# UNIT 1 INCUBATION AND HATCHING

**Structure**



## 1.0 OBJECTIVES

After studying this unit, you will be able to:

- explain selection and care of eggs meant for hatching;
- differentiate between natural and artificial incubation methods;
- summarize incubator and hatchery management principles; and
- assess efficiency of artificial incubation.

## 1.1 INTRODUCTION

You might have definitely noticed hens sitting on eggs (referred to as "Broody hen" and the process called "Brooding") for several days and hatching chicks. In fact, this was the only method of reproducing flocks before poultry business became commercial. If you watch carefully, you can notice that a hen can brood a maximum of 10 to 12 eggs at a time and it stops laying eggs at once brooding has begun.

Now, you can easily expect that production of thousands of chicks regularly on a specific date will be extremely difficult and needs huge number of broody hens. Therefore, the broody hen has to be replaced by something artificial which can handle many eggs and we must be able to control its all aspects. That is what has been discussed in this unit.

## 1.2 SELECTION AND CARE OF HATCHING EGGS

Once you are willing to set day-old chicks, you should learn about the process of hatching of chicks from fertile eggs and this process involves many steps which are discussed in this section.

### 1.2.1 Hatching and Table Eggs

The first doubt you would get is that are not the eggs available in the market are fit for hatching? If not, what is the difference between these eggs and hatching eggs?

The eggs available in the market are not fit for hatching; are you surprised? These eggs are produced by hens reared without cocks along with them. You would immediately ask, can a hen produce eggs without a cock? The answer is yes. Just think over; does a cow need a bull to come into heat (that is when you allow bull to mate or you take the cow to nearby veterinary hospital for insemination)? Your answer should be no. The natural process of release of female cell called "ovum" for production of young one occurs with or without a male being present. There is no doubt that for a cow to produce a calf, a bull is required.

You also know that human beings and animals like cow, buffalo, sheep, goat, pigs etc. do not produce eggs but directly produce young ones. But, chicken can produce only eggs from which chicks have to come out.

Obviously, each egg has all the necessary material for development of a chick. But, at once hen matures, ovum is released and all the material necessary for formation of a chick is added and laid as egg.

Hence, for laying of eggs, the cock is not necessary. When a cock has mated the hen, and the male cell called "Sperm" for production of young one has combined with ovum to form an embryo (developing young one), such eggs called as "Fertile eggs" or "Hatching eggs" can produce chicks. Eggs without embryo called "Infertile eggs" are not fit for hatching. Even such eggs contain all material necessary for development of a chick and they are used as human food as they are not fertilized. Infertile eggs used for human consumption are popularly referred to as "Table eggs".

Poultry farms rearing layers without cocks produce eggs exclusively for human consumption and are called "Commercial layer farms". Farms producing hatching eggs allowing mating of hens with cocks are referred to as "Breeding farms".

### 1.2.2 Hatching Eggs and Rearing System

If you can recall from earlier units that in cage system of rearing, one of the disadvantages was that mating is not possible. Therefore, if hatching eggs are required

from hens in cages, semen (fluid containing sperms) has to be collected from cocks (Fig. 1.1) and artificially introduced into the hen (Fig. 1.2); the procedure is called "Artificial insemination". However, most of the breeding farms follow deep-litter or slat and litter system of rearing. In any case, for all further discussions, assume that the flock is reared on floor (deep-litter or slat and litter).

**Fig. 1.1: Collection of semen from a cock**

**Fig. 1.2: Artificial Insemination**

## 1.2.3 Collection of Hatching Eggs

The following general guidelines are recommended for collection of hatching eggs:

- They have to be collected once every hour between 10 am and 3 pm to ensure egg quality especially when temperatures are above 29.4$^{o}$C.
- Eggs collected from nests and some laid on floor must be separately collected to minimize contamination.
- If any of the eggs, especially floor egg, is dirty, it should not be used for hatching.
- Eggs have to be checked for cleanliness soon after collection. Eggs which are visibly clean and those with a small amount of adhering dirt that can be easily removed are retained for hatching.
- Hatching eggs should not be washed. Bacteria can be forced through the porous shell and into the egg. Washing also removes the protective sealing substance from the shell, making it easy for penetration by bacteria.
- Only eggs of average size are incubated. Excessively large eggs hatch poorly; small eggs hatch into small, unthrifty chicks. Similarly, abnormally shaped eggs hatch poorly and hence not incubated.

## 1.2.4 Candling of Hatching Eggs

You may wonder, what is candling? Candling is a method to examine eggs by passing a beam of light in a dark room which helps to easily identify cracks in the shell and other defects inside the egg without breaking open the egg (Fig. 1.3). All eggs collected from the breeding farm have to be candled and only those eggs with no defect in shell and contents are selected for hatching.

**Fig. 1.3: Candling of egg**

## 1.2.5 Fumigation

Eggs and equipments before storage or use are fumigated. If fumigation is not as per requirements, it does not kill the bacteria or can even kill the chick embryo inside the egg. Therefore, you have to use recommended amounts of chemicals at the right time for the length of time specified.

A room or cabinet large enough to hold the eggs is required (Fig. 1.4). It must be relatively air tight and equipped with a small fan to circulate the gas. Calculate the inside volume of the structure by multiplying the inside length by the width and by the height.

**Fig. 1.4: Fumigation Chamber**

Eggs are stacked inside the room or cabinet on wire racks, in wire baskets, or on egg filler flats so that air can circulate among the eggs. Formaldehyde gas is produced by mixing 20 gram of potassium permanganate ($KMnO_4$) with 40 ml of formalin (37.5 % formaldehyde) for each $m^3$ of space (1 X concentration) in the fumigation chamber. The ingredients are mixed in an earthenware or enamelware container with a capacity at least 10 times the total volume of the ingredients. Sometimes, even 3 X concentration can be employed.

The gas within the structure is allowed for circulation for 20 minutes and then removed. The temperature during fumigation should be above 21.1°C. Eggs are allowed to come in contact with the air for several hours before taking them for storage.

## 1.2.6 Storage of Hatching Eggs

Assume that you have a breeding farm and a hatchery. You have to produce 5000 chicks every week for supplying to farmers. It is not possible to expect all fertile eggs to hatch and produce a chick. Let us assume that 90% of fertile eggs hatch. That means, to get 90 chicks, you need 100 fertile eggs. Hence, to get 5000 chicks you need $\left(\frac{5000}{90}\times 100\right)$ = about 5556 fertile eggs. Again, not all the eggs produced need be fertile. Let us assume 90% of the eggs will be fertile. That means, to get 90 fertile eggs, you should have 100 eggs. Therefore, to get 5556 fertile eggs, you need 6173 fertile eggs $\left(\frac{5556}{90}\times 100\right)$. Lastly, not all the hens produce eggs every day. Again, assume that 85% of birds produce eggs. So, to get 85 eggs, 100 hens are required. Therefore, to get 6173 eggs, $\left(\frac{6173}{85}\times 100\right)$ = about 7262 hens (or say 7250 hens) have to be maintained in breeding farm.

A serious problem arises now. About 7250 hens are expected to produce 6173 eggs daily. Those produced on the first day can be incubated to produce the required 5000 chicks; chicks hatch in 21 days. But, what you will do with the hatching eggs produced during the next 20 days before those eggs incubated hatch?

A mathematical solution was to produce less number of eggs over a period of time, pool them and incubate. But, the biology is different! Embryos continue to grow for sometime when temperature is above 25ºC, and die if proper temperature and other conditions are not provided. Hence, if the eggs are simply pooled over a period of time and incubated, number of chicks obtained will get reduced and all the eggs do not hatch on the same day. Therefore, we refer as "hatch is synchronized" or "Synchronization of hatch".

After continuous research work, scientists found that if hatching eggs are stored at 12.8 to 18.3ºC (55 to 65ºF), all eggs hatch on the same day and death of embryos is also minimized. However, storage should not be for more than 15 days and preferably not to exceed 7 to 10 days. Hatching eggs should never be exposed to temperatures 23.9°C or more and relative humidity of 40% or lower.

On opening an egg, you might have noticed yellow portion called "Yolk" at the centre and colourless portion called "Albumen or White" surrounding it (Fig. 1.5). White of egg has more water content (88%) and will be just below the shell. The shell has 5000 to 6000 pores (minute holes) so that embryo can breathe. Through these pores, water in albumen can escape even at low temperatures. Therefore, in addition to the low temperature, relative humidity (RH) is maintained at or above 80% during storage to minimize water (moisture) loss from hatching eggs.

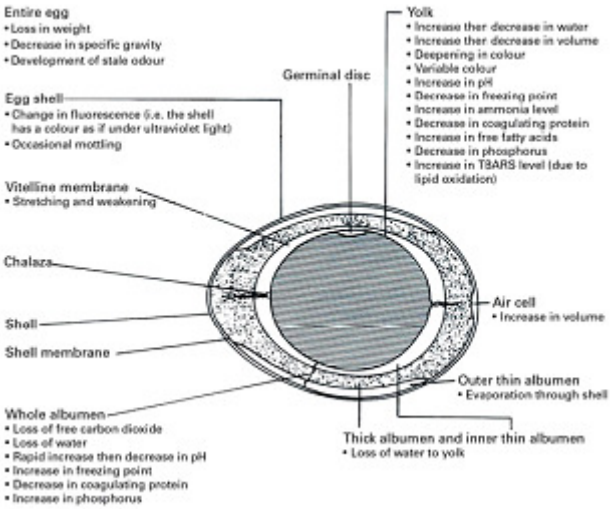


**Fig. 1.5: Cross-section of an egg**

## 1.2.7 Turning of Eggs During Storage

If the eggs are not incubated within three or four days, they can be turned daily at least twice. Turning the eggs prevents the yolk from touching the shell and injuring the embryo. Eggs are stored broad-end up in egg flats kept in cases with one end of the case elevated (Fig. 1.6) to give the proper slant (30 to 45$^{o}$). The other end of the case is elevated every day. Alternatively, eggs can be stored small end down and slanted at 30-45$^{o}$ by putting a wooden or thermocole piece of 5 cm × 10 cm cross-section under one end of the carton or storage container and changing it to the other end the next day; this process can be continued through the storage period.

**Fig. 1.6: Eggs kept in slant position**

## 1.3 NATURAL AND ARTIFICIAL INCUBATION

There are two types of brooding – Natural and Artificial which are discussed in detail below:

### 1.3.1 Natural Brooding

Heat transfer from the body of the hen to the egg is very difficult to measure. Most birds develop "brood patch", a seasonal bare (uncovered) patch of skin, on part of the thorax and abdomen through which it directly transfers heat to the eggs. In addition to loss of feathers, there will be increase in size and numbers of blood vessels in the brood patch. The hen can adjust to the rate of heat transfer by standing or leaving the egg, but also by closeness with which the bird applies its patch to the egg. In addition, the hen also responds to variations in the temperature of the egg, increasing its heat production whenever there is cooling of the egg. Brood patch temperature varies in different avian species from 34.9°C to 42.4°C so that the brood patch temperature is always 1.1 to 5.5°C warmer than the egg temperature in different species (Tazawa and Whittow, 2000).

The hen herself incubates the eggs by keeping the brood-patch on the top of the eggs. (Fig. 1.7). Most of the times, the eggs will be in horizontal position on the floor. The temperature at the top of the eggs will always be higher (37.2 to 37.8°C) because it is in contact with the brood- patch; the lower side of the egg will be cooler (32.6°C) and the centre of the egg will be in between (35°C). At the beginning, top of the yolk containing embryo is towards the brood-patch and it rotates when egg is rotated by the hen to keep embryo near the brood-patch. Therefore, embryo will be few mm away from the body of the hen.

**Fig. 1.7: Natural Brooding by Hen**

As the embryo grows, blood flow begins as early as the second day itself and warms the embryo. Hence, centre of the egg becomes warmer than before. Simultaneously, embryo also produces heat and hence, in the later stage of incubation, centre and bottom of eggs also become as warm as the portion in contact with the brood-patch. Hence, the hens leave the eggs for cooling during later stages.

With commercialization of poultry industry, natural brooding has been replaced by artificial methods of incubating and hatching eggs. However, under village and backyard rearing, even now, natural brooding is being practiced.

## 1.3.2 Artificial Incubation

You are now convinced that natural brooding in not practical under commercial conditions. Hence, in this Section, you will know more about artificial incubation.

### (i) Incubation period

You will be surprised to know that in artificial incubation, the machine tries to copy whatever the broody hen does and nothing more! Many of you might think that in a machine, eggs hatch the very next day or so; but, it is not so. Eggs take the same number of days whether kept under the broody hen or in artificial incubation.

Number of days required for an egg to hatch is called "Incubation period" and it differs between species. Incubation period (Table 1.1) of most common species of poultry is given below:

**Table 1.1: Incubation Period of Different Avian Species**

| Species | Average Days |
|---|---|
| Chicken, Mini (Bantam) chicken | 21 |
| Duck, Guinea Fowl, Turkey | 28 |
| Emu | 42-53 |
| Geese | 35 |
| Japanese Quail | 18 |
| Ostrich | 42 |

### (ii) Machinery requirements

Few years back, eggs used to be kept in a machine till they are hatched. After hatching and removal of chicks and other materials, they used to be cleaned and disinfected before next use. Even now, such machines are used on small-scale and they are referred to as "Setter-*cum*-hatcher". However, as the science of incubation advanced, separate machines for "Setting" the eggs and a "Hatcher" into which the eggs are transferred during the last 3 days were invented. Can you imagine the reasons for this?

You might have noticed that even the hen pecks at the eggs under her care 3 days before hatch so that chicks can come out easily. In fact, the developing chick actually cuts the shell from within by using what is called "Egg-cutting tooth". Obviously, pieces of shell and shell membranes fall out. As the chick hatches out, part of small hair-like feathers (down feathers) on the chick also falls. After coming out of the shell, chick passes its first faecal matter called "Meconium". Therefore, a setter-*cum*-hatcher will become dirty during hatching process. When many batches of eggs are set in the machine, it can infect other eggs and reduce hatchability.

In addition to the above, temperature and humidity requirements of eggs during hatching process are different. Therefore, it is better to have separate machine called "Setter" to keep the eggs during the first 18 days (in case of chicken) and transferred to another machine for the last 3 days exclusively for hatching purposes called "Hatcher". This arrangement will help cleaning and disinfection of hatcher and to provide correct requirements to the eggs during the last 3 days of incubation. You will know more about conditions required during artificial incubation later in this unit.

### (iii) Types of machines

Fairly constant environmental conditions can be maintained in a setter (Fig. 1.8). Setters (also called incubator) are available in many different models and sizes with

capacities ranging from few to many thousands of eggs depending upon the species. The larger setters are rooms in which required conditions are carefully controlled. The setters should be large enough to hold a three-week supply of eggs. The hatcher unit (Fig. 1.8) can be small, but large enough to hold the largest setting of eggs.

**Fig. 1.8: Setter**

**Fig. 1.9: Hatcher**

Eggs at various stages of incubation are held in the setter. The eggs are transferred to the hatcher on the 18$^{th}$ day and held in the hatcher until completely hatched. Hatcher is thoroughly cleaned and disinfected after each group of eggs hatches.

There are two basic types of setters, forced-air and still-air. The size and type of setter selected depends on needs and future plans.

*(a) Forced-air (Forced-draft)*

Here, as the name suggests, outside air is forcibly sucked in, warmed and distributed uniformly by a fan. Therefore, there is no difference in temperature within the setter unlike still-air setter. Therefore, we can have several layers or trays of eggs, limited only by your requirement. Most of the modern-day setters belong to this category.

Eggs are placed in stacks of trays. The capacity of these setters is large. Most units have automatic equipment for turning the eggs and spray-mist nozzles for holding proper humidity levels.

*(b) Still-air*

During the initial stages of development of artificial incubation technique, machines without fans were being used. These were usually small, holding about 100 eggs or more. You have studied about density (specific gravity) in your school. Therefore, you must be aware that hot air is lighter and hence moves up. While doing so, it creates vacuum and to that place, cool air comes in. In still-air setters, this principle is used; warm, stale air escapes at the top and cool air enters from the bottom. Air circulation is limited but heat is convected (do you remember conduction, convection and radiation from your school Science lessons?) to different parts of the setter; therefore, only one layer (tray) of eggs can be incubated. Egg temperature will not be uniform at all points and the top of the setter is warmest; in a way, it stimulates natural brooding. However, for large-scale production, this system is not feasible.

### (iv) Systems of incubation

You have already learnt that a setter can have only one batch of eggs or many batches of eggs can be set. Similarly, you know that eggs need to be transferred on 18$^{th}$ day (in case of chicken eggs) to a hatcher. Therefore, you can have 3 batches of eggs; each batch consisting of eggs collected over 6 days in a single setter. One hatcher is sufficient because, after 3 days, it can be cleaned, disinfected and ready for the next transfer. This system is referred to as "Multi-stage incubation".

Alternatively, you can have a setter to accommodate eggs produced over a maximum of 15 days (preferably 7 to 10 days) and a hatcher sufficient to hold that many

number of eggs. You can easily recognize that in this system, all eggs enter and leave a setter and hatcher at a time; hence, this system is referred to as "All- in- all- out or single stage incubation".

Which do you think is ideal on scientific grounds? Let us evaluate.

In multi-stage incubation, at any point of time, there are eggs at different stages of incubation. Therefore, it is very difficult to provide ideal temperature to all batches of eggs; and hence, no more improvement is possible by just hatchery management modification. In addition, over-hauling (rest, cleaning and repair) of the incubation machinery is difficult because one or the other batch of eggs will always be present in the setter. Even the setter cannot be cleaned and disinfected unless hatching program is stopped.

In single-stage incubation, modifications in temperature to maximize hatch results is possible as is done by the hen under natural brooding. This system facilitates sanitation, effective control of humidity and temperature, and over-hauling of the incubating equipment. Hence, durability of the equipment will increase, disease control will be efficient and hatch results will be maximized.

In India, forced-draft setters and hatchers with multi-stage system of incubation are common. In advanced countries, due to obvious benefits of single-stage incubation, it is becoming more popular especially in very large hatchery operations.

In view of the above discussions, all further discussions in this unit will be for forced-draft multi-stage incubation.

### (v) Location of Hatchery

All setters and hatchers are placed inside a building reasonably far away from the farm premises. It is preferable if it is located windward; that means, most of the times wind should move from hatchery towards other buildings.

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### Check Your Progress 1

**Note:** a) Use the space given below for your answers.

b) Check your answers with those given at the end of the unit.

1) What do you understand by "Fertile egg" and "Table egg"?

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2) Explain synchronization of hatch.

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3) What is "Incubation period"? List incubation period of common species of poultry.

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### Activity 1

Visit a nearby hatchery. Collect information on different equipments and their types available in the hatchery along with their capacity.

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## 1.4 INCUBATION AND HATCHING

Having the hatchery and eggs ready for incubation, you will be interested to know how to go about with artificial incubation and hatching. It is stressed at the beginning itself that we are only "copying" whatever the hen does and therefore, all steps must be followed perfectly so that you can get as many healthy chicks as possible which can be sold or reared.

### 1.4.1 Requirements in Setter and Hatcher (Chicken Eggs)

Scientists have discovered many things what the hen does; of the several requirements, the most important ones are tabulated below:

**Table 1.2: Requirements for Chicken Eggs**

| Parameters | Incubator (setter) | Hatcher |
|---|---|---|
| Number of days | First 18 days | $19^{th}$ , $20^{th}$ and $21^{st}$ days |
| Carbon-dioxide, % | 0.04 | 0.04 |
| Oxygen, % | 21 | 21 |
| Position | Broad-end up, in contact with each other | Horizontal |
| Relative Humidity, % | 55 | 65 |
| Temperature, $^{o}C$ | 37.6 to 37.9 | 36.1 to 36.7 |
| Turning | At least 6 times a day | Not required |

If you go through the above table carefully, you will be curious to know the reasons for each of the requirements. The reasons are discussed below:

- **Number of days:** You already know that embryos start coming out of the shell on $18^{th}$ day and therefore, they are shifted to a separate machine on that day.
- **Oxygen and Carbon-dioxide:** Embryos require these gases in the same proportion as in the normal air. Carbon-dioxide is also useful for embryo to begin breathing and come out of the shell.
- **Position of eggs:** When you break open an egg, look for a bubble of air under the shell; in most eggs it will be in the broad end. It is called "Air cell". Embryos breathe through the air cell. They are kept in contact because it is learnt that embryos talk to one another when kept in contact and it helps them to hatch together (synchronization of hatch). After $18^{th}$ day, these factors do not exist.
- **Relative Humidity:** It is necessary that eggs lose 0.5% weigh every day in setter. Hence, relative humidity is kept at 55%. In hatcher, embryos need extra humidity (wetness) to keep their beak wet so that they can easily cut the shell and come out. Extra humidity also helps the down feathers to absorb moisture, become heavy and settle down instead of floating in the hatcher due to fan movement. Insufficient water loss results in large, lazy, swollen chicks which are often in an improper position in the egg causing problems in coming out of the shell (pipping) and in hatching. Excessive water loss results in small, dehydrated, weak chicks that may not be strong enough to hatch.

- **Temperature:** Temperature in setter has been found to be ideal for chicken eggs. It can be reduced in hatcher because embryos also produce their own heat.
- **Turning:** As incubation progresses, yolk (having the embryo) comes to the surface and may get stuck to the shell and die. To avoid such possibility, during the first 18 days, eggs are turned through 90º, at least 6 times a day; more often once every hour (Fig. 1.10). After 18th day, the embryo is grown and there is no question of yolk coming to surface. In modern machines, turning is automatically controlled.

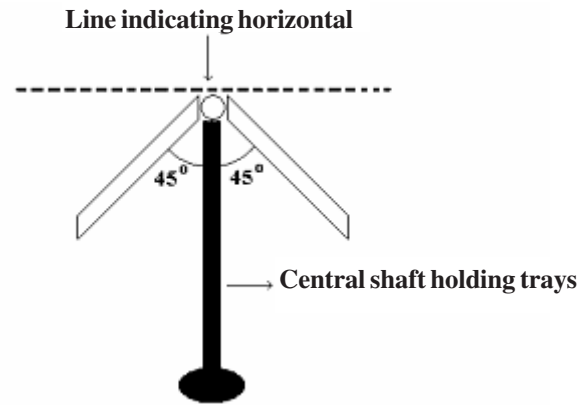


**Fig 1.10: Turning of eggs in a setter**

You may now raise another question: temperature can be known by a thermometer, what about humidity? You have studied dry and wet-bulb thermometer (Fig. 1.11) in you school. It is used to measure humidity. Remember; it does not give you humidity directly. If the difference between the dry-bulb (which is same as an ordinary thermometer) and wet-bulb thermometer (bulb covered by a cloth-like material which immersed in distilled water to keep wet always) is more, humidity is less and *vice versa*. If the difference between the dry-bulb and wet-bulb thermometer is 8.3ºC (15ºF) in a setter or hatcher, the humidity is 55%. If the difference is 5.6ºC (10ºF), the humidity is 65%. Now, you can easily estimate the wet-bulb reading in setter and hatcher; it is 29.5ºC and 30.6 to 31.1ºC, respectively.

**Fig. 1.11: Dry and Wet Bulb Thermometer**

The dry and wet bulb reading in setter and hatcher along with the corresponding humidity % is presented in Table 1.3.

**Table 1.3: Dry and Wet-bulb Readings and Humidity for Incubating Chicken Eggs**

| Equipment | Dry-bulb (°C) | Wet-bulb (°C) | Humidity (%) |
|---|---|---|---|
| Setter (Incubator) | 37.8 | 29.4 | 55 |
| Hatcher | 36.1 to 36.7 | 30.6 to 31.1 | 65 |

## 1.4.2 Requirements in Setter and Hatcher (Eggs of Other Species)

Conditions required for hatching eggs of other species are more or less the same. But, for duck and goose eggs, spraying water can improve hatchability. However, position, turning, oxygen and carbon-dioxide requirements are the same as in case of chicken eggs. The physical conditions required for incubating and hatching of eggs in a setter and hatcher for different species of poultry is tabulated below:

**Table 1.4: Physical conditions for incubating eggs of different species**

| Item | Chicken, Bantam | Japanese Quail | Duck [1] | Goose [2] | Guinea fowl | Turkey |
|---|---|---|---|---|---|---|
| Incubation period (days) | 21 | 18 | 28 | 28-34 | 28 | 28 |
| Temperature ($^oC$, dry-bulb) | 37.8 | 37.8 | 37.8 | 37.2 | 37.8 | 37.2 |
| Temperature ($^oC$, wet-bulb) | 29.4-30.6 | 29.4-30.0 | 29.4-30.0 | 30.0-31.1 | 29.4-30.6 | 28.9-30.0 |
| Egg not turned after (days) | $18^{th}$ | $15^{th}$ | $25^{th}$ | $25^{th}$ | $25^{th}$ | $25^{th}$ |

[1] Duck eggs hatch better in still-air incubators than in forced-air incubators.
[2] Better hatchability may be obtained if goose eggs are sprinkled with warm water or dipped in lukewarm water for half a minute each day during the last half of the incubation period.

## 1.4.3 Setting of eggs

Assume that you have sufficient eggs stored. How to proceed setting them? You may think that eggs from the cold store can be directly kept in the setter. It is not advisable to set eggs directly from cold storage into the setter. You will definitely question, why not?

Cold storage temperature is 12.8 to 18.3ºC, whereas, setter temperature is 37.8ºC. What would happen if you transfer many eggs into a setter, especially a multi-stage type which is common in our country? The changes will be same as you would see if a glass filled with cold water is kept on a table, what are the changes you expect?

- Water from air settles on the outer surface of the glass; the same thing happens on the surface of the eggs referred to as "Weeping or Syneresis" of eggs, but the water is taken from the air of the setter. Hence, humidity of the setter drops. Immediately, machine adds automatically moisture into the setter.
- Water on the glass surface slowly evaporates. Same happens in the setter; water evaporates from the surface of the eggs; consequently, there will be humidity build-up. Setter has no provision to remove humidity.
- Simultaneously, water in the glass reaches room temperature taking heat from air. Cold eggs absorb heat from the setter. Setter temperature falls. Machine puts on heaters to increase temperature.

It is therefore very clear from the above points that if eggs are kept from the cold store directly into the setter:

- Setter machinery is put to unnecessary strain, and
- Changes in temperature and humidity will certainly affect other batches of eggs which are already in incubation.

**Fig 1.12: Setter with eggs**

Therefore, eggs from the cold storage have to be brought to the room temperature slowly, or in other words, should be allowed to weep outside the setter. Under practical situations, eggs will be filled into the setter trays during which time they generally attain room temperature.

## 1.4.4 Fertility Testing

You will agree that all eggs laid by hens in a breeding farm need not be fertile. Unfortunately, it is not possible to test for fertility of a fresh egg without breaking it. At once you break open; it cannot be attached or fixed and incubated! Therefore, there is no alternative but to set all eggs and test for fertility after 4 to 7 days of incubation or when they are transferred to the hatcher.

In multi-stage incubators, fertility testing at 4 to 7 days of incubation may be beneficial because the space created by removal of infertile eggs can be utilized. But, remember, we will be opening the setter and handling the eggs. Fertility testing at the time of transfer is convenient because after all, eggs have to be handled on that day. Any of the methods can be practiced.

**Note:** Eggs from setter must be transferred to the hatcher with as little time gap as possible to prevent excess cooling of the embryos.

### (i) Equipments required

For fertility testing, a mass-candler, a modification of candler, is required. It consists of a table which suits exactly to the size of the setter tray so that it can be moved on its top surface. At the centre of the top surface, there will be a opening under which a fluorescent (tube) light is fixed to illuminate (Fig. 1.13). Mass candling is done in a dark room where the setter tray is moved to view one row of eggs at a time over the illuminated opening of the mass- candler.

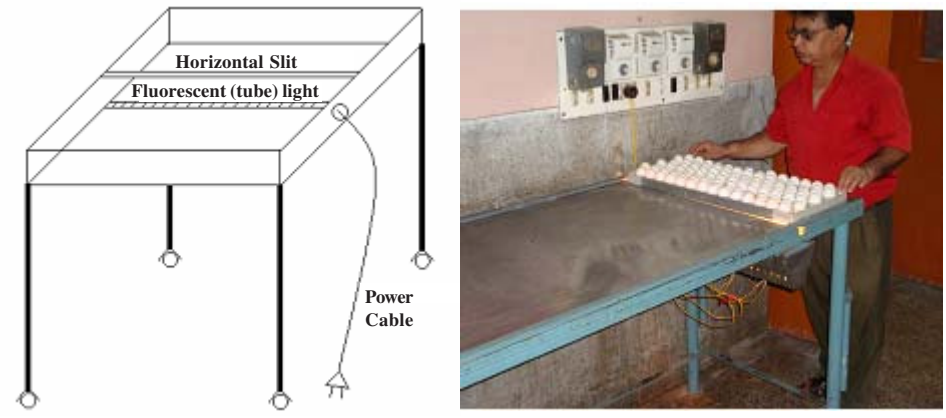


**Fig 1.13: Mass candler**

### (ii) Identification of fertile and infertile eggs

At the time of candling, one has to know how to identify an infertile egg from a fertile one; otherwise, candling has no meaning. Identification of fertile egg at 7th day and 18th day candling is illustrated below:

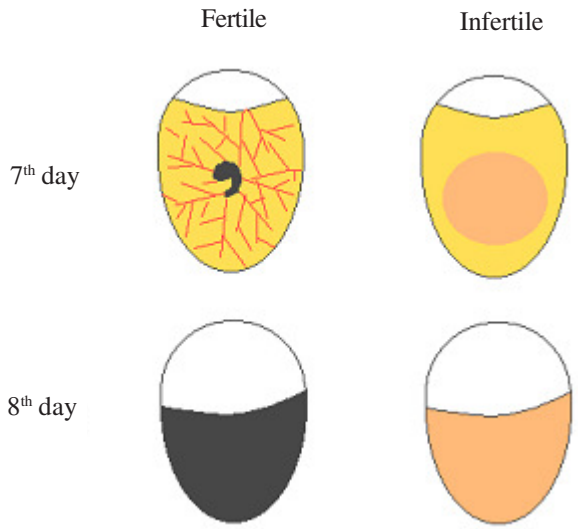


**Fig 1.14: Fertility testing during incubation**

Look at the figure above carefully (Fig. 1.14). Fertile eggs after 4 to 7 days of incubation clearly show development of blood vessels and moving embryo at the centre appearing dark. A live embryo is spider-like in appearance, with the embryo representing a spider's body and the large blood vessels spreading out much like a spider's legs.

At 18th day, a large air-cell at the broad end with the bottom portion opaque due to the presence of developed embryo is extremely easy to identify. In fact, an entire setter tray is candled at a time (mass-candling) and those appearing translucent are removes as infertile eggs.

## 1.4.5 Pulling the Hatch

On 22nd day morning, chicks will be ready for removal from hatchery. Chicks in hatcher are usually fumigated with 1X concentration for 3 minutes which gives an attractive bright yellow colour to the chicks at hatch.

Good quality chicks will have the following features:

- Good and uniform size; broiler chicks around 42 g and layer chicks around 38 g. Newly hatched chicks weigh about 60 to 65% of the weight of the eggs from which they hatched (Fig. 1.15).

**Note:** Layer chicks will be sexed to remove all males at hatch itself.

- Alert, strong and active.
- Free of defects and deformities like crossed beaks, blind chicks, lameness etc.
- Bright, plump and fully fleshed shanks; no signs of dehydration (skin folds or prominent blood vessels).
- No swelling or red colouration of joints in legs.
- Well-healed navels; no black buttons or weepy navels.
- Abdomen soft and pliable; not swollen, bloated or hardened.

**Fig 1.15: Newly hatched turkey chicks in hatcher tray**

### Fertile eggs not hatched

It is expected that all fertile eggs hatch. But, actually it does not happen either under hen or in a hatcher. Embryos may die at various stages of incubation. Broadly they are classified as:

#### a) Dead germs

Dead germ refers to an embryo that died after growing large enough to be seen when candled. A dead germ can be distinguished by the presence of a blood ring around the embryo. This is caused by the movement of blood away from the embryo after death. There will be no movement of the embryo and the network of blood vessels, if noticed, will not be extensive. Such eggs can be removed at 4 to 7 days candling itself by careful candling.

If not sure whether the embryo is alive or not, incubation of such eggs is continued and they are removed after confirmation on 18$^{th}$ day candling.

#### b) Dead-in-shells

This group comprises of embryos which have developed sufficiently but are unable to come out of the shells, whether they are able to pierce the shell or not. High incidence of dead-in-shells is indicative of improper hatchery management.

**Note:** In addition to the above, it is always advisable to break open all the unhatched eggs in a separate facility to find out the actual reason so that any improvements possible can be taken-up.

## 1.4.6 Embryo Mortality Pattern

You already know that not all fertile eggs will hatch. Due to various reasons, embryos do die. It has been found out that death of embryos has a pattern; most of them dying at specific age which has been summarized below (Table 1.5):

**Table 1.5: Embryo mortality pattern**

| Days of Incubation | Reasons |
|---|---|
| **Major Causes** | |
| 2$^{nd}$, 3$^{rd}$, 4$^{th}$ | a) Faulty heart formation – heart starts beating during 33 to 38 hours of incubation and if there is any failure, embryos die at this early stage and are referred to as early embryonic death.<br>b) Nutritional deficiency of the breeding flock, especially of Vitamin A and K.<br>c) Storage hygiene, faulty turning in setter.<br>d) Old eggs. |

| | |
|---|---|
| $18^{th}$, $19^{th}$, $20^{th}$ | a) The embryos are of cold-blooded nature (poikelothermic) till they are transferred to hatcher. They change over to warm-blooded nature (homoeothermic) in the hatcher.<br>b) Beginning of pulmonary respiration – first time embryo breathes outside air in the hatcher. If hatchery management is defective (high or low temperatures, vitamin deficiencies, damage at transfer, high $1^{st}$ week temperatures), well-grown embryos die, referred to as dead-in-shell.<br>c) Storage hygiene.<br>d) Diseases. |
| **Minor Causes** | |
| $4^{th}$, $5^{th}$, $6^{th}$ | Embryos are changing over from carbohydrate to protein metabolism; hence there will be accumulation of carbon dioxide, ammonia and other products. If ventilation is improper, the embryos are likely to die due to suffocation. |
| $14^{th}$, $15^{th}$ | a) The organs of the embryo organize themselves (organogenesis) and liver and other organs starts functioning. Hence, deficiency of nutrients in the egg, especially of Vitamin $B_2$, results in failure of organogenesis and the embryos die with characteristic clubbed-down syndrome.<br>b) Hygiene in the setter. |

**Note:**

- Mortality during the $1^{st}$ week of incubation is normally due to the way the fertile eggs are handled from farm to the incubation facility or to the health of the flock in question (diseases and deficiencies).
- Mid-term ($2^{nd}$ week) mortality are confined to either nutritional deficiencies or to a carry-over of earlier contamination problems.
- Embryo mortality during the last week of incubation is mainly due to failure of the embryo to position itself within the egg in "hatching position" i.e., parallel with the long axis of the egg, the head at blunt end and the beak under the right wing pointing to the air-cell. Any position which differs from the above is likely to result in failure or a delay in hatching.

## 1.4.7 Evaluation of Hatchery Performance

Even under natural conditions, neither all the eggs laid will be fertile nor will all eggs hatch. Hence, with artificial incubation also, there will be eggs which will be either infertile or fail to hatch for various reasons. Therefore, it is necessary that performances of the breeding farms as well as the artificial incubation facility are evaluated to take up suitable measures to obtain maximum profit out of hatchery business.

In view of the above, the following parameters are estimated to assess the efficiency of both breeding farm as well as incubation facility:

$$\text{Fertility, \%} = \frac{\text{Number of eggs fertile}}{\text{Total number of eggs set}} \times 100$$

$$\text{Hatchability, \% (on TES)} = \frac{\text{Number of chicks hatched}}{\text{Total number of eggs set}} \times 100$$

$$\text{Hatchability, \% (on TES)} = \frac{\text{Number of chicks hatched}}{\text{Total number of fertile eggs}} \times 100$$

Among the above estimates, fertility is compulsory for incubating any egg and hence it cannot account for efficiency of artificial incubation and hatching process. In simple terms, no one can expect chicks from infertile eggs and therefore, if fertility is poor, hatchery is not responsible. However, poor fertility definitely indicates health and management of the breeding stock.

If you carefully observe the above formulae, you will recognize that hatchability on total eggs set (TES) is less accurate because the denominator includes all the eggs set, whether fertile or not. Therefore, hatchability on TES will be adversely affected as fertility reduces. Let us consider an example:

**Table 1.6: Comparison of Hatchability on TES and on FES**

| Situation | Total Eggs Set | Fertile | Chicks Hatched | Fertility, % | Hatchability, % | |
|---|---|---|---|---|---|---|
| | | | | | On Fertile Egg Set (FES) | On Total Egg Set (TES) |
| A | 1000 | 900 | 675 | 90 | 75 | 67.5 |
| B | 1000 | 750 | 675 | 75 | 90 | 67.5 |

In both the situations, if 1000 eggs are incubated, 675 chicks are obtained. In situation A, many embryos failed to hatch and in situation B, many eggs failed to contain an embryo. But, hatchability on TES is same in both because. Therefore, it is clear that a poor hatchability on TES alone is a poor index for evaluating incubation performance and it must be studied along with hatchability on FES.

If you critically study the data in Table 1.6 you can make the following observations:

- If hatchability on TES and FES are low, problem lies both before and after the eggs are received at the hatchery.
- If hatchability on TES is low and hatchability on FES is high, problem lies before the eggs are received at the hatchery.
- If fertility of the eggs is satisfactory (say above 95 %), and hatchability on FES is low, problem lies after the eggs are received at the hatchery.
- Therefore, calculating fertility and hatchability (both on FES and TES) help identify the actual problems so that suitable correction measures can be initiated.

A good breeding farm-cum-hatchery must record a fertility of at least 95% and hatchability on TES and FES of 90% and 95%, respectively.

## 1.4.8 Incubation and Hatching of Emu and Ostrich Eggs

Conditions required for hatching of ostrich and emu eggs (which belong to the group of "Running birds: referred to as 'Ratites') are essentially the same as discussed under Section 1.4.2. However, the following modifications and special care are needed for obtaining satisfactory results:

- Most ratite eggs are laid in nests that the male has dug in the soil of the pen. The eggs are exposed to sun, rain, temperature extremes and the microbial inhabitants. Therefore, eggs should be kept dry and as clean as possible.
- Very dirty eggs can be washed, in water that is 5.6°C (10°F) higher than the temperature of the egg.

- They can be stored similar to chicken eggs.
- Common incubator (setter) temperatures for ratite eggs range from 35.9 to 36.5°C for multi-stage machines. Incubators without fans (still-air) are normally run about 1°C higher than those with fans (forced-air incubators).
- The hatcher temperature should be approximately 0.5°C lower than that of incubator (setter), because of the large amount of heat generated by the late-stage embryos.
- Most ratite eggs will perform well when a moisture loss of 12- 16% is achieved. It is interesting to note that the water content of the newly hatched chick (~76%) is essentially the same as the water content of the combined yolk and albumen of a fresh egg. Incubator manufacturers usually recommend optimum relative humidity settings for each model and each species of bird. Approximate relative humidity requirements are 15-20% for the ostrich and 25-40% for the Emu eggs.

**Note:** In eggs that lose 10% or less of their weight through 38 days, some advantage may be gained by drilling about four 2 mm holes in the shell over the air cell at the time of transfer to the hatcher. This has little effect on egg weight loss but does allow the chick to survive by lung respiration after pipping into the air cell. Many of these embryos will require some assistance in hatching because they will be in some degree of malposition due to their swollen condition.

- Humidity during the hatching process should be approximately 40% for ostrich and 60% for Emu eggs.
- Turning of eggs is similar to that for chicken eggs. If eggs are set horizontally, they hatch best when turned approximately 180° on their long axis.

## 1.5 HATCHERY HYGIENE

You might have noticed that hatchery is a special facility and absolute cleanliness or hygiene is compulsory. The most important micro-organisms are *Salmonella* and *Aspergillus* which come with infected eggs and chicks, air, personnel (both staff and visitors) and equipments. As a general rule, all personnel must wear suitable clothing, wash hands with soap every time they enter and leave hatchery premises and use foot-bath before entering hatchery. Practices to be followed at each stage at a breeding farm-*cum*-hatchery are detailed below:

### 1.5.1 Egg Transport, Receipt and Storage

Egg filler flats, trolleys and vehicles, if any, have to be regularly cleaned and disinfected. It is advisable to fumigate eggs before being shifted to hatchery. In the storage room, eggs can be fumigated especially when they are not fumigated before receipt at the hatchery.

### 1.5.2 Setter with Eggs

Since multi-stage incubators are more common, it is advisable to use fine mist (fog) of a disinfectant into the setter machine every time fresh batch of eggs are set. If for In case, any of the eggs gets rotten and explodes (such eggs called as bangers), it should be immediately removed and the area should be sprayed with a disinfectant.

**Fig 1.16: Setter tray with eggs ready for transfer to hatcher tray**

### 1.5.3 Setter when Empty

Whenever setter falls empty, the time must be utilized for thorough cleaning and disinfection of the setter and over-hauling of the machinery. All surfaces and crevices must be scrubbed, cleaned and disinfected. Fumigation also is a regular practice for empty setters.

### 1.5.4 Hatcher

When the hatch is completed, it is disconnected from the power supply and cleaned of all shells, unhatched eggs and debris. Interior is washed with a warm detergent solution, sprayed with a sanitizer and fumigated with formaldehyde.

Cleanliness and sanitation are the most practical and economical methods to prevent disease and produce quality chicks. Hatching area and equipments must be clean and dry. All windows, air intakes should be suitably covered and doors covered with screens to keep out insects and rodents.

**Fig 1.17: Hatcher tray with eggs**

### 1.5.5 Setting Room, Transfer Room, Candling Room and Sexing Room

The walls, floors, ceiling etc. of setting, transfer, candling and sexing rooms must be cleaned of dust and debris followed by scrubbing, washing and disinfection.

### 1.5.6 Setter and Hatching Trays, Egg Flats and Other Movable Equipments

All setter and hatching trays, egg filler flats and other movable equipment should be thoroughly washed, disinfected, rinsed in clean water and dried. Again, disinfectant spray is applied on the equipment. Water under pressure is preferred to increase efficiency of cleaning.

**Check Your Progress 2**

**Note:** a) Use the space given below for your answers.

b) Check your answers with those given at the end of the unit.

1) What are the conditions required for artificial hatching of chicken eggs?

.....

.....

2) Why eggs are turned in setter but not in hatcher?

.....

.....

3) How do you test for fertility during incubation?

.....

.....

## 1.6 LET US SUM UP

Transformation of poultry rearing into commercial business has resulted in replacement of broody hens for hatching eggs to artificial incubation and hatching. Fertile eggs are obtained from breeding farms where hens are allowed to mate with males. They are carefully collected, transported, candled, fumigated and stored. The fertile eggs are stored in cold storage maintaining a temperature of 12.8 to 18.3ºC and 80% humidity. After required number of eggs is available, they are brought to room temperature and placed in setters for 18 days and then shifted to hatcher for the last 3 days. Recommended temperature, humidity, turning, oxygen and carbon dioxide levels are provided in these machines. Eggs during incubation are candled to identify infertile ones from fertile on 4 to 7$^{th}$ day or on 18$^{th}$ day of incubation. Chicks hatch and will be ready for dispatch by 22$^{nd}$ day morning. Incubation period differs with different species of poultry. Performance of the hatchery is assessed by calculating fertility as well as hatchability values. Setter and hatchery machines and the building housing them are regularly and thoroughly cleaned and disinfected.

## 1.7 GLOSSARY

**Albumen** : White portion of an egg.

**Artificial Insemination** : Transfer of semen collected from a cock into the reproductive tract of a female artificially.

**Brood Patch** : Area of bear skin on part of thorax and abdomen of a broody hen.

**Broody** : Tendency to sit on eggs to hatch.

**Candling** : Method to see contents of an egg without breaking it through a beam of light.

**Cold Storage** : Facility to store fertile eggs for 7 to 14 days.

**Convection** : The transmission of heat caused by movement of molecules from cool regions to warmer regions of lower density.

**Dead-germ** : Embryo dead at an early stage.

**Dead-in Shell** : Embryo developed but not able to come out of the shell.

**Disinfection** : Clean so as to destroy or prevent growth of disease-carrying micro-organisms.

**Durability** : Ability or Capacity to withstand wear and tear or decay.

**Forced Draft** : Forcing outside air to enter inside.

**Fumigation** : Disinfection by fumes (formaldehyde).

**Hatcher** : Equipment in which fertile eggs are transferred for the last 3 days of incubation.

**Homoeothermic** : Animals maintaining a constant body temperature.

**Incubation Period** : Time required for a fertile egg to hatch into a healthy chick.

**Meconium** : First faeces of the embryo.

**Mortality** : Death.

**Multi-stage** : Many stages; many batches at a time.

**Opaque** : Not able to be seen through; not transparent.

**Ovum** : Reproductive cell of female.

**Pen** : An enclosure in which domestic animals/birds are kept.

**Poikelotherm** : Cold-blooded animal.

**Ratites** : Running birds.

**Relative Humidity** : The ratio of the amount of water vapour in the air at a specific temperature to the maximum amount that the air could hold at that temperature, expressed as a percentage.

**Setter** : Machine for incubation of eggs for the first 18 days; also called Incubator.

**Sperm** : Male reproductive cell.

**Still-air** : Without air movement; motionless air.

**Synchronization** : Planning to happen together.

**Syneresis or Weeping** : Condensation or settling of moisture.

**Table Eggs** : Eggs without embryo.

**Yolk** : Yellow part of the opened-out egg.

## 1.8 SUGGESTED FURTHER READING

Ensminger, M.B. 1993. *Poultry Science,* 3rd Edition. International Book Distributing Company, Lucknow, India.

North, M.O. and Bell, D.D. 1990. *Commercial Chicken Production Manual*. AVI Publication, Van Nostrand Reinhold, New York, USA.

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Sreenivasaiah, P.V. and Venugopal, S. 2008. *Small-Scale Layer Production*. International Book Distributing Company, Lucknow, India.

Tazawa, H. and Whittow, G.C. 2000. Incubation Physiology. *In: Sturkie's Avian Physiology*. Whittow, G.C. (Editor), Academic Press, USA.

## 1.10 ANSWERS TO CHECK YOUR PROGRESS

**Check Your Progress 1**

1) A fertile egg is the one produced by a hen when being allowed to mate with a cock; the egg will have an embryo in it. A table egg, on the other hand, is an egg produced by a hen without mating with a cock. It does not contain any embryo but has all the essentials for development of a chick. Hence, it is a good human food.

2) Commercially, it is not possible to have large breeding farms to produce all the required number of eggs on a single day. Such an establishment will be very expensive and fertile eggs cannot be used unless very large hatching facility is available. These increase maintenance and labour costs thereby increasing chick cost. Therefore, under practical conditions, in a breeding farm eggs produced over a period of time (maximum 15 days, preferably 7 to 10 days) are collected, stored in cold storage at 12.8 to 18.3ºC and 80% humidity so that all these eggs hatch at the same time. This is referred to as synchronization of hatch.

3) Time required for a fertile egg to produce a healthy chick is called incubation period. It varies with the species. The incubation period (in days) of common poultry species are: Japanese Quail : 18, Chicks and Bantam: 21, Duck, Guinea fowl, Turkey: 28, Geese : 35, Emu : 42 to 53 and Ostrich : 42.

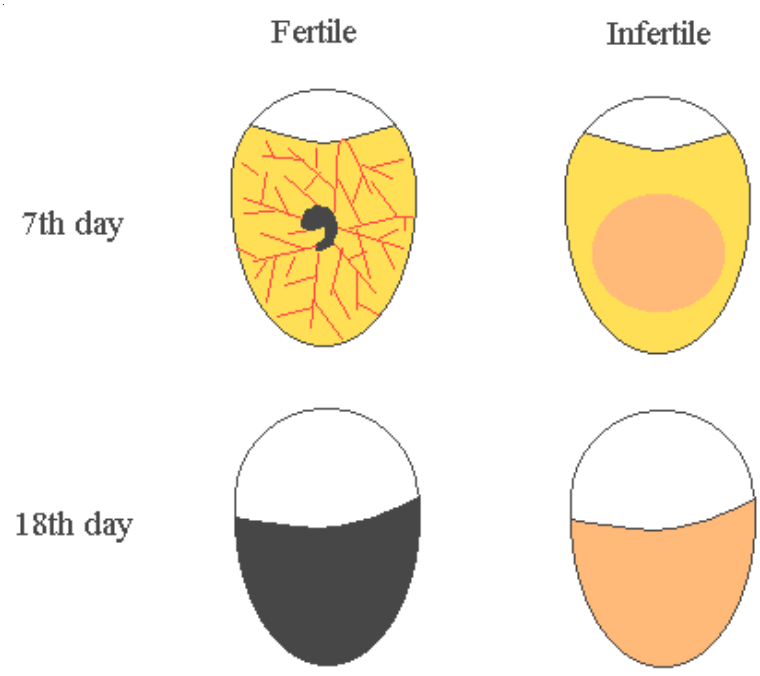
## Check Your Progress 2

1) The conditions required for fertile chicken eggs are as follows:

| Parameters | Incubator (setter) | Hatcher |
|---|---|---|
| Number of days | First 18 days | $19^{th}$ , $20^{th}$ and $21^{st}$ days |
| Temperature, $^{o}C$ | 37.6 to 37.9 | 36.1 to 36.7 |
| Relative humidity, % | 55 | 65 |
| Position | Broad-end up, in contact with each other | Horizontal |
| Turning | At least 6 times a day | Not required |
| Oxygen, % | 21 | 21 |
| Carbon dioxide, % | 0.04 | 0.04 |

2) During embryo growth, yolk comes to the surface and is likely to get attached to the shell and die. Therefore, eggs in the setter are turned. In case of the hatcher, embryo has completely grown and there is no question of yolk coming to the surface. Therefore, eggs in the hatcher are not turned.

3) Testing for fertility is done by candling one row at a time the setter tray at 4 to 7 days of incubation. It can also be done by the same method while the eggs are transferred to the hatcher on $18^{th}$ day. The appearance of the fertile and infertile eggs will be as follows:




Fertile eggs after 4 to 7 days of incubation clearly show development of blood vessels and clearly moving embryo at the centre appearing dark. A live embryo is spider-like in appearance, with the embryo representing a spider's body and the large blood vessels spreading out much like a spider's legs. At $18^{th}$ day, a large air-cell at the broad end with the bottom portion opaque due to the presence of developed embryo is extremely easy to identify.