggs on their side and space them as evenly as possible allowing room for turning. Do not place the egg with the small end above the large end. If the incubator has a mechanical egg-turning device, set the eggs according to the manufacturer's instructions. This is usually with the large end up. Don't allow the eggs to touch the side of the incubator or get too close to the heat source, which will cause uneven heating and lead to a poor hatch.

Managing the incubation process

During incubation, eggs found to be leaking, cracked, or moldy should be removed and disposed of. Such eggs may explode because of high microbial populations. The released odor is very offensive and would require expedient removal of all the eggs.

The normal incubation time of most chickens is 21 days to 21 days, 6 hours. Table 3 shows normal incubation times for other birds. Incubation time may vary according to temperature of weather and incubator, size of egg, fertility of egg and vigor of the embryo, and a host of other factors.

Several factors affecting the duration and success of incubation are within your control. Four important considerations to keep in mind during incubation are temperature, humidity, turning and ventilation.

Table 3
Incubation periods for various birds.

Bird	Incubation period
Pigeon	18 days
Pea fowl	28 days
Chicken	21 days
Turkey	28 days
Pheasant	21 to 24 days
Goose	28 to 32 days
Guinea	26 to 28 days
Muscovy duck	35 to 37 days
Duck	28 days
Ostrich	42 days

Temperature

Temperature is probably the most important single factor influencing the development of the embryo. Near the optimum incubation temperature ranges, a higher temperature will advance the hatch and a lower temperature will delay hatch. A one-half-degree change in average incubation temperature will move the average hatch time by about 5.4 hours.

To monitor the temperature, place a calibrated and accurate thermometer 1 inch above the wire mesh screen on which the eggs sit. This location corresponds approximately to the top of the eggs, where the temperature should be measured.

Temperature too high. Younger embryos are especially susceptible to high temperatures because the upper lethal limit is very close to the optimum incubating temperature. Operating the incubator at 105 degrees Fahrenheit for 30 minutes will seriously affect, if not kill, the embryos. High temperature will lead to nervous problems, heart and circulatory problems, and kidney problems and will cause the embryonic membranes to dry out too soon. Chicks that hatch may have clubbed, wiry down and an unsteady gait.

Temperature too low. Slightly low temperatures for short periods will have a less severe effect on the embryo than high temperatures. Subnormal temperatures lower the metabolism of the embryo, slowing its growth until the temperature returns to normal. Low temperature for short periods leads to disproportionate growth, because organs and tissues respond differently to temperature variation. Low temperature can also cause heart and circulatory problems, reduce membrane growth and nutrient uptake by the embryo, and cause slower growth after hatching. Older embryos are more susceptible to low temperature.

Humidity

Proper humidity is important because it keeps the egg from losing too much or too little moisture during the incubation process. Eggs should lose between 11 and 14 percent of their weight from day 1 to day 18 of incubation. This weight loss is a direct indicator of humidity control.

Humidity should be balanced with temperature; different temperatures require different relative humidities. Relative humidity should be 60 to 65 percent for the first 18 days of incubation, and 70 percent for the last three days. The water pan in the incubator should be kept full at all times. Use warm water to fill the pan. Humidity adjustments are made as discussed above in the calibration section.

Opening the incubator to turn the eggs will cause a loss of humidity. In very dry environmental conditions, sprinkle the eggs with a little warm water after turning them. You can determine the rate of dehydration by using a flashlight or slide projector to candle, or shine through, an egg so that you can examine the contents. If the air cell is too large, the humidity must be increased. Low humidity can cause the chick to stick to the shell and membranes at hatching. If the air cell is too small, the humidity must be decreased. Excessive humidity will weaken the chick to the point that it can't emerge from the shell at hatching.

From day 19 on, condensation on top of the incubator indicates adequate humidity is present. The amount of condensation varies depending on the temperature of the room where the incubator is located.

It is best not to open or move the incubator during the last three days of incubation for more time than it takes to add water to the pan.

Turning eggs

It is believed that turning the egg prevents adhesion of the embryonic membranes, facilitates movement of the embryo into the normal hatching position (thereby reducing abnormalities and malposition), stimulates the growth of the membranes, and increases the heart rate. The increased heart rate and membrane growth facilitate absorption of the nutrients from the yolk, albumen, and shell, and improves gaseous exchange.

It is necessary to turn the eggs at least three times a day to ensure that the embryo remains close to the center of the egg and does not stick to the shell membranes. Turn the eggs the first thing in the morning and the last thing in the evening and at least one or two times in between. Turning the eggs an odd number of times (5, 7, 9) each day is recommended. Avoid rotating the egg in a full circle, which can cause the embryo and egg components to become tangled and twisted.

Turning should be done through day 17 of incubation, after which the chick is positioning itself for the hatching process. The most important period is from day 1 through day 12, when the chorion and allantois are developing and eventually fuse, forming the chorioallantois. During this time the most critical period is from day 3 through day 7, when the circulatory system is developing and beginning to function. Researchers have found that turning is not necessary past as early as day 14 of chicken egg incubation, although most systems continue to turn the egg through days 17 to 19.

Ventilation

The embryo is living tissue and as such needs to exchange oxygen and carbon dioxide throughout the growth process. The still-air incubator needs holes in the sides to provide air circulation within the incubator. Atmospheric air is best for ventilation since it contains 21 percent oxygen and produces optimum hatching results. It is critical to supply just enough fresh air without overworking the temperature-control system of the incubator.

Preparing for the hatch

Approximately three to four days before hatching is a good time to remove eggs that appear to be infertile or contain dead embryos. Check the eggs by candling, and handle the nonhatching eggs carefully.

It may be helpful to place several layers of cheesecloth over the wire mesh on the bottom of the incubator four days before hatch. This provides a smooth surface to help keep the chicks from injuring their navels or getting their legs caught in the mesh. This also helps keep the incubator clean and the shells out of the water pan.

The hatching process releases much fluffy debris inside the incubator. Care should be taken not to open the incubator in drafts and to carefully remove shells and debris. Wearing gloves and a face mask may help to provide better hygiene while doing this cleanup.

When eggs fail to hatch

Approximately two out of every 10 eggs normally do not hatch. The majority of this expected embryo mortality occurs during the first and last weeks of incubation. Mortality during the last three days of incubation may be the result of an accumulation of factors that weaken chicks to the point that they cannot survive the normal rigors of the hatching process.

Other causes of mortalilty can be related to inappropriate management or function of the incubation process. Common causes of abnormal mortality levels during the first and second weeks of incubation include improper temperature or ventilation. Incubator overheating, for example, can quickly kill the developing embryo. Early in the incubation period, overheating can also contribute to the incidence of exposed viscera (yolk sac and internal organs protruding from body cavity) in the nearly fully developed chick. Overheating, together with rough handling of the eggs, can contribute to malformed head parts, such as a protruding brain, deformed beak or lack of eyes.

Improper temperature or ventilation can also cause death during the pipping stage as chicks peck through their shells. Other possible causes of death at this late stage of development include improper humidity control, disease and even thin egg shells.

Diagnosis of failure to hatch

You may be able to learn why some eggs failed to hatch by breaking and examining them for certain diagnostic signs based on the appearance and comparative development of the egg and embryo. Note that this procedure can be dirty and produce unpleasant smells, so care should be taken. Break the egg into a flat container, such as an old plate, and evaluate the contents according to the following criteria:

Clears
Absence of a blood ring or embryo development indicates that either the embryos died early in incubation or the eggs were infertile.

Blood rings
Clear eggs with a formed blood ring or small embryo indicate that death occurred in the first three days of incubation. Possible causes are incubator malfunction during days 1 to 3 or improper storage of the eggs before setting.

Dead early or midterm embryos
Many factors can cause embryos to die early or in midterm. Possible causes include excessively high or low incubation temperatures, improper turning, low viability of the egg caused by parental nutrition or inheritance, improper ventilation and suffocation, disease, poor egg shell, and contamination. Embryos subjected to overheating will appear red because of hemorrhaging of blood vessels.

Fully formed and not pipped
When chicks die fully formed without pipping, the usual causes include low average incubation temperature, weak viability of setting eggs, improper humidity, genetic defects, contamination or temperature malfunction.

Malformed chicks
Genetic and chance deformities may occur. High temperature during certain formation times may lead to deformities. Rough handling of incubating eggs may contribute to malformations.

Cull chicks
Dry chicks with egg shells sticking to their down may indicate low humidity after pipping starts. Chicks hatching earlier than usual with bloody navels or navels not healed properly might indicate too high temperature or too wide temperature swing during incubation. Chicks hatching later than 24 hours after the start of hatch are commonly cull chicks that will not grow well and will be more susceptible to stress and disease challenges. Prolonged hatches typically result from poor egg vigor or an unbalanced environment throughout the incubation period, not just at the time of hatch.

Weak chicks may be placed in special isolation housing for their protection. However, chicks will be more settled if they are placed with other chicks. Some methods to terminate incubating eggs include placing the eggs in a container filled with carbon dioxide or in a low-temperature environment.

Early chick care

Newly hatched chicks are wet and easily chilled as this moisture evaporates. Chicks should be removed from the incubator when they have dried and the down becomes fluffed. This drying normally takes about 12 hours. The chick also rests following its efforts to cut and exit the egg shell. Avoid frequent opening of the incubator to remove hatching chicks, because this will cause problems related to chilling and loss of humidity for the remaining eggs in the setting.

The newly hatched chick is unable to maintain or regulate its body temperature. The ability to regulate body temperature increases during the first three weeks of the chick's life. The body temperature of a very young chick is below that of the mature fowl. This difference disappears at about three weeks of age. By this time the chick's feathering, metabolism rate, and ratio of surface area to body mass allow the bird to accommodate to a lower environmental temperature. Minimum room temperature is 75 to 80 degrees Fahrenheit for holding the chicks.

Keep the chicks together. A chick placed by itself usually becomes distressed and will cheep loudly for the other chicks. They are best maintained as a flock.

Chicks should be kept in a draft-free area with plenty of nonstale air for them to breathe. A thousand chicks have about the same oxygen demand as one adult human.

Chicks will get a good start if they drink and eat within a few hours after removal from the incubator. The yolk sac they absorb just before hatching can supplement early food needs. If chicks are offered food, they will normally begin eating soon after they are hatched, dried, warm and rested. Bread crumbs, oatmeal, or hard-boiled eggs can serve as temporary diets for the chicks during the first day or two, but a complete commercial diet is recommended.

Early housing of chicks

Brooding is the term used for the early care of the chick. Brooding can be accomplished by the setting hen or by humans acting as surrogate

mothers.

You can provide temporary housing for small groups of chicks, four to 12, using an open-topped cardboard box or similarly constructed container. Allow at least 6 square inches per chick. Cover the top of the box securely with wire mesh, such as chicken wire, to keep the chicks in and pets and other animals out. Attach the wire cover so that entry is not too difficult for the daily care and attention of the birds. Everything the chicks need must be provided in the box. You must provide feed, water, and a supplemental heat source such as a light bulb in a reflector placed above one corner of the box.

Place about an inch-thick layer of pine shavings, peat moss, or sand in the floor of the box to help keep the chicks warm and dry. Clean out the litter as it becomes soiled and wet. This is especially important as the chicks become older and create more waste. Spills and wet areas should be cleaned immediately.

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Related MU Extension publications

- G8350, Small Flock Series: Managing a Family Chicken Flock
  http://extension.missouri.edu/publications/DisplayPub.aspx?P=G8350
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