Chapter 3

Incubation Principles and Hatchery Management

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Abstract

More number of hatching eggs from breeder flocks requires precise technical input for production of quality chicks. Good sanitary conditions are required in hatchery. Incubators with recent advanced technologies provide precise incubations requirements resulting in more number of quality chicks. In this chapter, egg development and incubation process is described. Factors affecting fertility, hatchability and incubation requirements are discussed. Collection, selection, candling, setting, transfer candling, shifting of eggs, hatching and hatchery services have also been discussed. Hatchery building design, incubation methods, types and handling of incubator are given. Major problems in hatchery and their remedies are also discussed. Taking off hatch and hatch processing have been discussed.

Keywords: Incubation, Hatchery Design, Types and Handling of Incubators, Incubation Requirements, Hatchery Trouble Shooting.

3.1 Introduction

Incubation is a process in which a microscopic germ cell is being transformed into a chick, capable of walking, feeding and drinking. Incubation period (days) of different poultry birds are shown in Table 3.1. Different species of birds have different incubation period e.g., chicken egg hatch in 21 days, whereas

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eggs of quails, ducks, pheasants have 17, 28-30 and 28 days incubation period, respectively. During this period, suitable conditions are provided to the hatching eggs for best hatching results. Incubation is of two types, namely, natural incubation and artificial incubation. Natural incubation is commonly used for backyard poultry keeping in villages in most of the tropical countries of world. In this method, eggs are incubated with the help of broody hens. Most important thing in this method is the selection of a broody hen. It should be of medium body size to accommodate fair number of eggs and should be a good-sitter, quiet and free from ectoparasites. A nest bedded with clean, dry and comfortable litter is prepared for this purpose. Nest is usually placed in a dark area of the house with minimum disturbance. During incubation, hen should not be disturbed. Hens should be taken out at least twice a day for about 30 minutes for feeding and watering. The hen should be well taken care of and protected from predators. Depending on size of hen, 10-15 eggs can be placed under one bird. The best time of set hen is at a night as now she is more likely to settle down to her job. Besides, when eggs are put under the hens at night, the chicken are more likely to appear on the night of 21st day and will have whole night to rest and gain strength. In Artificial incubation, requirements of incubation are fulfilled by a machine called incubator. This method uses high modern and sophisticated technology with automation for maximum hatchability. This method of incubation has many advantages over natural incubation which includes possibility to set large number of eggs at a time, throughout the year with less risk of disease transfer. Incubation requirements are provided with their optimum levels to get maximum hatchability and minimum chances of infections. Automation of incubators saves time and labour.

Table 3.1. Incubation period of different poultry birds.

Poultry birds	Incubation period (days)
Chicken	21
Duck	28
Turkey	28
Pigeon	17-19
Peafowl	27
Quail	17
Geese	28-35
Pheasant	23-37
Falcon	28
Ostrich	42

Source: Haq and Akhtar (2004)

3.2 Development of Egg

3.2.1 Female Reproductive System

Female reproductive system consists of ovary and oviduct as given in Figure 3.1.

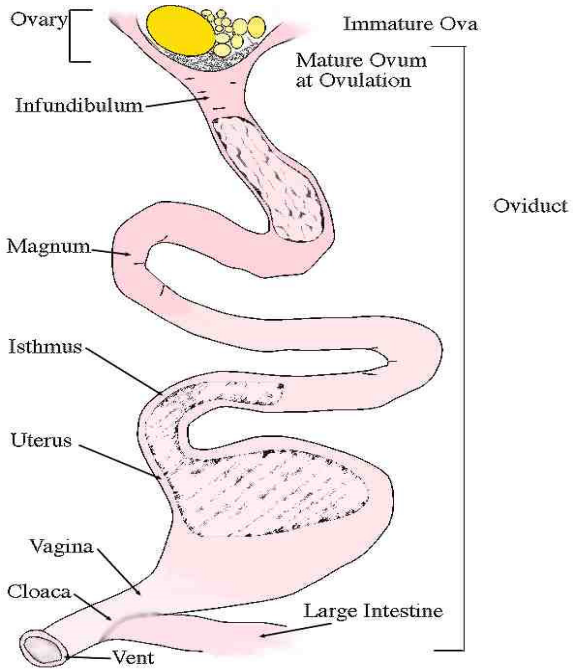


Fig. 3.1. Female Reproductive System of Chicken
Source: Haq and Akhtar (2004)

3.2.2 Ovary

Female chick has two ovaries. Left ovary in adult birds is functional while right ovary atrophies. An ovum from left ovary is received by infundibulum. Each ovum contains germinal disc where fertilization takes place.

3.2.3 Oviduct

Female chick has two oviducts. Left oviduct in adult birds is functional while right oviduct atrophies Oviduct is a coiled tube that extends to cloaca. Oviduct has following five distinct parts.

3.2.3.1 Funnel of Infundibulum

It is funnel shaped anterior portion, which receives ovum or yolk immediately after release. Infundibulum length is 9 cm which receives ovum from ovary. Ovum remains here for 15 minutes before moving to magnum.

3.2.3.2 Magnum

Largest portion of oviduct is magnum which is 33 cm long. It secretes thick albumen and developing egg spends about three hours in magnum.

3.2.3.3 Isthmus

Developing egg stay in isthmus is for about 74 minutes. It is 10 cm long in laying birds as given in Table 3.2. Isthmus secretes shell membranes.

3.2.3.4 Uterus

Uterus or shell gland secretes outer thin albumen and eggshell. It is 10-12 cm long in laying birds. Developing egg stays here for 19.5 to 20.0 hours as given in Table 3.2.

3.2.3.5 Vagina

It is terminal portion of oviduct and 12 cm long in adult hen. It holds egg until laid (Austic and Nesheim 1990).

Table 3.2. Oviduct parts and their functions

Parts	Length	Egg stay time	Function
Infundibulum	8- 10 cm	15-20 min.	Fertilization
Magnum	30-40 cm	3-4 hr.	Albumen secretion
Isthmus	10 cm	1-1.5 hr.	Shell membrane formation
Shell gland (Uterus)	10 cm	19.5-20 hr.	Shell formation
Vagina	6-7 cm	15 min.	Hold egg before it is laid

Source: Haq and Akhtar (2004)

3.2.4 Ovulation

Follicle stimulating hormone is produced by anterior pituitary which in turn causes ovarian follicles to increase in size eleven days before the first egg is laid. Ovary starts generating estrogen, progesterone and testosterone hormones. Progesterone induces hypothalamus to release Luteinizing hormone (LH) from anterior pituitary. LH causes release of ovum from ovary which is received by the infundibulum.

3.2.5 Pre-Laying Development

After fertilization in infundibulum ova transfer to magnum where it prepares itself for cell division. In isthmus cell divide itself into 8 cells. In shell gland cells divide up to 256 cells up to entrance to vagina. Cells arrange themselves into a single layer called blastodisc. Due to continuous cell division, further layers formed beneath blastodisc called as blastoderm stage. Centrally located cells of blastoderm form a cavity called Blastocele. Transparent detached area of yolk is called area pellucida while opaque and contact area of yolk is called area opaca. Blastoderm develop into two layers by gastrulation process which involves segregation of cells to form an inner layer Endoderm (Hypoblast) and a surface layer Ectoderm (Epiblast) (Bell and Weaver 2007).

3.2.6 Post-Laying Development

Mesoderm layer of cells develop in the center of Ectoderm and endoderm. During first 24 hours of incubation a distinct line called primitive streak develop by

thickening of ectoderm. A longitudinal groove "primitive groove" appears on primitive streak, which develop into Central Nervous System or spinal cord.

Ectoderm develops to nervous system, eyes, feathers, beak, claws, skin, mouth lining and vent. Endoderm gives rise to the respiratory, secretary and digestive systems. Mesoderm gives rise to bones, muscles, blood circulatory, reproductive and excretory systems (Bell and Weaver 2007).

3.2.6.1 Extra Embryonic Membranes

These are four in number and supply nutrients to developing embryo.

3.2.6.2 Yolk Sac

It comprises of mesoderm over a layer of endoderm, richly supplied with blood vessels, connected to vitelline membrane for provision of nutrients of yolk (48% water and 3.1% fat) to embryo. It secretes enzyme for yolk solubilization as nutrient.

3.2.6.3 Amnion

Transparent and non-vascular membrane, containing amniotic fluid, formed (2^{nd} or 3^{rd} day of incubation) around embryo tending to enter yolk. Fluid bath embryo, protecting it from dehydration, mechanical shock, temperature stress.

3.2.6.4 Chorion

Chorion with outer layer of ectoderm and inner layer of mesoderm surrounding extra embryonic sac fuses to the inner shell membrane of the egg. It helps later in completing its metabolic function.

3.2.6.5 Allantois

Allantois made up of endoderm, occupies space between amnion and chorion, having direct contact with shell membrane through capillaries, it serves as an embryonic respirators surface, deposits excretion of embryonic kidney, aid in albumen digestion as a nutrient and absorb Ca of shell for embryo structural needs.

3.2.6.6 Physical Act of Hatching

Spasmodic contraction of the chick causes reflection in muscles of back and neck. This reflection results in jerky movement of head in forward direction, which eventually contacts allantois and rupture it entering to air space. Air cell has air mixture containing 9% CO_2 and 9% O_2, which stimulates chick to break the shell at one point by striking shell with beak a process called pipping.

3.2.6.7 Mal-Positions of the Embryo

Right position of embryo before hatching is head towards right, beak under right wing and beak towards air cell/broader end. Malpositions are head towards smaller end, head between thighs, head under left wing, body rotated from its normal position, feet over the head, head over wing and body across the egg.

3.2.6.8 Critical Periods in the Life of the Embryo

There are mainly two most important critical periods, first is 42 hours of incubation (Heart begins to beat) and second at 20th day (Pulmonary respiration begins and lungs become fully functional).

3.2.6.9 Causes of Developing Embryo Mortality

First week =Cause is improper storage and infertility.

10-12 days=Nutritional deficiency in the breeder flock diet.

19-21 days = Improper temperature, humidity and ventilation of incubator.

There are four critical periods.

a. Period-1 (Pre-ovipositional Mortality)

When eggs are held under the hen too long or egg laid earlier cause embryo mortality. This factor either advances the embryonic development too far than the gastrula stage or either gastrulation has not been completed.

Large eggs take longer time than small eggs. Eggs with thick shells take longer time than those with thin shells. Eggs of poorer producer require longer period in the oviduct. Certain respiratory diseases cause eggs to be laid early. During period-I mortality is 0.6 percent as given in Table 3.3.

b. Period-II (3-5 days of Incubation. Early Dead Embryos)

During this period, there are two main reasons of death.

At 24 hours of the incubation primary blood vessel system develops. If not develop, it causes death on 3rd day of incubation. Second cause of death is non-adjustment of utilization of feed from simple carbohydrates to complex protein and fats, at the fourth day of incubation. There is excessive accumulation of CO_2, NH_3 and acetic acid in blood circulation leading to death of embryo.

Main reason of mortality is poor hygienic, storage conditions of eggs before setting, high incubator temperature and insufficient turning of eggs. Mortality -during this period may become higher up to 25 percent.

c. Period-III (10-14 days Mortality. Middle Period)

During this period mortality may be up to 50 percent. Main reason is deficiency of nutrients such as Riboflavin in breeder diet. Deficiency results in clubbed down, generalized oedema of the embryo, curled toes, crooked keel and beak, blood clots.

d. Period-IV (19-21 days Mortality, Late Period)

Main reasons of high mortality during this period are:

Early weakening of embryos, incorrect temperature, humidity and ventilation, of incubator. Rough and careless handling of the eggs during transfer from setter to hatchery (Jadhave and Saddiqui 2007).

Table 3.3. Mortality rate during critical stages of chick development.

Critical Stage	Mortality (%)
Period I	0.6
Period II	2.0
Period III	0.6
Period IV	3.0
Infertile	5.0
Pips	0.8
Total	12.0

Source: Haq and Akhtar (2004)

3.3 Collection and Cleaning of Hatching Eggs

Provide one egg nest for 4 or 5 hens. Number of nests should be increased during high temperature. Nest should be placed at dark area up to the height of tail of the bird. Nesting material should be dry and in good condition. Provide proper ventilation to the nests. Hatching eggs should be collected at least 6-8 times/days. Culled eggs should be separated during collection. Washing of hatching eggs may introduce microorganisms into egg and is not a good practice and excessively dirty eggs should be culled. Slightly soiled eggs are cleaned with a blade/sand paper.

3.3.1 Selection of Hatching Eggs

Hatching eggs should be of medium size i.e. 54-64 g average weight 57 g. Eggs should be oval shape. Eggs shell should be smooth and strong with 0.33-0.35 mm shell thickness. Eggs should be clean without cracks. Position of yolk should be in center without blood or meat spots.

3.3.2 Storage of Hatching Eggs

For one-week storage of hatching eggs temperature should be 59-60°F for longer storage temperature should be 50-55 °F. Relative humidity should be 55%. During storage, broader end of hatching eggs should be in upward direction.

3.3.3 Fumigation

It is a process in which through chemical reaction formaldehyde gas is evolved to kill harmful germs in an incubator, hatchery or farm. $KMnO_4$ and formalin are used for fumigation. For every 100 cubic feet volume, 17.5 g $KMnO_4$ and 35 ml formalin (40%) is used. This is called single strength (1X concentration). For different purposes concentration, can be increased up to 5X as shown in Table 3.4.

3.3.3.1 Method

Add 17.5 g $KMnO_4$ in an earthen pot in air tight fumigation chamber then add formalin and close door for 20-30 minutes preferably at 55 °F temperature.

Table 3.4. Formaldehyde fumigation concentration recommendations.

	Fumigation	Concentration	Time (min.)
i.	Hatching eggs after laying	3x	20
ii.	Eggs in setter (1st day)	2x	20
iii.	Chicks in hatchers	1x	30
iv.	Incubator room	1x, 2x	30
v.	Hatchery between hatches	3x	30
vi.	Hatchery room, chick room between hatches	3x	30
vii.	Wash room	3x	30
viii.	Chick boxes, pads	3x	30
ix.	Trucks	5x	20

Source: Haq and Akhtar (2004)

3.4 Hatchery Design

A modern hatchery can be divided in two major parts namely administrative side and works side. Administrative side consists of offices where records and correspondence is done here. It consists of inquiry office, switchboard room, a waiting room and working rooms for different offices. Works side comprises all rooms set aside for receiving and eggs setting, pre-fumigation of eggs, setters and hatchers, sexing, packing and dispatch of chicks, washing and sterilizing, stores, boiler house, workshops and garage. Rooms should be in orderly sequence to ensure minimum internal travel and crossing of lines of movement within hatchery.

3.5 Incubation Methods

Process of change of fertilized egg to a living organism capable of walking and eating is called incubation. Incubation is done by natural and artificial methods.

3.5.1 Natural Incubation

Natural incubation is a process of setting hatching eggs under the hen. Natural incubation is better on small scale for house hold purposes. A medium sized broody hen is required characterized by ruffled and loose feathers from under hen's wings and legs. It should be properly checked for parasites and to kill external parasites Neguvan can be effectively used. Deworming should be done to kill internal parasites. 12-15 eggs can be set under a broody hen. Dimension of broody nest should be (14" × 14" with 16" height) about 4" high from ground. Nest should be lined with clean nesting material and dusted with insecticide powder. Floor of nest should be saucer shape to prevent rolling out of eggs. Every day hen should be taken off the nest for exercise and feeding for 10-20 minutes at the same time. Eggs should be tested on 9th and 16th days and all dead in shell should be removed. As soon as hatch is off, unhatched eggs and nesting material should be removed. Nest should be dusted before adding new litter in it.

3.5.2 Artificial Incubation

All the necessary requirements of incubation are provided artificially through the help of machine called incubator and process is known as artificial incubation.

3.6 Types of Incubators

There are two types of artificial incubators i.e., small and large incubators.

3.6.1 Small Incubators

Small incubators are flat type incubators (these incubators are heated with oil) and electrically heated incubators (heat source is electricity).

These incubators are used for production of chicks on small scale. 50-500 eggs can be set in only single layer. Position of the eggs is flat. Ventilation is provided through natural means i.e. holes are provided for ventilation. Ventilation is affected by changes of internal temperature. Eggs are turned manually and individually. 3-5 turnings are required per day. Incubation temperature is as given in Table 3.5.

Table 3.5. Incubation temperature of small incubators.

Incubation time (days)	Incubation temperature (°F)
1-7	102.5 - 103.0
8-18	102.0
1-21	101.0

Source: Haq and Akhtar (2004)

3.6.2 Large Incubators

These are mammoth/cabinet/forced draft incubators and walk-in incubators. These incubators are used by commercial chick hatcheries for production of chicks on large scale. Their capacity ranges from 10,000 to 138,000. Incubator has two parts: setter and hatcher. Setter and hatcher may be separate or combined in an incubator.

3.6.2.1 Setter

This is part of incubator where fertile eggs set for 1-18 days. It has multiple trays for setting of eggs. Eggs are set with broader end up and pointed end down. These eggs turned automatically after each hour. Ventilation is provided through ventilators. Heat source is electricity and uniform temperature is provided with the help of fans and paddles. Temperature is maintained at 99.5°F in setter.

3.6.2.2 Hatcher

Eggs remain in hatcher for 19-21 days. Eggs should not be turned during this period. Its capacity is one third than setter. Temperature of hatcher is 98.5°F.

3.7 Requirements of Incubation

3.7.1 Temperature

Temperature of setter should be 99.5°F for first 18 days. As incubation proceeds ahead heat production of embryo increases, so during 19-21 days temperature of hatcher should be reduced to 98.5°F. Higher temperature results in small or weak chicks with unhealed navels, cross beaks, stubby down, stargazer, missing eyes and brain hernia. Lower temperature results in delayed incubation and sticky chicks.

3.7.2 Relative Humidity

Relative humidity is percentage of moisture relative with water content in the air. In setter, relative humidity is 83-85% (wet bulb reading) which increases in the hatcher. High relative humidity results in less evaporation of water from egg, hatching delayed and soft abdomen chicks. Lower relative humidity causes excessive loss of water from egg resulting in early hatching and dehydrated chicks.

3.7.3 Ventilation

Ventilation is incoming of fresh air and removal of foul gases. Embryo being living creature need oxygen for respiration and excretes carbon dioxide. Provide proper ventilation in incubator. CO_2 should be 0.03% above 0.5% CO_2 causes slight decrease in hatchability, 2% CO_2 causes marked decrease and at 5% CO_2 hatchability is zero.

3.7.4 Altitude

As altitude increases, hatchability decreases. At 2500 feet altitude from sea level hatchability is 85% (normal). Hatchability reduces to 74% at 3950 feet while at 7160 feet. altitude hatchability is 64%. Recommended level for attaining maximum hatchability should not be more than 2500 feet. from sea level.

3.7.5 Position of the Eggs

Broader end of eggs should be upward for establishment of pulmonary respiration of chicks into air sac of the egg. If pointed end of the egg is upward, it causes 50% dead in shells, due to difficulty of establishment of pulmonary respiration.

3.7.6 Turning of the Egg

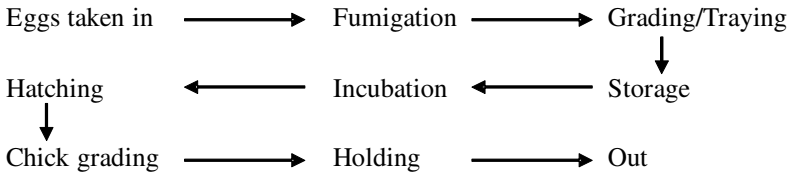
Turning should be done in opposite directions up to 40-45° to each side after each hour. Turning of the egg avoid sticking of embryo to the egg shell membranes and it provide uniform temperature to all sides of the egg in incubator.

3.7.7 Candling

Eggs are candled at completion of 18 days in the setter. Purpose of candling is to remove infertile eggs and dead embryos.

3.7.8 Design of Hatchery

There should be one way flow in hatchery so that hatching eggs may be taken at one end and chicks removed from other end. There should be no back tracking to reduce the risk of disease transmission.



3.8 Factors Affecting Hatchability

Factors affecting hatchability are feed, egg size, eggshell thickness, male to female ration, spiking, egg storage temperature, ventilation, setting eggs, turning, fumigation, hatchery hygiene and eggs from disease free flock. If embryonic mortality is very high continuously during hatching, then send chicks to veterinary pathology laboratory for proper diagnosis.

3.9 Hatchery Trouble Shooting

3.9.1 Too Many Clear or Infertile Eggs

Wrong proportion of males to females (check mating ratios according to breeder recommendation). Males undernourished (see that the cocks can get feed separately, otherwise they may allow the hens to eat all that is there). Interference among the males during mating (do not use too many males: always rear breeding males together: put up temporary solid partitions between breeding pens or inside large pens). Damaged combs and wattles among the males (see that housing is comfortable and that proper drinking fountains are provided for the breeding pens). Males too old (replace elder/aged males with young cock). Sterility in male or preferential mating in pen mating (replace another male). Eggs kept too long or under wrong conditions before setting (do not keep hatching eggs longer than 10 days: store them in cool, 50° to 60°F and at a RH around 75-80%).

3.9.2 Blood Rings: Which Indicate Very Early Embryonic Death

Incubator temperature too high or too low (check thermometer, thermostats and current supply. Follow the incubator maker's instructions). Incorrect fumigation procedure (ensure correct amount of fumigants. Do not fumigate between 24th and

96th hours after setting and keep eggs too long or under wrong storage conditions before setting.

3.9.3 Dead in Shell

Dead in shell are due to too high or too low incubator temperature (check thermometer, thermostats and current supply), eggs not properly turned (turn eggs regularly at least 3-5 times a day: always turn eggs in reverse direction each time, never in same direction) and faulty nutrition of breeding stock. If death losses are heavy in 10th-14th day (pay attention to farms, from where the eggs are collected: check that no deficiency in feed). Faulty ventilation of incubator (increase ventilation by normal means: additional O_2 is not needed at altitudes below 5000 ft. above sea level). Pullorum disease or other infectious disease (use eggs from disease free stock and assure sound hatchery hygiene).

3.9.4 Pipped Eggs Failing to Hatch

Insufficient moisture in incubator. Too much moisture at earlier stages (check wet bulb readings). Nutrition problem (check flock feeding).

3.9.5 Hatching Too Soon/ Hatching Too Late/Sticky Chicks

Incubator temperature too high or Incubator temperature too low.

3.9.6 Malformed Chicks

Incubator temperature too high or too low (check thermometer thermostats and current supply. Follow the maker's instructions). Eggs set incorrectly or not properly turned after setting (turn eggs regularly at least 3-5 times / day: always turn eggs in reverse direction each time and never in same direction.

There may be spreading chicks due to too smooth trays in hatchery and weak chicks due to overheating of incubator. Small chicks are hatched due to setting of small eggs (only set eggs of recommended sizes) and too little moisture in incubator. Heavy breathing chicks are produced due to too much fumigant left in hatcher and too much moisture in hatcher (maintain proper relative humidity). Low average temperature and poor ventilation during incubation (check thermostat) results in Mushy Chick disease. Disease is also known as Omphalitis or Yolksac infection. Uneven hatch is the result of setting eggs too diverse in age (set eggs at least once a week and never store hatching eggs longer than 10 days).

3.9 Taking off Hatch

Chicks need 21 days and 5 hours to be taken out from hatcher. Chicks are wet and exhausted, when they hatch out so, they need 4-5 hours for drying. Hatch should be taken out when more than 95% chicks are dry. Set eggs in incubator in such a way that hatch during taking off can be arranged in such a way that vaccination, dubbing or detoeing can be done in day time. Room temperature for keeping chicks

should not be less than 75°F. Room should be properly ventilated, so that chicks can breathe easily.

Conclusion

More number of hatching eggs from breeder flocks requires precise technical input for production of quality chicks. Good sanitary conditions are required in hatchery. Incubators with recent advanced technologies provide precise incubations requirements resulting in more number of quality chicks.

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