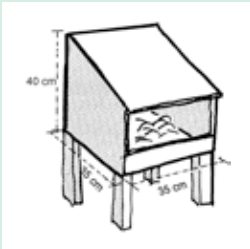
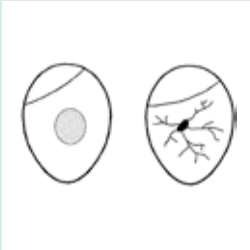


Improving hatching and brooding in small-scale poultry keeping



Agrodok 34

Improving hatching and brooding in small-scale poultry

Farzin Wafadar
Ineke Puls

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Foreword

This booklet is about small-scale poultry hatching and brooding practices, focusing on successful keeping of the standard backyard poultry flock. We have thoroughly revised the previous editions of this manual, creating a whole new version adapted to the latest insights into efficient village poultry hatching and brooding practices. It includes both natural and artificial hatching and brooding, both of which have their due place depending on the farmer's objectives.

Acknowledgments

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We wish the reader good readings and good business.

The editors,
Wageningen, 2011

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1 Introduction

Poultry plays an important role in most developing countries, as it contributes to the livelihood of rural smallholder farmers who keep village chickens.

General information on chicken farming is discussed in many booklets on the subject, like Agrodok No. 4: small-scale chicken production.

This booklet focuses on upgrading hatching and brooding practices in the free-range poultry flock in order to:

- Achieve an optimal number of chickens.
- Implement regular flock replacement.
- Successfully raise the young chicks through their first 8 weeks of life.

Both hatching and brooding can be natural, by a hen or a substitute mother (turkey, duck), or artificial, in an incubator (hatching) and a brooder (brooding).

Three village-based poultry systems may be distinguished according to the definitions of the Food and Agriculture Organization (FAO):

- traditional free-range system (1-10 birds)
- improved free-range system (5-50 birds)
- small-scale confined system (50-200 birds)

Village poultry, as kept in the first two groups above, receives hardly any care. As a result almost half of the young birds die within the first 8 weeks of life. Simple management tools such as better housing and feeding can prevent this.

Chapter 2 describes the factors that influence the choice between natural and artificial incubation.

Chapter 3 provides basic information on eggs, storage of fertilized eggs, handling practices and the development of chicks during incubation.

Brooding and raising the chicks either by hens, or artificially in incubators and brooders, is discussed in Chapters 4-7. By simple management and selection measures the hatching and brooding results of family poultry can be improved quite considerably.

The final Chapter gives an overview of feed and health and clearly states the importance of sanitation practices.

Some general advice

When starting hatching and brooding it is best to use local breeds that have proved their worth under local conditions. Furthermore, it is essential to consult the extension agents in the area about any required medication/vaccinations against infectious diseases. Enquire also about the most appropriate season to start raising chickens.

Replacing your hens every year is sometimes recommended. Old hens lay fewer eggs, but eat the same amount of feed. Usually you can get a good price for old hens because people like their taste. But some hens prove to be excellent mothers, so it would be unwise to slaughter them early. And never get rid of your laying hens until you have young hens ready to take over!

2 Natural or artificial incubation?

The choice between natural incubation (by a hen) and artificial incubation (in an incubator) largely depends on the production strategy, and the number of eggs to be hatched at a given time.

Factors to be taken into account when deciding whether to use a broody hen or an incubator:

- production system and number of eggs to be hatched
- labour involved
- investment in buying or building an incubator and running it
- different results from either hens or incubators

A general word of caution: any improvement in your present poultry production system will involve additional investments in time, equipment and funds, which should never be underestimated. Before starting, take time to consider who will provide the additional labour inputs and how the improvements will be financed. Never act on the spur of the moment!

2.1 Production systems

Traditional free-range system

In the family or backyard poultry system hens are kept under free-range conditions, picking and choosing insects and plant food. They only have a night shelter and receive some kitchen leftovers.

Broody hens will hatch the eggs in this system. A hen will go broody after laying a batch of 8-14 eggs. She will then sit on the eggs, hatch them, and raise her chicks for up to 8 weeks. She teaches her chicks how to survive and look for food.



Figure 1: Night shelter as protection against predators and bad weather

When the hen has finished raising her chicks she will start laying eggs again for a period of 8-10 months. Under normal conditions a hen has a 5-year lifespan. Apart from feeding the hens, the role of the poultry farmer is to protect the hens and chickens from predators, thieves and bad weather.

Improved free-range system

The scale of the improved home flock production system is larger than that of the traditional free-range systems (say up to 50 birds). It includes both indigenous and improved poultry breeds, somewhat better feeding, simple housing and some medical care.

Egg and meat production are increased correspondingly, allowing a modest level of sales of eggs and/or poultry at local markets in addition to household consumption.

Under these conditions using brooding hens for hatching eggs is adequate, allowing the farmer to spread the production of eggs and meat evenly throughout the year

Small-scale confined system: use of an artificial incubator

More intensive poultry farms (more than 50 birds) keep commercial breeds for egg production (layers) or meat (broilers). Because many birds are kept together, their housing must be clean and their diet must be of good nutritional value.

An even-aged flock facilitates management, implying that all chicks in the flock should have hatched out at approximately the same time. As hens do not go broody simultaneously, an even-aged chicken population of any size demands artificial incubation.

In some areas, day-old chicks can be regularly obtained from commercial hatcheries. Sometimes poultry farmers who have learned how to run an incubator also provide 'hatching services' to other poultry keepers.

2.2 Number of eggs to be hatched

A hen can hatch 8-14 eggs at a time. The yearly egg production of a hen is limited to 30-90 eggs. Thus, if you only need chicks to replace old hens, you will find using broody hens perfectly adequate.

If you want more eggs to hatch out at the same time you will need an incubator, which can be used whenever it is needed. A small incubator can accommodate 20-50 eggs; furthermore, two or three batches of 50 eggs can be hatched within a few months.

2.3 Required labour

Looking after the hens

When using broody hens, the time spent on looking after them is limited to feeding and supervising them. The hens will need a safe, clean and quiet place and a nest or nest box, as well as easy access to food and water. Although it might seem a simple and easy job, the time and care required to manage a healthy flock with brooding hens should not be underestimated.

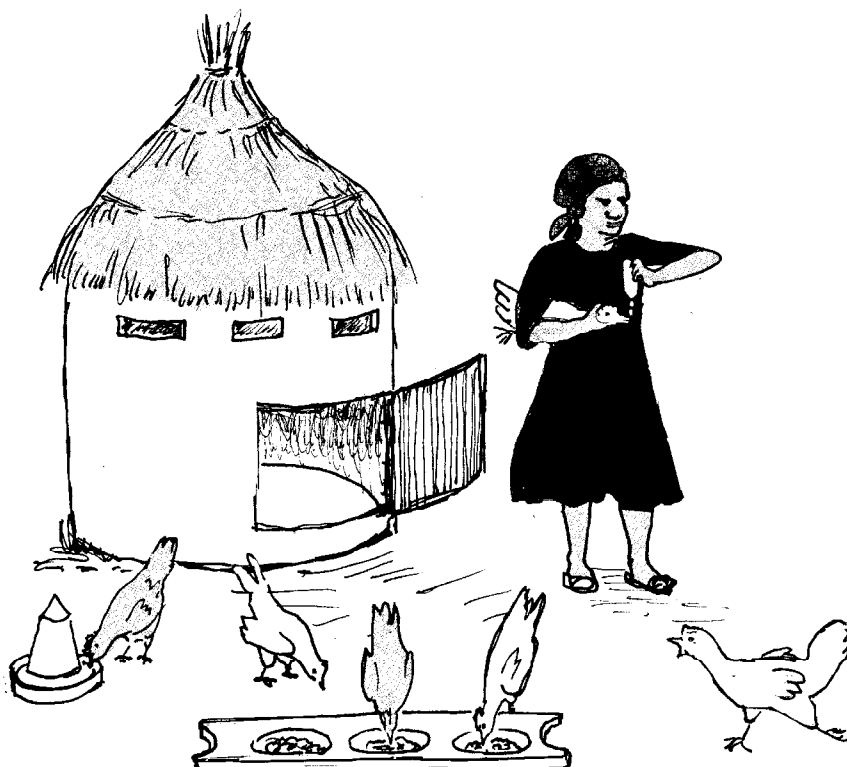


Figure 2: Good management and sanitation practices will prevent diseases and imply healthy chickens

Using an incubator

Using an incubator is more time-consuming. Apart from purchasing or constructing an incubator, operating it demands careful attention, skills and experience to execute the following tasks:

- Controlling and regulating incubator temperature and humidity
- Turning the eggs regularly up to day 19 (preferably three times a day)
- Frequent checking of all devices and equipment; the light bulbs or the solar equipment and adding fuel to the burner and/or water to the reservoir or the water pans
- Regular and thorough cleaning and disinfecting of the incubator immediately after each hatch and preparing it again for the next batch of eggs

In addition to present duties or occupation the tasks just mentioned above will demand *at least* one or two working hours a day (for a small incubator containing up to 50 eggs), and special skills and accuracy on top of that.

2.4 Costs

Costs of hatching by hens

The costs of hatching by broody hens only involve the expenses for feed and vaccinations, and the material needed for building a shelter and adequate nests or nest boxes. Shelter and nests can usually be made from local materials. Thus, broody hens are more economic in time and money than artificial incubators, as they only need to be given a safe and clean shelter and (adequate) feed and clean water to hatch 8-14 eggs at a time.

Costs of an artificial incubator

Costs of owning and operating an artificial incubator are much higher and pertain to the following: purchasing or constructing the incubator, necessary equipment and operating it.

A choice can be made between buying an incubator and making one yourself. This will depend on the kind of incubator you want to use, its availability and your personal skills. A simple, small electric incubator (for 20-30 eggs) may cost around 150 or \$218; A *solar powered* incubator (for 50 eggs) is available for about \$500.

If you choose to build an incubator yourself you will need to buy a variety of materials, such as timber, wire netting, sheet iron, water containers, and equipment like a thermometer and a hygrometer. Most of the material should be available locally.

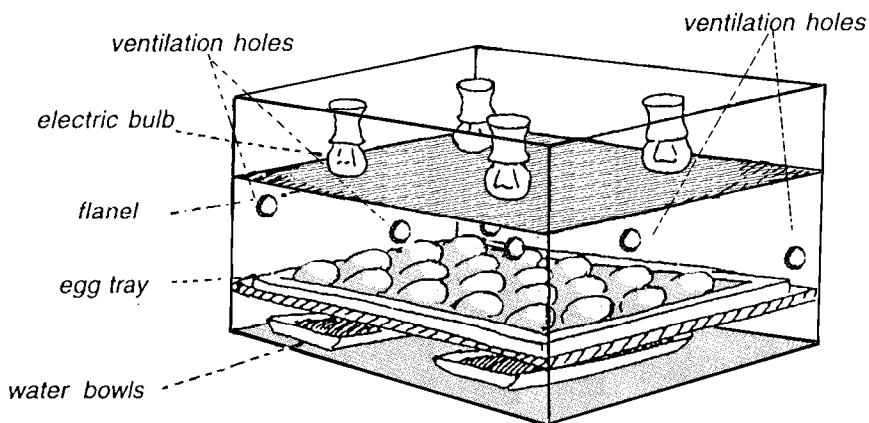


Figure 3: A home-made incubator

Heating the incubator requires the use of kerosene, gas, or electricity from light bulbs or a solar panel. So, before you decide to use an incubator, make sure you have calculated these costs (or the cost of the preliminary investment, if planning to use a solar panel)!

Example: the kerosene incubator described in Section 6.1, case study 2 will use up about 0,5 litres of kerosene every 24 hours for 40 eggs. If 70% of the eggs hatch this will give 28 chicks (male and female) in 21 days. You will need 21 x 0.5 litres of kerosene. Thus each chick can be said to cost about half a litre of kerosene.

2.5 Different performances of hens and incubators

A hen sitting on eggs will provide exactly the right temperature, humidity, ventilation and turning frequency required for the eggs to develop well. The risks of hatching by hens are low; if a hen abandons her nest only 8-14 eggs will be lost.

A home-made incubator will not easily meet the requisite standards of temperature, humidity and ventilation. To optimise the hatching results, some experience with the careful operation of the incubator is necessary.

Even then, results may be below expectation. If you run out of fuel or experience a prolonged power cut you will lose 40 to 100 eggs or even more, depending on the number of eggs and size of the incubator.

2.6 Summary

The table below gives an overview of the various factors to be taken into account when choosing your hatching method.

Table 1: Choosing between hens and an incubator

Aspect	Hens	Incubator
1. Technique	(10-50 eggs at a time, with 1 to 5 broody hens) Not always broody when required Not always cooperative	(40-100 eggs at a time) Always available
2. Labour costs	(a minimum of) cleaning Water Shelter Protection	(Building the incubator) Checking and regulating heat source and temperature Turning the eggs artificially Refuelling the lamp Filling the water container
3. Construction costs	Limited: Nest boxes or baskets Feeders Drinkers	Local materials Thermometer Thermostat Hygrometer
4. Running costs	Limited: Feed	Electricity, gas, kerosene, solar power

Aspect	Hens	Incubator
	Nesting material Vaccinations	Vaccinations
5. Performance and results	Natural hatching conditions guaranteed (temperature, relative humidity, ventilation) Hens of local breeds usually stay broody during the hatching period, with improved breeds this is less certain	Almost optimal conditions (if well managed!) Improved breeds may permanently produce eggs over a long period
6. Risks	Few risks	Technical risks: loss of all or some of the eggs

3 About eggs

Poultry can produce large numbers of eggs during their lifespan. Some elementary information about eggs is given below.

3.1 Biology of eggs

Structure of eggs

The egg is a complex structure consisting of: the eggshell, shell membranes, egg white (albumen), two twisted cords (chalazae), yolk and egg cell. The unfertilised/immature egg cell is also known as the oocyte or female gamete, the fertilized one the blastoderm or embryo.

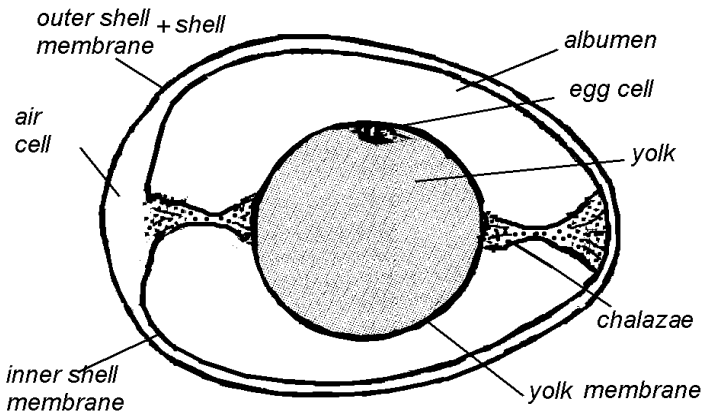


Figure 4: The structure of an egg

The following components can be distinguished:

- **Eggshell**, a hard and rigid layer of calcium protecting the interior of the egg.
- **Two shell membranes** (outer and inner shell membranes); they separate at the broad end of the egg and form the **air cell**. As moisture is lost through evaporation the air cell in older eggs gets bigger.

This explains why old eggs will float in water and fresh eggs will sink. The airspace is important in hatching (see Section 3.4).

- **The egg white** (albumen) is a jelly like substance that turns white when the egg is boiled. In old eggs the white will become more liquid, so when you break an old egg onto a plate, it will cover a greater surface than a freshly laid egg.
- **Two twisted cords** (chalazae) of egg white keep the yolk in the centre of the egg.
- **The yolk** is a yellow coloured substance surrounded by a yolk membrane. The colour of the yolk depends on the food eaten by the hens.
- **The egg cell** (oocyte/female gamete) is located on the surface of the yolk. Development of the chicken embryo starts here once the egg cell has been fertilized.

The yolk and egg white contain highly nutritious substances (proteins and fats) used by the developing embryo and the newly hatched chick.

Production of eggs

Egg production starts when hens have reached sexual maturity. For commercial layer breeds this will be around the age of 20 weeks, later for local breeds (24-32 weeks). The hen does not need a cockerel to start laying, but eggs will not hatch unless fertilized!

Egg-forming organs inside a hen's body are: the ovary where many egg yolks (and egg cells) develop, before they are released into the oviduct.

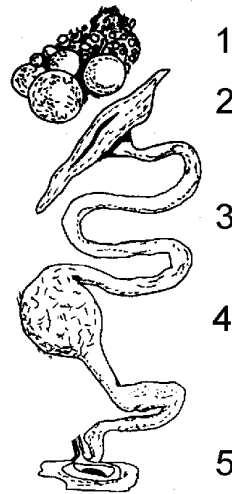


Figure 5: Egg-forming organs.

- 1: ovary;*
- 2: funnel like first part of oviduct where egg cell can be fertilized;*
- 3: egg white forming part;*
- 4: shell forming part;*
- 5: vent.*

The oviduct is a tube where a yolk enters at one side, and 24 hours later, a complete egg – with shell – will come out at the other side.

Shortly after an egg is laid, a new yolk will be released from the ovary. Thus a hen can continue laying an egg a day for several days. A local hen will lay 8-14 eggs after which she will become broody. A commercial layer will lay up to 30 eggs and will resume laying after a break of just one day. Therefore she does not get broody at all.

During the period a hen is laying, the oviduct tube is quite long (65-70 cm). When a hen is not laying the tube will be much shorter.

3.2 Egg production

How to determine whether a hen is laying or not

A method to distinguish laying birds from non-laying birds consists of examining the vent (*cloacae*) and measuring the distance between the pubic bones and breastbones.

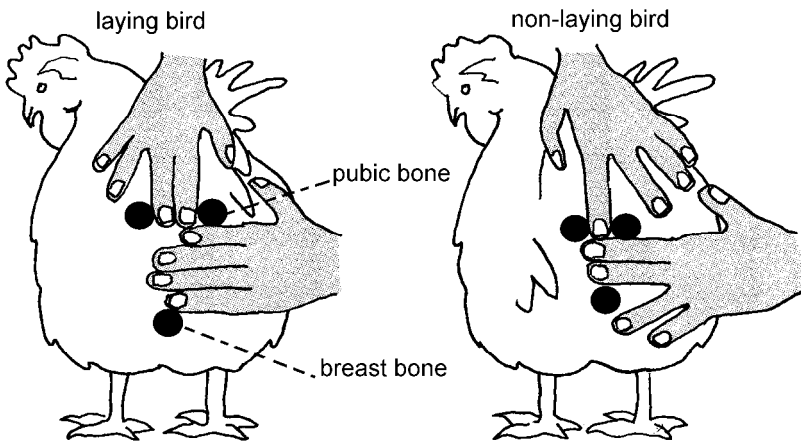


Figure 6: Measuring, with one's fingers, the distances between the hen's breastbone (keel bone) and pubic bones and between the 2 pubic bones

The hen is most likely to be laying when:

- The hen's vent looks moist and pink coloured, and
- There is ample space (4 fingers) between the pointed end of the breastbone and the pubic bones and (2 fingers) between the 2 pubic bones.

The hen is not laying when:

- The vent looks dry and yellowish, and
- There is little space between the pointed end of the breastbone and the pubic bones and between the 2 pubic bones.

Fertilization of eggs

Chicks can only come from fertilized eggs. Therefore it is important to keep an active and fertile cockerel (of cock?) with the hens so that mating can take place.

One cock for 10 hens

Put the cock amongst the hens two weeks before starting to collect eggs for hatching, to ensure that the eggs are fertilized. One cock can serve several hens; best results are achieved with 10 hens per cock.

Cocks have testicles where sperm cells are produced. During mating the sperm cells are ejected into the hen's oviduct from where they move to the upper part of the tube near the ovary. One sperm cell will merge with the germ cell on a yolk just after it is released from the ovary. The remaining sperm cells stay alive in the oviduct for roughly 10 days, thus a hen can continue to lay fertilized eggs for around 8-10 days after mating just once.

The fertilized egg

The egg containing the fertilized germ cell will be laid 24 hours later. By that time the embryo has developed into a small white disc (*blastoderm*) on the surface of the yolk.

From the outside you cannot see whether the egg is fertilized. You can see the blastoderm on the yolk only if you break the egg onto a plate.

Egg production characteristics

Number of eggs

Hens of traditional and local breeds will lay eggs for 8-14 days and then sit on them to hatch them.

After 3 weeks of hatching and several weeks caring for her chickens, the hen will start laying 8-14 eggs again. It means that the annual production of a local hen is limited to 30-90 eggs.

If the chicks are taken away from the hen earlier, she will start laying again sooner, so the annual number of eggs should increase slightly.

Broodiness

Broodiness is an inherited characteristic. Modern commercial layers have had the instinct to go broody bred out of them. It implies that after laying their cluster of 30 eggs or more, they will recommence laying after only 1 day's rest. In this way, the yearly egg-production of layers will be much higher than that of traditional hens, and can reach 300 eggs.

Egg weight

Egg weight varies between breeds: from 35-50g for local breeds and 50-70g for commercial layers. At first the eggs of young hens will be smaller than the eggs they lay a few months later.

Selection of eggs for hatching

Collect hatching eggs from the nests at least twice a day. Select the best eggs. Take into account the size of the eggs, their shape, the cleanliness and condition of the shell. Only use fresh eggs. If you want to hatch a lot of eggs together, it is preferable that you only use eggs up to one week old, and only those that they have been stored in a cool place at a temperature of 16-20 °C.

Eggs from different hens

It could be that a hen may not lay fertile eggs, or be less fertile than others. When using a foster hen or an incubator, therefore, you would be wise to use eggs from different hens in order to reduce the risk of failure.

Normal-sized eggs

The eggs of different poultry breeds vary in weight from 30-70g. Best hatching results are obtained by using normal-sized eggs from hens that lay well. Eggs from good stock will produce good quality chicks because the hen's qualities are passed on through her eggs.

Odd-shaped eggs

Never use odd-shaped eggs for incubation (too long, too round, too small or misshapen), as the likelihood of getting chicks from them is very small.

Double yolk

Some eggs have two yolks, so-called double yolks. Such eggs are larger than normal and when incubated no chicks will hatch.

Very small eggs

Sometimes very small eggs are found. They never contain a yolk (and a germ cell).

Bad or deformed eggshells

Bad or deformed eggshells can be caused by: diseases, lack of calcium and disturbance of the hens during the (20-hour) shell formation.

Cracked eggs

There should be no cracks in the eggshell as excessive moisture will be lost during incubation leading to either weak or dead chicks. Moreover, cracks provide an entrance for bacteria and other causes of disease.

Dirty eggs

Reduce disease risk by using only clean eggs. Avoid using eggs contaminated either with droppings, dirt or with the egg content of a broken egg. These eggs might contain pathogens. Moreover, the dirt blocks the pores in the shell restricting the embryo's respiration through the shell. The eggshell is porous – air has to be able to pass through it. Dirt and disease-bearing organisms can also pass through the eggshell if the shell is moist.

Never use very dirty eggs for hatching. Slightly soiled eggs may be cleaned with a dry cloth or brush. Never wash eggs in water, as it will help micro-organisms to pass through the eggshell and cause the embryo to die.

3.3 Storage of fertilized eggs

Temperature of storage

Eggs for hatching should be collected at least twice a day and cooled down to storage temperature (preferably below 20 °C) as quickly as possible in order to stop embryo development. This is especially important in hot climates! If eggs remain too warm over a longer period, the embryo will develop too quickly and its chances to survive the storage period will be reduced accordingly.

Do not store hatching eggs too cold (eg. storage in a refrigerator at 4 C results in a very poor hatch!).

When the egg cools, embryonic development stops. Embryonic development starts again when the temperature is increased. If the temperature is decreased a second time, the embryo will die!

Eggs should be stored in a cool shady place, for instance, in a clay pot embedded in moistened earth/sand mixture. Take care to avoid direct contact between eggs and moisture by placing pieces of cloth or jute between the sand and eggs. Obviously, the pot should be placed in a cool spot. This method has proved valuable in hot and dry summer months, when outside temperatures can reach 40 °C and more.

Safe egg storage time is strongly correlated with temperature levels.

- 20 °C eggs can be stored for three days.
- 16-18 °C storage can be prolonged up to 1 week.

Preferably, use eggs that have been stored for no longer than one week. Both hatching results and chick quality will be reduced by prolonged egg storage.

Humidity during storage

The optimal level of relative humidity for storing hatching eggs is 70-85%. Mould or water drops appearing on your eggs will mean that the humidity is too high.

Never use mouldy or wet eggs for hatching!

Position of eggs during storage

All poultry eggs should be stored with the air space inside the egg (the 'air pocket' or 'air cell') uppermost; in other words small end down and broad end up.

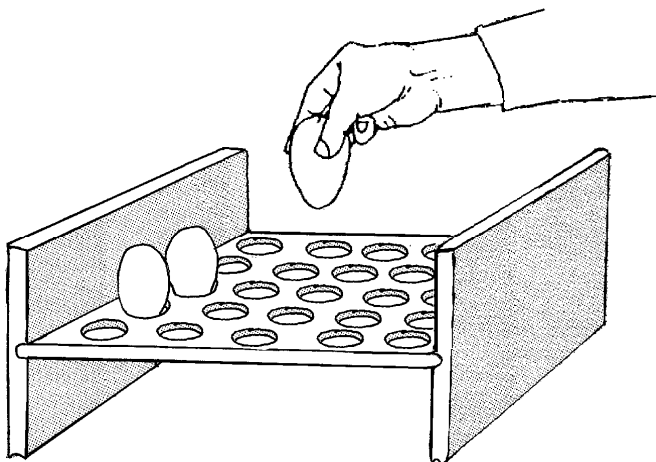


Figure 7: When storing the eggs, always place them with the air pocket at the top (small end down and broad end up)

If, for instance, during a cool season, a broody hen is allowed to collect eggs in her nest day-by-day until she starts sitting on them, she will turn them regularly so no separate egg storage will be needed.

In case egg trays are used for storage of hatching eggs, plastic trays are preferred over paper trays. Plastic trays can be washed and disinfected, and dried in the sun, which will greatly reduce the number of germs on them. On older paper trays germs can accumulate from all the places where these trays have been used and transported (chicken houses as well), so with paper trays there is always a risk of contamination.

Pre-warming before hatching

It is very important to avoid sudden temperature changes, as they will cause the embryo to die.

Thus, eggs that have been stored below 20 °C should first be kept at a temperature of 23-27 °C for 12 hours, before being transferred to the incubator. This method is called 'pre-warming'. A gradual warming up also greatly reduces the risk of condensation wetting the eggs, which might allow bacteria to penetrate the eggshell and spoil it.

3.4 Development of chick embryos

When stored at a temperature below 20 °C, embryo development in fertilized eggs will stop. The incubation process will recommence under a broody hen or in an incubator.

The incubation process

When incubation starts, the white disc on top of the yolk (blastoderm or fertilised egg cell) will start to grow and develop into an embryo. Heart and blood vessels are formed. The blood vessels can be observed by candling after 7-9 days of incubation (see Section 3.5: Monitoring egg development). During incubation, the chick embryo will continue to grow inside the egg. It will consume most of the egg white and some egg yolk.

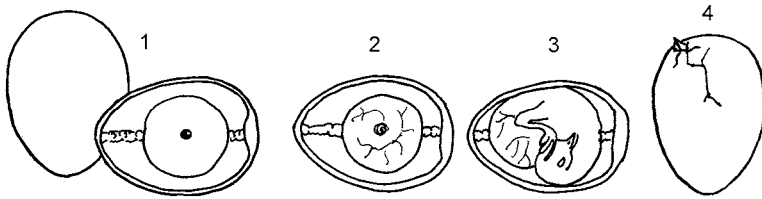


Figure 8: Development of a chick embryo inside the egg. 1 egg cell, 2 heart and blood vessel, 3 embryo, 4 pipping chick

Increase of size of air cell

Water inside the egg will evaporate during incubation. It is replaced by air at the broad end of the egg. Thus, the air cell gradually increases in size (see Figure 9).

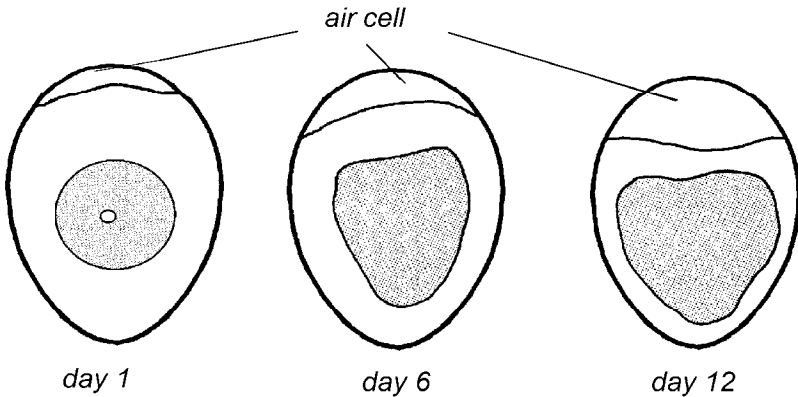


Figure 9: Air-cell size in relation to days of incubation

Pipping

A few days before hatching, the chick has to use its beak to pierce the cell membrane below the air space in order to start normal respiration with its lungs (see Figure 8).

From that moment the chick can be heard peeping inside the egg. When the chick is used to breathing normally it will start making a small hole in the eggshell (pipping).

Humidity level

Too little humidity and the eggs will dry out. Too much humidity will result in an air space that is too small for the chick to survive to the end of incubation.

Some humidity in the environment is essential when the chicks are coming out. When the air is too dry, the chicks will stick to the inside of the eggshell and can die easily.

3.5 Monitoring egg development

Careful monitoring the chick development in hatching eggs is important for improving hatching results. This can best be done by candling, which is discussed below. There are 2 other methods to monitor the egg development: weighing the eggs, and measuring the air cell. These are discussed in Section 6.4, although the methods are mainly used to monitor humidity.

Candling

Infertile eggs and dead embryos can be detected by candling. Candling is very helpful during incubation, as it helps to determine whether the embryo is developing.

An egg candler can be purchased, or a torch can be used. Hold a small torch against an egg in a dark room. Looking through the egg, part of the inside becomes visible.

Visibility in white and brown eggs

After 5 days of incubation, blood vessels should be visible if the eggshell is white. If the eggshell is brown, several more days may be required before blood vessels are visible. If development does not occur, the egg is infertile, or there is an incubation problem.

First candling

Candling is best started on the 9th day of incubation. By day 8 or 9, the light may startle the chick, and its movement can be seen. Once you have some experience you can start a few days earlier. Infertile eggs and cracked eggs with dead embryos should be removed immediately.

Second candling

A second candling can be done after 14 to 18 days of incubation. Once again remove any dead embryos.

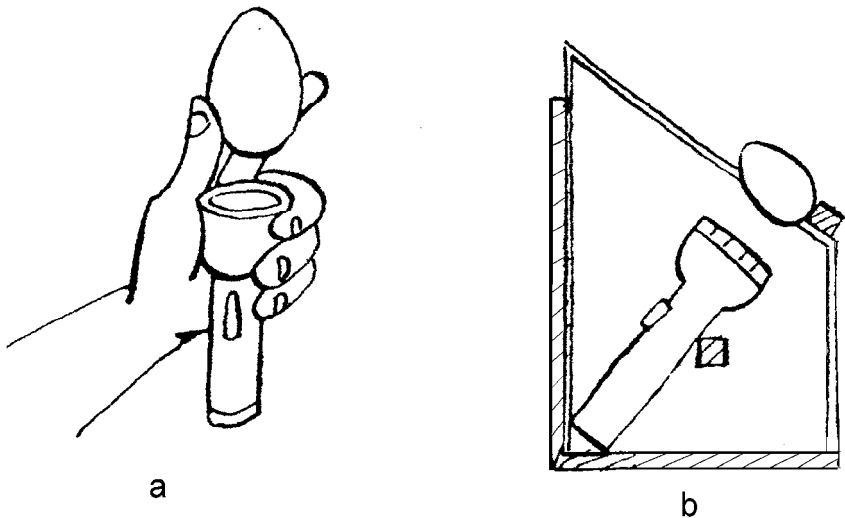


Figure 10: Home-made egg cdlers using either your hand or a wooden box and a torch in a dark space!

Do not candle eggs after the 18th day so as not to disturb the growing chicks. As breaking out of the eggs is very tiring for the chicks, they need their rest and should not be handled during these last days. Moreover, opening the incubator during the last days of incubation will cause an unwanted drop in relative humidity.

Figure 11 shows what might be seen when candling an egg after 8 days of incubation.

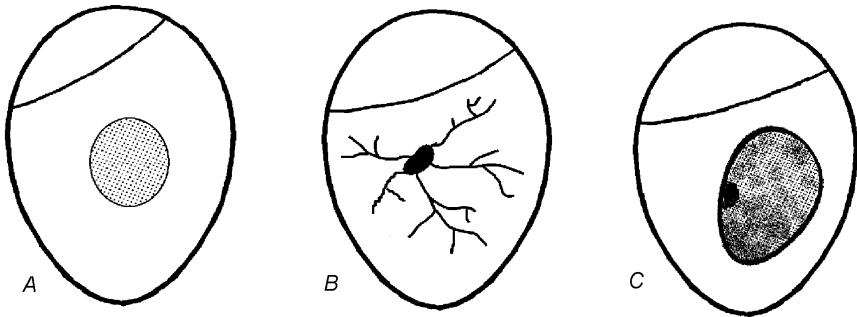


Figure 11: What can be seen when candling an egg after 8 days of incubation

A: in an infertile egg only the shadow of the yolk and the air cell can be seen.

B: in a fertile egg blood vessels are spread all over; they are most easily observed close to the air cell. The embryo can be seen as a dark shadow. The air cell is more clearly visible than in an infertile egg.

C: in an egg containing a dead embryo blood vessels have contracted in a ring around the embryo, which is visible as a dark shadow. The air cell is clearly visible.

Remove immediately any infertile egg or eggs containing dead embryos, as these will decompose and may break and thus spoil the other eggs. After any cold eggs have been removed from the incubator the temperature in the incubator will be more stable.

Keeping records

Not only should you remove the infertile and cracked eggs but also try to find out why the eggs did not develop properly. This is best done by keeping records. The guidelines in Table 5, Section 6.8 and the more detailed Appendix 3 may give some clues.

4 Natural incubation

In traditional or improved free-range poultry production systems (see Chapter 2), allowing a healthy hen to do the incubating and brooding is generally the most efficient option for acquiring new chicks.

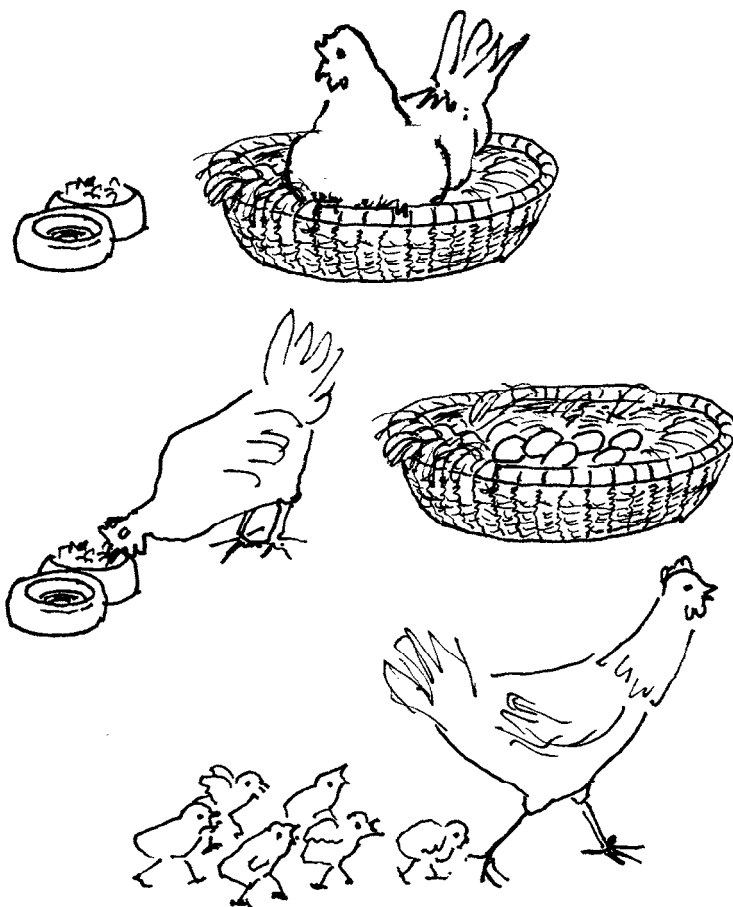


Figure 12: Natural incubation and brooding

4.1 Selection of hen and eggs

Selecting the hen

Look for a hen that is clearly ‘going broody’. She will display typical behaviour:

- She will be making a typical broody hen sound.
- When she is approached she will raise the feathers in her neck and back.
- Her comb shrivels up.
- She occupies her nest, refusing to leave it.

If this behaviour lasts for two days you can assume that the hen is ready for brooding. Broody hens should be healthy and not too small. Below are suggestions for improving hatching conditions.

Substitute mother hen or foster hen

Not all hens are equally fit for brooding, but it is possible to get a broody hen to sit on the eggs of another. The following hens are good brooders and good mothers.

- hen from local poultry breeds
- turkey hen
- female duck*

*Take care that ducks do not push the newly hatched chicks into the water in order to make them swim.

In general commercial layers will not develop broodiness.

Different hatching times

Eggs of ducks and turkeys take longer to hatch than chicken eggs. If you want to incubate both chicken eggs and, for example, turkey eggs in the same nest, place the chicken eggs in the nest a week later in order to synchronise the hatching.

Selection of eggs for hatching

To improve hatching results, start by selecting good eggs. See the criteria for egg selection in Section 3.5.

Do not leave eggs laid in the hen's nest until she gets broody, and especially not in a hot and dirty environment. Store the eggs in a dark, cool and dry place, like a clay pot filled with moistened sand or wood shavings, or a cooling device. Return the eggs to the nest or nest box when the hen becomes broody.

An alternative is to place the eggs (at night) under another broody hen, duck or turkey, to complete her batch of eggs (maximum 8 -14 eggs)

Number of eggs

The size of the hen and the temperature during the night will determine the number of eggs she will be able to sit on for successful hatching. Large hens with good plumage can cover and keep warm as many as 14 eggs, but smaller local hens may be able to properly cover no more than 8 eggs.

4.2 Preparing for hatching

Dusting the hen

Dust the broody hen with an insecticide against fleas and lice. Be careful when using these products; in the wrong quantities they are harmful to poultry and humans alike! If lice and fleas remain a problem, dusting should be repeated after 10 days.

After dusting, place the broody hen in a clean nest or nest box (see below) with the eggs you have selected for hatching.

Preparing the nest or nest box

Different types of nests can be used: baskets, clay pots, cardboard boxes, wooden boxes, etc.

The nests should be set slightly apart (about 1 metre) to avoid the hens quarrelling. Place nests or nest boxes in a safe, dark and dry place, out of reach of dogs, rats and snakes.

Before using a nest box (or nest pot), clean it thoroughly and dry it in the sun.

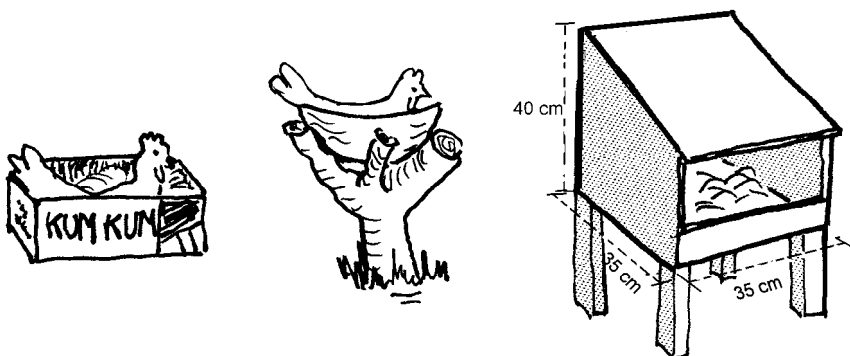


Figure 13: Nests for broody hens should be placed in a quiet place set apart from other hens

Nest litter

Fill the nest up to 1/3 with sand mixed with ashes and put some fresh straw, wood shavings, hay or dry leaves on top, but not more than 3/4 full, to prevent the eggs from rolling out. A (wooden) nest box should be about 35 x 35 cm square and 40 cm high.

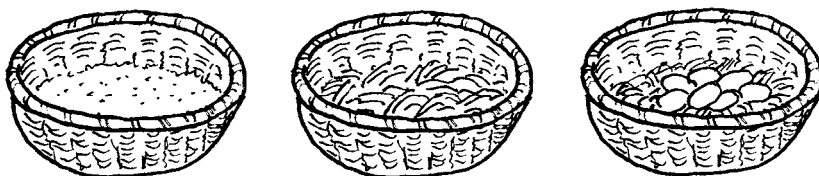


Figure 14: Preparation of a clean and attractive nest for a brooding hen

If available, a handful of dry crushed tobacco leaves will help to keep the nest free of parasites (nicotine is an insecticide!).

4.3 The incubation period

The nest or basket with the broody hen should be set apart to prevent other hens from disturbing her.

The hen will leave her nest to drink, eat and defecate. Initially she will hardly leave her nest at all; after 2 weeks more frequently and for longer periods. Sufficient feed, fresh water and clean sand (for dusting) should be placed near the nest(s). If the hen refuses to leave her nest, she can be lifted off gently and put in front of the feed. She should not leave the nest for more than 15 minutes.

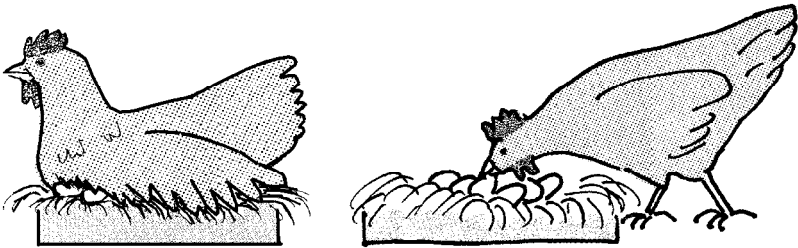


Figure 15: Broody hen on nest and shifting and turning her eggs

Instinctively, the hen will often stand up and shift or turn the eggs because the best and warmest place is in the middle. Regular turning is also important to ensure the eggs are heated uniformly and not only on one side, as well as to keep the developing embryo centred.

Candling the eggs

The eggs can be examined by candling on the 9th day (see Section 3.5). Remove infertile eggs and eggs with dead embryos immediately.

Infertile eggs can be sold or eaten. Eggs with dead embryos (when boiled and crushed with their shells) can be used as chicken feed. They are a good source of protein and calcium for the broody hen or the fast growing young chickens.

Hatching

The eggs will hatch after about 21 days (for chicken eggs). If chicks have difficulty hatching out, the humidity is probably too low. To help them hatch, the nest material can be moistened a little with water so evaporation can take place thus increasing humidity.

Case description: Improving backyard poultry-keeping in India

Case description from India showing that productivity of backyard poultry keeping can be improved with simple low-cost interventions.

Candling of eggs early in the (natural) incubation period (around 7 days)

Non-fertilized eggs can be removed and sold or eaten: "Poultry-keepers were quick to understand the candling technology, and to recognise the fact that it makes eggs available for consumption which would otherwise have been left to hatch and eventually become spoiled. Some of the villagers who were trained in its use are now providing a candling service to others, for which the client pays them in kind giving them half of the infertile eggs that have been 'saved' as a result of the candling. Those involved in providing advice and training to poultry keepers should vigorously promote the use of candling. It has several advantages over many poultry-related interventions, namely:

- The technology is simple and relatively inexpensive.
- The benefits are visible and fairly immediate, and it can make a significant contribution to the nutrition of the poultry-keeper and family.

'Cold' storage of hatching eggs

Cold storage of the eggs from the time they are laid to the time the hen starts sitting on them improves hatching: more chickens will hatch. The eggs were placed in pots or baskets containing a moistened earth/ sand mixture. Pieces of cloth/jute were put on the sand to prevent direct contact of the eggs with the moisture. Especially in hot and dry summer months, when temperatures can reach 40 °C, this storage will prevent dehydration of eggs and later spoilage due to death of the embryo.

Source: Agren Network paper 146 (July 2005)

5 Natural brooding

Once the eggs are hatched, the chicks will have to be reared and looked after. The mother hen ensures her chicks are warm until their feathers have grown. She will take care of her chicks, shelter them and protect them with her wings from bad weather conditions and against predators. This is called the brooding period.

5.1 Shelter for mother hen and chicks

In hot climates, the best and cheapest method to guard newly hatched chicks is the so-called ‘basket system’.

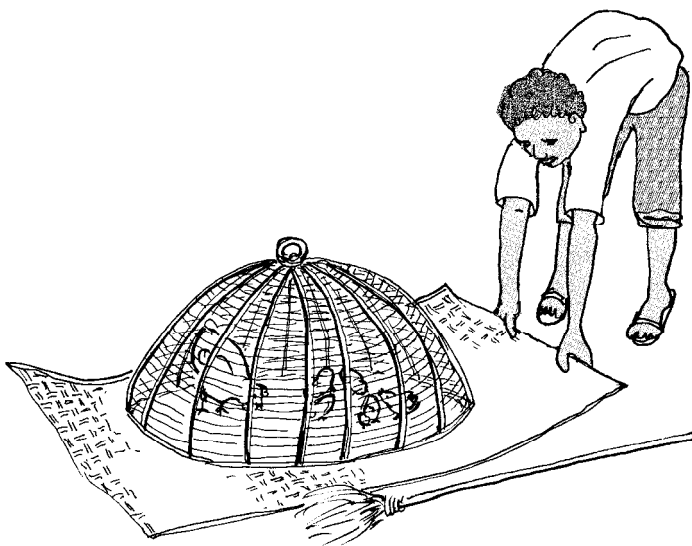


Figure 16: Night basket should have a floor or be placed on a mat to protect against cold. The mat should be cleaned daily.

With the basket system the farmer can provide the young chicks with feed without competition from other birds and keep them safe from

predators. The result is faster growing chicks, less expense for feed, and more chicks surviving.

Small chicks should be kept with their mother overnight in a night basket, which is a round, conical cage with a floor. A night basket may be constructed from bamboo or thin pieces of wood. The night basket should be closed in order to prevent predators from entering and to keep the birds warm at night. For a layer of litter 5 cm deep simply use dry cut straw, rice husks, wood shavings.

In the morning, the chicks should be removed from the night basket and kept in a day basket. The day basket is a bottomless conical cage, see Figure 17. If the soil is damp or wet, place a dry jute or straw mat in the cage. The mat should be cleaned or replaced daily. And, equally, the day basket should be moved to a clean spot every day to avoid disease. The droppings can be used in the vegetable garden.

Four stages of management can be distinguished

0-1 week of age

Keep the mother hen with the chicks for 4 to 7 days after hatching to protect them and help adjust their temperature. The chicks' chirping will guide the hen.

1-3 weeks of age:

Keep the chicks in the cage all the time, but let the hen out for scavenging during the day. She should be able to hear the chicks from where she is and be able to enter the cage when she wants to. So someone should be in attendance nearby. Keep hen and chicks together at night.

Make sure of easy access to clean water and high-protein feed for the chicks. Ensure that the basket floor is kept clean. Place a sheet of paper or a woven mat beneath the basket so that droppings and spilled feed can be easily removed.

3-6 weeks of age:

Continue to keep hen and chicks together at night, but now let the chicks out for scavenging with their mother during the day, at first for a few hours in the morning, and then gradually a little longer. Make sure that the chicks still have easy access to clean water and high-protein feed in the basket, taking care that the entrance is too small for older birds to enter. Ensure that the basket and the ground are kept clean at all times.

After 6 weeks:

You can now do away with the basket and let the chicks scavenge freely with the mother hen. Give supplementary feeding in the evening to the whole flock, according to their needs.

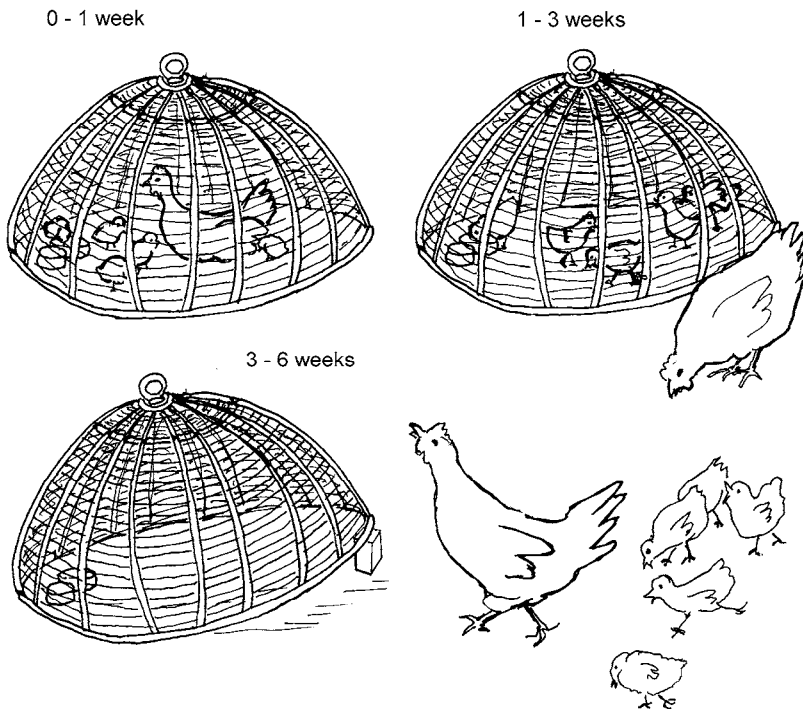


Figure 17: Management of small chicks using the basket system

5.2 Hens raising chicks from another hen or from an incubator

A hen can handle twice as many chicks as she has hatched herself, provided the other day-old chicks are added (preferably at night) to her own brood. Under normal circumstances and depending on her size, a hen can look after up to 15 chicks. You could also buy chicks from a farmer providing hatching services, or from commercial hatcheries.

Day old chicks from commercial hatcheries

Commercial hatcheries deliver in large numbers only and mostly sell improved breeds (*hybrids*). Hybrids are bred for either egg production or meat production. These breeds generally require higher standards of feeding and management (medication) than the more resistant local breeds. If you can meet these standards – then and only then – will the extra cost of buying in quality chicks be worthwhile.

6 Artificial incubation

Chickens can be hatched by either using a sitting hen or an incubator. An incubator is an enclosed space with controlled temperature, humidity and ventilation. This chapter provides information on small incubators, and how to set up and operate them.

6.1 Types of incubators

Incubators come in different types, shapes and sizes. Small incubators are boxes made of plywood, fibreglass, plastic, etc. (with insulation material in the walls), with a door in front or a lid on the top and ventilation holes for fresh air. They could hold up to 50 eggs. The eggs are placed on racks, trays or drawers. Turning of the eggs is done by hand.

Small incubators can be purchased but can also be homemade. Larger incubators have a fan, can hatch more eggs and require less attention. These so-called ‘forced-air’ incubators may have automatic turners.

Heating elements

To control the temperature a heat source is needed. This can be a kerosene lamp or burner, 1 or more electric light bulb(s) or an electric heating element. A solar panel with battery can be used to empower the light bulbs or the heating element.

Led light does not generate heat and is therefore unsuitable for warming an incubator.

Kerosene incubators

In kerosene incubators often the kerosene lamp or burner is placed under a metal reservoir or tank filled with water. After some hours the heated water tank will warm its surroundings.

Electric incubators

Most electric incubators come with a thermostat, which will automatically switch off the heat when the temperature exceeds a set limit and switch on again when the temperature drops.

Larger electric incubators especially those with more than one egg tray, have ventilation openings as well as a fan or a ventilator inside to distribute the hot air evenly. This is less important for single-tray incubators.

Solar powered incubators

Apart from the energy supply these incubators come in the same types as the standard electric powered ones mentioned above.

As solar power is readily available in tropical areas it constitutes a good and cost effective solution. Although solar-powered incubators have been under development since 2003, notably in Africa and India, they are still quite expensive. In due course solar power will become a safe, clean and economic option for running an incubator or a brooder in areas where no electricity is available.

Some cases of home-made incubators

1. Mwatate, Kenya

This is a simple incubator heated by a kerosene lamp and has only one way of controlling the internal conditions – a thermometer. This small incubator can hold 50 eggs and was built by the manager of a rural livestock centre in Mwatate, Kenya.

Only the cheapest local materials were used to build the incubator. Three air holes were pierced in two sides of the incubator. The hot water tank, full of water, was positioned above the lamp. A plastic plate could be filled with water to adjust humidity levels.

Wood: 200 cm x 5 cm x 5 cm for the framework, 100 cm x 2.5 cm x 30 cm for the stand for the water tank

Insulation panels: 2 m² for all sides of the incubator case

Hardboard: 1 m² for the sides of the incubator case

Lamp: Kerosene lamp with a half litre capacity

Thermometer: veterinary thermometer + *observation window* in the incubator
Hot water tank: an empty 4 litre cooking oil tin, to which a tube (1.2 cm diameter, 1 metre long) was soldered. The tube is transparent at the end so that water level can be checked.

Hosepipe: 2 m

Egg tray: wire mesh covered with a cotton cloth

Water container: plastic plate

One torch: to candle the eggs

20 Eggs were incubated. They were turned 3 times per day up to the 18th day. A torch was used to candle the eggs. A thermometer was placed next to the eggs on the tray in order to check the temperature.

The results: of the 20 eggs in the incubator, 11 hatched out, 6 embryos were dead in shell, 2 eggs were infertile and 1 was broken. Although these are not outstanding results, they are sufficiently encouraging to justify further attempts. Once a good routine is established for using the incubator the hatching rate will almost certainly improve.

2. Agromisa kerosene incubator

Agromisa designed and tested a home-made kerosene-heated incubator, described in detail in previous editions of this AD and in a recent *Agrobrief*. It consists of a stand for a 10-litre hot water tank heated by the lamp (total height 55 cm, including tank) and a 25 cm high superimposed wooden incubator box for the egg tray. One side has 3 ventilation inlets at the lower end, the opposite side 3 outlets at the high end. There should be 10 cm space below the egg tray to allow placing water containers to adjust humidity.

The sides of the incubator box should preferably be double-walled to permit insulation by stuffing hay, cotton or coconut fibre in between. Polystyrene (e.g. from a discarded icebox) is an excellent insulation material, but should never be used near a kerosene lantern because it is highly inflammable. A thermometer should be set up inside the box (its bulb level with the top of the eggs). The glass door should preferably slide up and down to reduce heat loss when it is opened.

The wire netting egg tray can hold up to 30 eggs if its internal dimensions are 35 x 35 cm, up to 50 eggs at 45 x 55 cm, and up to 70 at 50 x 60 cm. The water, once heated, acts as a heat store, buffering small variations in (indoor) heating and outside temperature.

Like all other new incubators this one should also be operated for at least 1 week without eggs to learn the routine and make the necessary adjustments. Consult the above-mentioned '*Agrobrief*' for further details on construction and operation of this incubator. (To be ordered from Agromisa.)

3. Tanzania 'KUKU' box incubator

The 'Kuku' (chicken, in Swahili) box incubator is a simple do-it-yourself design developed in Tanzania. Building and operating instructions can be downloaded free from the Internet site:

<http://www.the-testament-of-truth.co.uk/web/incubat2.htm>

The incubator consists of a 60 x 40 x 23 cm box (outside dimensions) made of wood, plywood, or MDF compressed board and 1 egg tray resting on slats fitted 7 cm below the top of the box. The egg tray is made of 12.5 x 12.5 mm galvanized steel mesh with nylon mosquito mesh on top. The tray holds 30-35 eggs.

The box can be insulated with 1.5 cm foam glued to the inside, in which case its heating efficiency will improve, but fewer eggs can be incubated because the egg tray will be smaller.

The incubator box is fitted with a front door, hinged at the bottom, and a top door (60 x 16 cm) hinged at 2/3 of the top lid. Ventilation holes are drilled in the 2 sides. Water trays to regulate air humidity can be placed under the egg tray.

The incubator is heated by 2 x 60 watt light bulbs or a 100-watt heater fitted on the back, a few cm above the bottom. A bulb-type thermometer is fitted inside the incubator to measure air temperature at the top of the eggs. A thermostat (e.g. the 'Ether Wafer thermostat') with its probe fitted at egg level may be used to regulate the temperature. A 38-38.5 °C egg temperature is best.

(If ambient air temperatures exceed the 38.5 °C level the author recommends placing the incubator in a cellar, or in a hole dug in the ground in a shaded location, with at least 15 cm earth above it. This does not sound very practical; it is probably best to postpone egg hatching until the cooler season).

A +60% hatching result is achievable.

6.2 Incubator management

The incubator should be placed in a cool, shady and quiet place (no trembling by passing trucks or heavy machinery) and certainly not in the chicken house! The room should be well ventilated but free from draughts.

Before using the incubator for the first time, operate it for at least one week without eggs.

Four factors are crucial to incubating eggs:

- Temperature
- Humidity
- Ventilation
- Turning the eggs

Of these factors, temperature is the most critical. Humidity also tends to be overlooked and may cause many hatching problems if not properly controlled.

Table 2: Incubator management

Days of incubation	Temperature	Relative humidity	Minimum turns/day	Ventilation
0-18	37.8-39.2 °C or 100-103 °F	50-60 %	3	Gradually increasing
18-21	37.2-37.8 °C or 99-100 °F	50-60 % until 1/3 of eggs is pipped; thereafter 70-75 %	No turning	

Note: the eggs should not be turned after day 19, because the chicks are starting to pip and the incubator should not be opened unnecessarily to maintain an optimal relative humidity. See Appendix 1 for Celsius to Fahrenheit conversion.

6.3 Temperature

An incubator must provide temperature conditions comparable to that provided by a hen warming her eggs by her body heat.

To regulate the temperature in an incubator a thermometer is indispensable – preferably one that can be read accurately (0.05-0.1 °C) within the range 35-40 °C. Heat in an incubator is either controlled manually or by a thermostat.

A well-insulated incubator not only reduces energy costs but also avoids temperature fluctuations inside caused by changes in temperature in the environment in which incubator is placed.

Do not incubate eggs in seasons when normal day temperatures exceed 40 °C. The heat will destroy the embryos, thus incubation is impossible under such conditions.

Temperature is extremely important during incubation (especially during the first week). Optimal temperature in the first two weeks is 38.5 °C with no more than half a degree of variation up or down. Variations in temperature of more than 0.5 °C will affect the number of eggs that will hatch successfully. A rise in temperature can have disastrous results. Any rise above 40.5 °C is fatal. Temperature drops will delay hatching but are less harmful than increases in temperature.

After placing the eggs in the incubator, the temperature of the incubator will probably drop while the eggs take the 6-8 hours they need to warm up to the incubation temperature. Do not increase the heat supply to the incubator during this warming up period.

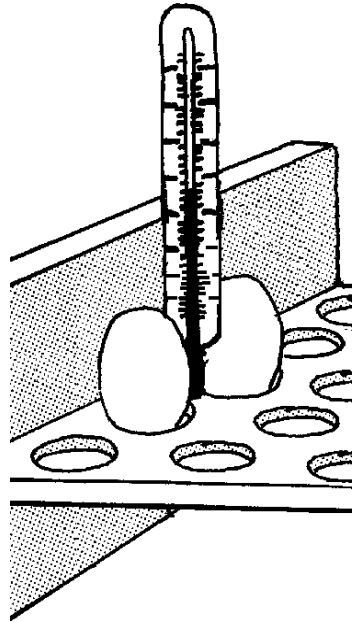


Figure 18: Checking the temperature of the eggs

Run the incubator without eggs at first to find the optimum temperature adjustment.

Measuring temperature

In home-made incubators the temperature will vary considerably between the top and the bottom of the eggs.

To obtain reliable readings the bulb of the thermometer should be at the same height as the top of the eggs (the level where the embryos develop) and away from the source of heat. Make sure that the ther-

meter bulb is not in contact with the eggs or the sides of the incubator, because this will give an incorrect indication of the air temperature: an egg with a living embryo is much warmer than an egg with a dead embryo.

Several thermometers

Using two thermometers will ensure an accurate reading and permits checking if the heat spreads evenly across the tray.

6.4 Humidity (RH)

Eggs lose water during the incubation period; the rate of loss depends on the relative humidity maintained within the incubator. For optimal results the weight loss after 18 days of incubation should be 11-13 % of the initial egg weight. To achieve this, the humidity inside the incubator should be kept between 50 and 60% (RH) until the eggs begin to pip.

Increasing humidity (at time of hatch)

When the chicks start to hatch (when 1/3 of the eggs have pipped) it is important to gradually increase the humidity to 70%. This will partially happen automatically: a lot of water will evaporate from the inside of the eggs after the chicks have made the first hole in the shell. To keep this water vapour inside, keep the incubator door closed as much as possible.

Humidity levels

Correct humidity levels are obtained by putting water in bowls inside the incubator below the egg tray(s). A hygrometer can be used to measure relative humidity, but there are other ways to check the humidity level (see below).

Humidity levels will also be influenced by the amount of ventilation and by the humidity of the incoming air.

High humidity

High humidity occurs rarely in incubators relying on evaporation from water pans. However, fully developed chicks unable to hatch because of too much water inside their shells ('drowned chicks') are a sign that the humidity is too high. Correct temperature and ample and proper ventilation will prevent this condition.

Low humidity

Low humidity causes sticky embryos during pipping. It results in weak, small chicks that cannot stand, walk or orientate themselves to reach food and water, or spread-legged chicks.

Checking humidity

There are several methods to check the relative humidity in the incubator.

- A hygrometer (applicable only in incubators equipped with a fan!)
- A set of wet and dry bulb thermometers
- Estimating the size of the air cell
- Weighing the eggs

Hygrometer

A hygrometer is a device for measuring the relative humidity (RH) of the air. Hygrometers are very sensitive instruments and dust will affect their accuracy.



Figure 19: Hygrometer

At the moment of hatching a lot of dust comes free from the broken eggshells. Therefore it is very important to check the correct functioning of the hygrometer by placing it in a wet cloth.

After a minimum of 30 minutes it should read 95-100%. If not, it can be adjusted with a small screwdriver.

Wet and dry bulb thermometer

A wet and dry bulb thermometer set is a good tool for determining relative humidity. The higher the evaporation the lower the tempera-

ture reading on the wet bulb thermometer and the larger the difference between wet bulb and dry bulb readings.

In incubators equipped with a fan using a wet bulb thermometer in combination with a dry bulb thermometer is a good alternative to the costly and sensitive hygrometer.

To make a wet bulb thermometer, just wrap a cotton cloth around the end of a thermometer and place the end of this cotton wick in water. The cotton will absorb the water. Due to evaporation the wet bulb thermometer will show a temperature below that of the dry bulb thermometer in the same compartment. Compare the reading on the wet bulb thermometer with that on the normal dry bulb thermometer to calculate the actual relative humidity (see Table 3).

Where possible and practical, use a dual set of wet and dry bulb instruments per incubator.

Table 3: Humidity and wet bulb reading temperature (see Appendix 1 for Fahrenheit to Celsius conversion).

Incubator Temperature (Dry Bulb Reading)	Wet Bulb Reading					
100°F	81.3	83.3	85.3	87.3	89.0	90.7
101°F	82.2	84.2	86.2	88.2	90.0	91.7
102°F	83.0	85.0	87.0	89.0	91.0	92.7
Relative Humidity	45%	50%	55%	60%	65%	70%

Old and dirty wicks tend to give higher than actual readings, resulting in an overestimation of relative humidity. This may reduce hatching results. Regular wick changing is important.

Estimating the size of the air cell

Figure 20 shows the correct air cell size in relation to incubation time. The air cell can be made visible by candling as described earlier, in Section 3.5. Logically, there is a strong correlation between air cell size, relative humidity (RH) and weight loss.

Weighing the eggs

During incubation, eggs lose a certain amount of weight by evaporation of water from the inside of the egg through the pores in the shell. Incorrect levels of relative humidity will result in the eggs losing too much or too little weight hindering good results. Weight loss after 18 days of incubation should be 11 to 13%. If the weight loss is higher, humidity should be increased.

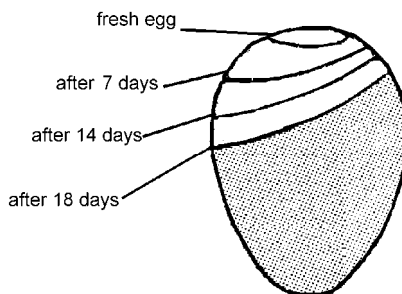


Figure 20: Air cell development at various days of incubation

Adjusting humidity

Proper humidity levels can be obtained by placing water in small containers inside the incubator. Humidity inside the incubator can be adjusted by changing the surface area of the water containers: a larger surface will increase evaporation and consequently increase the relative humidity (RH). To prevent a temperature drop keep the water containers filled with water at body temperature rather than cold water.

If you do not have enough water containers put a wet sponge or a wet cloth inside the incubator.

6.5 Ventilation

The chick developing inside the egg needs to take in oxygen and give out carbon dioxide. As the embryos grow, they must receive an increasing supply of fresh air. Good ventilation is therefore important, especially as other poisonous gases may have formed from any rotten eggs present. Provide ventilation openings both above and below the eggs for proper air exchange.

The more eggs in the incubator and the older the embryos the more oxygen is required. Ventilation therefore has to be increased gradually during the incubation period!

Fans or ventilation holes

Kerosene and smaller electric incubators rely on 'natural ventilation' through air holes with a diameter of about 1 cm. The openings can be opened and closed using plugs.

Electric incubators are often equipped with (a) fan(s). Note that a fan ensures a uniform distribution of hot air within the incubator but will not draw in fresh air unless ventilation inlet and outlet holes are opened!

By sucking in fresh air a fan may 'serve' more eggs within a confined space.

It is difficult to specify how many holes you have to open. In any case at least two holes (one at the lower level for air inlet and one at a higher level for air outlet) will have to be permanently open. Fresh air will enter every time you open the door. Therefore, when you stop turning the eggs after 18 days you may need to open extra holes.

If you use an automatic turning device more holes should be opened.

6.6 Turning the eggs

To keep the growing embryo centred and prevent it from sticking to the shell, turn the eggs 3 times a day during the first 18 days.

Regular egg turning keeps the developing embryo centred. It is more important to turn the eggs at regular time intervals rather than turning them more often than three times a day. Hatching results will be poor if you do not turn the eggs.

Turning an odd number of times (i.e. 3) will alternate the side of the egg that is uppermost at night. This is important and helpful because the interval between nightly turnings is longer than during the day.

When turning the eggs, move them to a different part of the tray to minimize the effects of temperature variation within the incubator.

The best way is to take the entire egg tray out, turn the eggs 180° and, if feasible and the size of the egg tray allows it, put the tray back the other way around. Keep the door of the incubator closed while turning the eggs.

Take care that your hands are clean. Dirt and grease on an egg's shell will seal it and air will not be able to pass through the shell, causing the chick to die in shell.

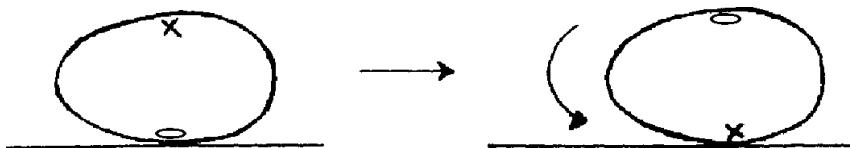


Figure 21: Turning the eggs manually

Marking the eggs

Use the X and O marking technique to help keep the turning correct. Mark in pencil one side of each egg with an X (or a number) and the other side with an O (or another number). Whenever the egg is turned 180° the marks should change place. Make sure that the eggs are NOT continuously turned in the same direction, as this will reduce the hatching results! Turn the eggs clockwise and the next time anti-clockwise and so on.

Between turning times, do not move the eggs at all.

No more turning after 18 days

After 18 days turning is no longer necessary. Eggs should not be turned within three or four days before hatching. Chicks need to position themselves for pipping and do this better if allowed to remain still while that process takes place. The embryo is large enough by this time as it has used up most of the yolk for food and is no longer in danger of being squeezed between the yolk and shell.

Cracked shells

Some producers open an incubator, pull out a flat tray, and run their hands over the eggs. This, to them, is turning the eggs. Actually it is only stirring the eggs, because there is no definite way to tell whether the eggs are just rolled around or whether they actually end up in a different position. Many of the eggs may not get turned at all – just rolled around. Turning eggs in this manner can also crack the eggshells.

Many chicks develop in eggs with cracked shells (only the shell, not the membranes) but not many will pip and hatch completely because dehydration makes the environment sticky. The chick will not have enough strength to pip and free itself from its sticky environment.

In small incubators eggs are commonly laid down flat or, if possible, with the small end slightly downwards (the way a broody hen positions them in her nest). The eggs are turned 180° over its long axis.

If the incubator is equipped with (an) egg tray(s) in which the eggs are standing up it is essential that they are positioned with the broad end up (the air cell side) and the small end down. In this case the eggs must be turned

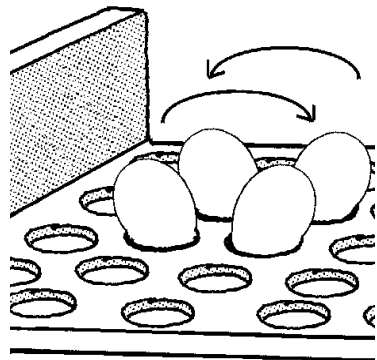


Figure 22: Positioning of eggs in a tray

90° over the short axis, that is to say the first turning should be 45° to the left (or right) and every following turning 90° in the opposite direction. At all times the air cell side must remain uppermost with the small end pointing downwards (see Section 3.3).

6.7 Hatch time

Chicks do not all hatch at the same time; there might be a 40-hour difference between the first and last hatched chick!

Do not open the incubator before most of the eggs have hatched, as this will disturb the climate inside the incubator and cause difficulties for the slower chicks. (Newly hatched chicks can survive for 1-2 days without food, though feeding them from the start is better).

As soon as most of the chicks are dry and fluffy remove all chicks from the incubator at once. Do not wait for the remaining eggs to hatch: remove them and after thorough boiling they can be used as chicken feed.

6.8 Keeping records

It is very important to keep records! Use Table 4:

- Note the date the eggs were placed in the incubator.
- Note temperature and humidity twice daily.
- In the last column (Remarks) do remember to mark candling (see Section 3.5) and the egg losses indicating the cause: infertile egg, dead embryo, or other.

If hatching results are poor at the end of the incubation period your records will tell you whether temperature or humidity levels were to blame. Normal hatching rates vary from 50 to 70%; out of 100 eggs only 50 to 70 will hatch.

It is rare to achieve a hatching rate of 80% or over with home-made incubators.

Table 4: Example of a record sheet

Date start of incubation:					No. of eggs set:			
Day no.	Time 1 (mor ning)	Temp.	Humid-ity	Time 2 (eve ning)	Temp.	Humid-ity	No. of times turned	Remarks *
1	06.30	38.5°	60%	18.30	38.5°	3	
2							3	
3								
4								
5								2 infertile
6								
19							None	1 dead in shell
20								
21								2 dead on tray
* Make note of candling under remarks								

Additional information may be collected by breaking the eggs that did not hatch. If they are broken onto a flat surface, the contents will indicate an infertile egg or show how far development had proceeded before death.

Table 5: Solving incubation problems (Ohio State University)

Indications	Possible Causes	What to do
No blood vessels at candling	Eggs not fertile	Check flock management
	Embryo died very early	Check egg holding conditions Check incubation operation
Many dead embryos	Temperature too high or too low	Check incubator and accuracy of thermometer
	Improper turning	Turn gently three times a day
	Poor oxygen supply	Increase ventilation
	Poor nutrition	Check breeder flock diet
Pipped eggs not hatching	Low humidity	Have correct wet bulb temperature
Hatch too early	High temperature	Check temperature
Hatch too late	Low temperature	Check temperature

Indications	Possible Causes	What to do
Shells stick to chicks	High humidity early or low humidity late	Check humidity
Cripples	Temperature problems	Check incubator
	Humidity problems	Check incubator
	Improper turning	Correct turning
	Hatching trays too smooth	Provide better traction
Large, soft-bodied weak chicks	Low temperature	Check temperature
	Poor ventilation	Improve air flow
Mushy chicks, dead on tray	Navel infection	Improve sanitation
Rough navels	High temperature or wide temperature fluctuations	Check temperature
	Low moisture	Check wet bulb temperature

For more detailed information see Appendix 3: Troubleshooting

7 Artificial brooding

Chicks hatched in an incubator will have to be kept warm during the first weeks of life. Although they can move around and support low temperatures for a short period, it is important that they are able to warm themselves up as soon as they get cold.

The equipment providing heat and shelter is called a brooder.

Cold chicks will not die immediately but will start to develop digestive disorders (diarrhoea) and die within a week.

Different heat sources can be used to maintain the correct temperature: a charcoal stove, an infrared lamp or a simple light bulb (100-Watt), or an oil or gas lamp.

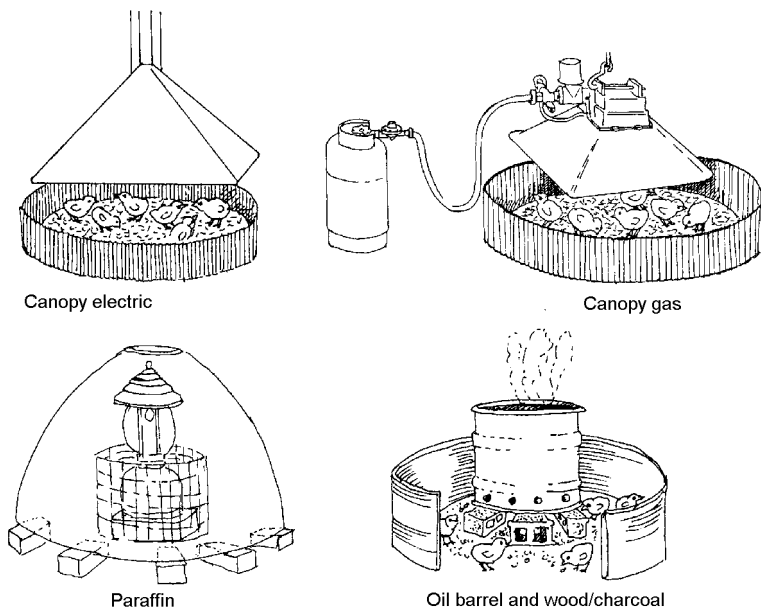
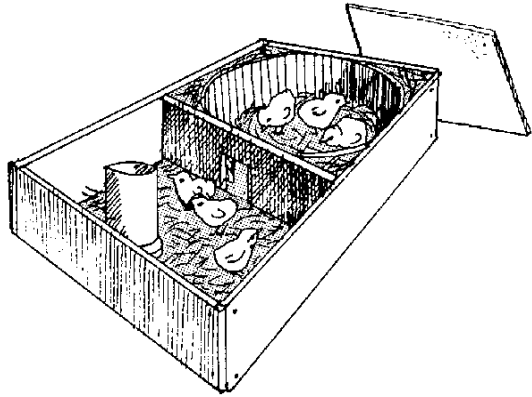


Figure 23: Possible heat sources for brooders

The brooder should be placed in a predator-free environment. Although apparently rarely done, placing it on a table or bench is useful to protect it from predators and facilitate tending it.



The brooder should have a circular floor to avoid corners where young chicks might get stuck or trampled. The walls can be made from (corrugated) cardboard or wire mesh. As the chicks grow, simply add extra pieces of cardboard to increase the surface area of the brooder.

Figure 24: If no external heat source is available, a hay box is a good alternative to keep the chicks warm

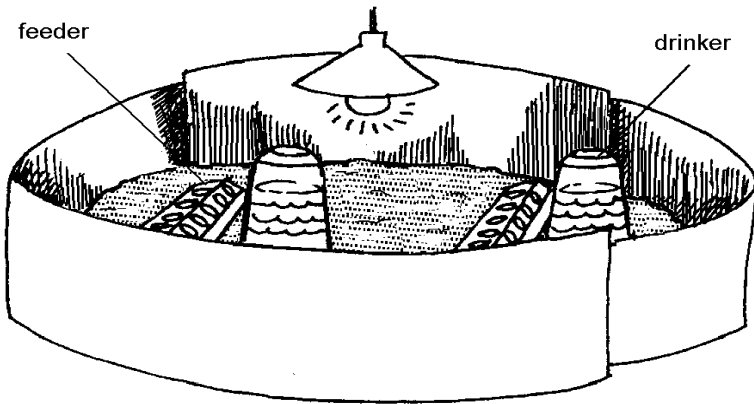


Figure 25: Simple brooder made from cardboard. Circular floor should be covered with clean, dry litter like rice husks, dried grass or leaves. (News) paper should be avoided or only used as an under layer and top covered with a cloth or with tissue paper.

Figure 25 shows an example of a cardboard brooder with a 100-watt light bulb as a heat source. The light bulb can be covered with a conical shade to direct the heat to the chicks. The lamp should hang in the middle of the brooder so its heat spreads to the whole area.

Led light will not generate heat and is therefore unsuitable for heating a brooder or an incubator.

Cool areas

It is equally important to provide cooler areas for the chicks too. Chicks should have a localized heat source and access to a cooler, unheated area. This allows the chicks to determine their own heating needs by moving between hot and cold areas.

7.1 Placing the birds

The brooding area should be prepared properly (clean and warm) and ready before the newly hatched chicks arrive.

Temperature and chicks' behaviour

During the first week the lamp should be placed 10 cm above the ground. For the first few days keep the temperature at 32 °C. Check the temperature at the level of the chicks, i.e. 5 cm above ground level. At the end of week 1, start reducing the temperature by 5°F or 2 °C per week until reaching 70°F or 20 °C, and then try maintaining that level (see Table 6).

The chicks themselves are the best thermometers available; their behaviour indicates whether the temperature should be adjusted. See Figure 25:

- Chicks all huddled together in one area and peeping need additional heat.
- Chicks sheltering in one direction suffer from drafts.
- Chicks scattered around the area and chirping loudly or panting with their beaks open need cooler temperatures.

- Chicks scattered through the brooding area making contented sounds are comfortable.

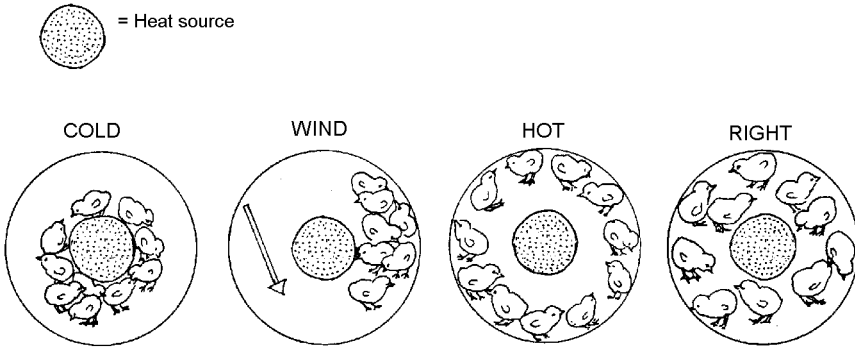


Figure 26: Chick behaviour in reaction to temperature (top view)

Raising the lamp

Raise the lamp 5 cm each week as the chicks will need less heat as they grow older. Once the chicks are better protected by their new feathers the temperature can be reduced slightly. See Table 6 below.

Table 6: Recommended temperatures in the brooder (at chick height)

Age in weeks	Temperatures in °C
0-1	32-30
1-2	30-28
2-3	28-25
3-4	25-22
4-5	22-20
5-6	20-18

Litter

The floor of the brooder must be covered with dry litter material, like dry grass or leaves, wood shavings, coarse sawdust, chopped straw or rice husks.

Do not use newspapers as litter material. It is too slippery for young chicks. They will risk developing spread legs, which is fatal.

As soon as the litter becomes wet or dirty from spilled food, water or droppings, it should be removed and replaced by clean dry material. Any moisture in the litter will promote fungal growth; if young chicks inhale fungi they will die from 'brooder pneumonia', for which there is no treatment.

Avoid using very fine sawdust; the chicks will eat it and it can block the intestinal tract. Scatter some grains each day in amongst the litter to encourage the chicks to scratch.

Drinkers and feeders

There should be drinkers and feeders and a box with dry sand for dust bathing inside the brooder. All chicks should be able to eat and drink at the same time. Feeder space requirements vary according to feeder type and the age of the chicks. The chicks will also eat some sand but this will not harm them. The drinkers and feeders should be cleaned and filled every day.

All chicks should be able to drink and feed at the same time

Perches

From the age of 2 weeks perches should be installed in the brooder. Chicks, young layers in particular, have to get used to sleep on the perches. You can assist them by putting the 'floor sleepers' on perches at night after 2 weeks (if temperatures are OK).

7.2 The growing birds

Keep an eye on the chicks to make sure that they are comfortable – are they huddling around the heat or do they move away from it? If so you should adjust the brooding conditions. If the chicks are comfortable they will scatter around the brooding area and make contented sounds. After two weeks the chicks should be able to walk in and out of the brooder. The artificial heating can be turned off after 4 weeks, pro-

vided that the day temperature outside is above 20 °C. You may have to keep the lamp burning if the nights are cold.

Feed

Baby chicks need a balanced diet in order to grow and thrive. From the third day onwards, start feeding them mash but still sprinkle some grains in amongst the litter to keep them busy.

Feed mash in small quantities, three to four times a day. This will encourage the chicks to eat more, resulting in more uniform growth and reduced wastage. Some food should be left in the chicks' feed containers at the end of the day.

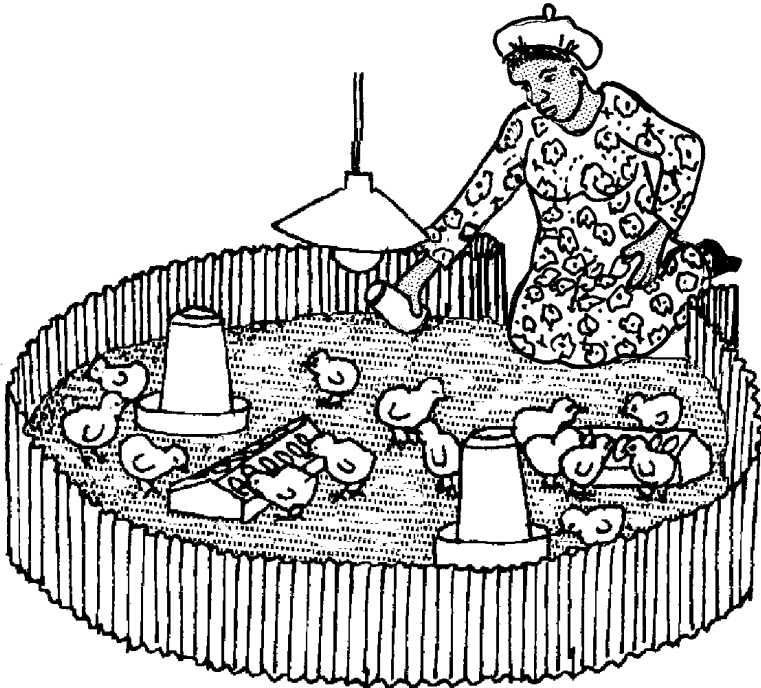


Figure 27: As the chicks grow, the size of the brooder can easily be increased by adding extra pieces of cardboard.

Young chicks will soon start moving in search of whatever feed they can find. They need good quality food, (rich in *proteins*) even better than that of the hens. If the weather is good and the place is safe from predators like rats, large birds and dogs you can let them pick at some vegetation or put some greens in the brooder in addition to their normal concentrated feed.

Water requirements

Fresh and clean water must be constantly provided. Many birds refuse to drink warm water, so make sure the water does not become too hot from the heat source in the brooder.

Predators

Once the chicks start leaving the brooder they are vulnerable to all sorts of predators. Make a good habit of inspecting the brooder area and immediate surroundings frequently to be sure that predators do not reach the young chicks.

Vaccination

Young chicks need to be vaccinated in time against a variety of diseases; at least for the so-called ‘*Newcastle disease*’ (ND). So keep in touch with your local poultry advisor about the vaccination programme for your chicks and stick carefully to it.

Table 7: Vaccination programme (for commercial breeds)

Age	Disease	Vaccine	Method of application
Ist week	Newcastle Disease Infectious Bronchitis	Clone 30 or Hitchner B1 Ma 5 or H120	spray* or eye drop eye drop or spray*
Day 10-12	Newcastle Disease	Clone 30	spray/drinking water
Day 14	Gumboro	Mild strain	drinking water
Day 18	Newcastle Disease	Clone 30	spray/drinking water
Day 21	Gumboro	Mild strain	drinking water

*Check whether any vaccines are given at the hatchery

For Gumboro disease many vaccine strains are available, ask the vet office about strains and best vaccination days.

Mostly vaccines are only sold in vials of 500 or more. Try to join up with neighbours who also have chickens that need to be vaccinated
Note: Local chickens will normally only be vaccinated against ND

7.3 Guidelines: a good start for your chicks

During the first few days feed the chicks by sprinkling broken grain on the brooder floor. From the third day on, start feeding them mash but still sprinkle some grains on the litter to keep them busy.

Feed mash in small quantities, three to four times a day. This will encourage the chicks to eat more, resulting in more uniform growth and reduced wastage. Some food should be left in the chicks' feed containers at the end of the day.

Fresh water must be available at all times. Provide enough food and water containers for all the chicks to be able to feed and drink at the same time.

Keep the brooder and its surroundings clean. Wash food and water containers daily. Pay particular attention to litter near the water dishes. Turn litter frequently to prevent it from caking. Water dishes can also be put on bricks or wire, so overflowing water does not soak the litter. Wet litter should be replaced.

If you find lice, mites and/or fleas, spray the empty brooder with a good disinfectant (consult your local advisor). If a chick suffers from a disease (e.g. coccidiosis) consult your vet to get prompt and proper treatment. Consult your local advisor about the medication/vaccination programme for your chicks.

In the 2nd week install perches and sand boxes in the brooder. Young layers should learn to use perches as soon as possible.

8 General care

8.1 Feed

Adult birds

Free-range village chickens do not need commercial chicken feed. They can be given meal leftovers and other household food, and green food such as grass, comfrey (*Symphytum officinale* L, Boraginaceae family) alfalfa and weeds like pigweed or white goosefoot, (*Chenopodium album*). Give a little in the morning – as they need to be hungry in the morning before letting them out to scavenge – and a little in the afternoon. Then in the evening give them again a little to attract them back inside.

Newly hatched chickens

Newly hatched chicks can survive for 1-2 days without food. However, in order to reach their full potential, they need nourishment quickly, so they should be introduced to feed and water soon after hatching. The same is true when chicks are purchased from a hatchery: they should be introduced to feed and water upon arrival.

Use good feed

Never buy cheap, poor quality feed. It lacks essential vitamins, minerals and proteins to prevent disease. Be careful when buying good quality commercial feed; it should not be old (stored longer than 3 or 4 weeks), or mouldy.

8.2 Cleaning practices

Even if all incubation factors like temperature and humidity are right, poor hatching results can be caused by poor cleaning. Poor cleaning causes not only poor hatching but also early mortality during brooding. It is vitally important that you set only clean and well-cared-for eggs in meticulously clean incubators.

For cleaning you only need water, soap and a proper scheme of regular hard work!

A thorough cleaning job, using plenty of elbow grease, will remove 95-99% of microbes. When done on a regular basis, little additional disinfectant is needed (assuming you are setting only clean eggs).

Best is best to always clean your incubator(s) thoroughly with water and soap immediately (within 24-48 hours) after the chicks have been removed. And once again before you set new eggs.

Do not forget to clean and disinfect the other equipment like trays, water pans and thermometers and to replace the wick(s) of the wet bulb thermometer(s). Scrape off all eggshells and adhering dirt. Wipe clean surfaces thoroughly with a cloth dampened in quaternary ammonium, Clorox or other disinfectant solution.

The same rule applies to cleaning brooders. With each new batch of chicks – apart from the daily cleaning routine – drinkers and feeders should be thoroughly cleaned and disinfected or replaced. Litter should be removed completely and floor and surroundings cleaned with plenty of soapy water. Before the arrival of new chicks, draught shields should be replaced by new ones or thoroughly cleaned, disinfected and left to dry.

Disinfectants

Disinfectants cannot replace good cleaning. It is impossible to disinfect a dirty environment.

Contrary to what most people think it is not solely the use of disinfectants that will do the cleaning job. All disinfectants lose their effectiveness as soon as they come into contact with organic matter: the dirtier the surface, the less effective the disinfectant application.

Quats

If after cleaning with a detergent you want to use a disinfectant, Quaternary ammonia is best. It is the most commonly used disinfectant for equipment like incubators. Quats are relatively non-irritating, non-corrosive, of low toxicity, and reasonably effective.

Appendix 1: Temperature conversion

Celsius to Fahrenheit $F = C \times 1.8 + 32$

Fahrenheit to Celsius $C = (F - 32) / 1.8$

Table 8: Conversion Fahrenheit to Celsius and Celsius to Fahrenheit

F	C	C	F
51	10.6	11	51.8
53	11.7	12	53.6
55	12.8	13	55.4
57	13.9	14	57.2
59	15	15	59.0
61	16.1	16	60.8
63	17.2	17	62.6
65	18.3	18	64.4
67	19.4	19	66.2
69	20.6	20	68.0
71	21.7	21	69.8
73	22.8	22	71.6
75	23.9	23	73.4
77	25	24	75.2
79	26.1	25	77.0
81	27.2	26	78.8
83	28.3	27	80.6
85	29.4	28	82.4
87	30.6	29	84.2
89	31.7	30	86.0
91	32.8	31	87.8
93	33.9	32	89.6
95	35	33	91.4
97	36.1	34	93.2
99	37.2	35	95.0
101	38.3	36	96.8
103	39.4	37	98.6
105	40.6	38	100.4
		39	102.2
		40	104.0

Appendix 2: The eggs of other types of fowl

The eggs of other birds are not incubated in quite as the same way as hens' eggs. Here follows a brief explanation of the incubation of the eggs of two types of domestic duck, turkeys, quail and guinea fowl. When eggs are stored they should be placed with the air pocket up-permost; in other words small end down and broad end up. This is true for almost all types of fowl.

A few days before putting in the chicks, the brooder should be cleaned thoroughly with a good disinfectant.

Keep the brooder dry and avoid draughts during brooding.
--

Cover the floor with clean dry litter (chopped straw, dry sand, etc.). Start with 2 cm at first and add clean dry litter daily, gradually building up to 7 cm thick.

Eggs of the Peking duck and the Barbary or Muscovy duck (*Cairine moschata*)

For artificial incubation, a temperature of 38 °C is best. During the first 24 days of incubating duck eggs, relative humidity should be at 70% (wet-bulb temperature = 31 °C). During hatching the humidity should be raised to 80%. Turning should be carried out several times a day, until the 26th day.

Most of the Peking duck's eggs will not hatch out before 28 days, and the Barbary duck's will even take 35 days. As duck eggs are dirtier than poultry eggs, they need to be cleaned as soon as possible, preferably without wetting them.

Storing conditions are the same as for poultry eggs. A hen that is willing to sit is capable of hatching almost as many duck eggs as she

would her own eggs. If the hen has no direct access to water, Peking duck eggs should be sprinkled daily with lukewarm water from day 15 to 24, and again on the last day of incubation. Barbary duck eggs should be sprinkled from day 15 to day 32, and on the last day.

Incubation conditions for the Peking duck are as follows.

Table 9: Incubation conditions for eggs of the Peking duck

Day	Temperature °C	Relative Humidity %	Wet-bulb temp. °C	Max. weight loss %	Minimum turns per day
1-24	38	70	32		5
24-26	38	60	31	} -	5
26-28	37.5	80	32.6		0

The ideal temperature for artificial incubation is 38 °C. Relative humidity should be at 70% until day 24 (wet-bulb temperature of 31 °C). During hatching out the humidity should be raised to 80%. The eggs should be turned daily until the 26th day.

For the Barbary duck eggs, only the time intervals are different. Ideal temperature is also 38 °C. Relative humidity should not exceed 70% until day 29 (wet-bulb reading 32 °C). During hatching out, the humidity should be raised to 80%. The eggs should be turned daily until day 32.

Table 10: Incubation conditions for eggs of the Barbary duck

Day	Temperature °C	Relative Humidity %	Wet-bulb temp. °C	Max. weight loss %	Minimum turns per day
1-29	38	70	32		5
29-32	38	60	31	} -	5
32-35	37.5	80	32.6		0

For more information on duck keeping see Agrodok 33: Duck keeping in the tropics.

Turkey eggs

Turkey eggs also hatch after 28 days. Medium size eggs give better results than large eggs. They will develop faster in storage than poultry eggs. For this reason they should not be stored any longer than necessary and they should be collected from the nest several times a day, every 3 hours for example. Not every turkey pullet is a good sitter. However some are very good at it and even willing to hatch guinea fowl eggs. A broody turkey pullet must be watched especially during the last (4th) week of sitting. A turkey can cope with 15-18 eggs, whereas a hen can only manage 8-10 turkey eggs.

Table 11: Incubation conditions for Turkey eggs

Day	Temperature °C	Relative Humidity %	Wet-bulb temp. °C	Max. weight loss %	Minimum turns per day
1-24	39.0	60	31	} 12	5
24-28	37.5	75	33		0

Quail eggs

Quail eggs should not be older than five days when they are set to incubate. Turning should be done seven times a day. Incubation takes 18 days. The ideal temperature is 37.7 °C. Humidity should be at 60% until day 16. After day 16 the relative humidity may be raised to a very high level: 90% (wet bulb temperature = 34 °C).

Table 12: Incubation conditions for Quail eggs

Day	Temperature °C	Relative Humidity %	Wet bulb temp. °C	Max. weight loss %	Minimum turns per day
1-16	37.7	60	31	} 21.5	7
16-18	37.2	90	34		0

Guinea fowl eggs

Guinea fowl hens can lay 90-170 eggs per year, and the average egg weight is 45 g. The incubation period of guinea fowl eggs is 28 days.

Incubation practices are similar to those for ducks, although the birds are smaller. The eggshell is very strong and the yolk is bigger than that of a chicken egg. The production capacity of guinea fowl hens is higher than that of hens of local chicken breeds. Guinea fowl hens are bad ‘brooders’ and bad mothers, as they are easily disturbed. For this reason many farmers use *local chicken hens* or *turkey hens* to hatch guinea fowl egg.

Table 13: Incubation conditions for Guinea fowl eggs

Day	Temperature °C	Relative Humidity %	Wet bulb temp. °C	Max. weight loss %	Minimum turns per day
1-24	37.2	70	29.1		5
24-26	37	60	29.6	} -	5
26-28	36.8	80	32.6		0

Appendix 3: Troubleshooting

Problem 1:

Too many ‘clears’ (infertile eggs or very early mortality). When these eggs are opened no development and no blood rings are visible.

Probable cause	Prevention
a. Too many hens per male bird.	Use 1 male for every 10 hens.
b. Males are undernourished.	Feed the males separately.
c. Males fighting or interfering during mating.	Do not keep big flocks, for which many males are necessary. Always rear breeding males together.
d. Sterility, disease or leg-disorders in the male, or male prefers to mate only with certain hens.	Change the male bird.
e. Male bird too old.	Change the male bird.
f. Eggs are too old or have been stored or transported under poor conditions.	Avoid using eggs over 1 week old.

Problem 2:

‘Clear’ eggs with signs of very early development (a blood ring or a small dead embryo found when opened)

Probable cause	Prevention
a. Temperature in incubator is too high or too low.	Check thermometer and thermostat. Follow advice in Chapter 6.
b. Eggs have been stored cold.	Do not store eggs in a cold and or draughty place.
c. Eggs are too old or have been stored or transported under poor conditions.	Avoid using eggs over 1 week old.
d. The birds have been kept under poor conditions.	Do not incubate the eggs of sick birds.

Problem 3:

Many dead chicks

Probable cause	Prevention
a. Incorrect temperature. See 2.a	Check thermometer and thermostat. Follow advice in Chapter 6.
b. Incorrect turning.	Turn the eggs carefully, and as often as recommended in Chapter 6.

Probable cause	Prevention
c. Chicks die towards the end of week 2, probably caused by poor feeding of the parents.	Feed good rations, paying special attention to the vitamins A, B2 and B12.
d. Insufficient ventilation.	Open more air holes.

Problem 4:

Chicks have developed well but have failed to hatch (unable to break the shell)

Probable cause	Prevention
a. Incorrect turning.	Turn the eggs carefully, and as often as recommended in Section 6.6.
b. Incorrect humidity: 1. Too dry: air pocket too big. 2. Too humid: air pocket too small.	Adjust relative humidity as recommended in Section 6.4. Add water containers or spray more often. Remove water containers.

Problem 5:

Chicks break the shell but fail to leave the egg

Probable cause	Prevention
a. Air too dry.	Check the relative humidity; Add water containers or a wet cloth.
b. Chicks develop late (See Problem 8).	See Problem 8.
c. Temperature peaks very high for a short period of time.	Check the thermostat and the heat lamp.

Problem 6:

Sticky chicks – the shell sticks to the hatched chicks

Probable cause	Prevention
a. Dehydrated eggs.	Low humidity; check the relative humidity.
b. Humidity too low during hatching out.	Raise the humidity to 70-80% during hatching out process, but not before; keep the incubator closed during hatching out.

Problem 7:

Weak chicks

Probable cause	Prevention
a. Incubator temperature too high.	Check the thermometer.

Problem 8:

Small chicks

Probable cause	Prevention
a. Eggs to be incubated too small	Use only medium size eggs
b. Humidity too low.	See 5a.

Problem 9:

Weak and bad-smelling chicks. Many deaths.

Probable cause	Prevention
a. Omphalitis or navel infection.	Clean and thoroughly disinfect the incubator and all other equipment used. Use only clean eggs

Problem 10:

Irregular hatching out of chicks

Probable cause	Prevention
a. Eggs with different storage periods used.	Do not use eggs stored for longer than 1 week. Start incubating stored eggs earlier (correction 1 hour for every day of storage)
b. Different sized eggs.	Start incubating large eggs (correction of 30 minutes for 2.5 grams extra egg weight above 50 gram)
c. Changing temperatures during incubation.	See 5c.
d. Temperature higher in the centre of the incubator than at the sides.	Improve incubator insulation.

Problem 11:

Chicks walking uncertainly

Probable cause	Prevention
a. Brooder floor too smooth.	Use rougher material to cover floor.

Further reading

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Information on the Internet

www.backyardchickens.yuku.com This is a forum site where you can find, as well as participate in, discussions regarding Eggs hatching.

Useful addresses

Ileia: Center for information on low external input and sustainable agriculture

ILEIA promotes exchange of information for small scale farmers in the South through identifying promising technologies involving no or only marginal external inputs, but building on local knowledge and traditional technologies and the involvement of the farmers themselves in development. Information about these technologies is exchanged mainly through the LEISA Magazines in English, French, Portuguese, Spanish, Indonesian and Chinese. All articles accessible on-line.

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ILRI: International Livestock Research Institute

ILRI helps the world's poor people build and protect their livestock based assets so that these, not poverty, are passed on to the next generation.

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INFPD: International Network for Family Poultry Development

Family Poultry publishes reviews and original papers on all aspects of family poultry science, reports on the development of family poultry production from all over the world, reports from conferences, seminars, symposia and scientific working groups, as well as book reviews, news and a listing of forthcoming relevant events.

www.fao.org/ag/againfo/themes/en/infpd/home.html

Practical Action

Practical Action helps people to use technology in the fight against poverty. Keywords are: 'practical answers to poverty, sustainable solutions and people focused'. W: www.practicalaction.org

PTC+: Practical Training Centre

PTC+ is an international training institute, which focuses on all the links in the production chain on plant and animal commodities, (agricultural) technology, (food) technology and natural areas. Training programmes are practice-oriented and mix theory with practical classes. PTC+ offers 'open entry' programmes, 'tailor-made' programmes and consultancy. Programmes are offered in the Netherlands and/or at location. It is the policy of PTC+ to search for partnerships and co-operation programmes with national and international institutions abroad.

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Glossary

<i>Air cell</i>	The air space between the two shell membranes, usually in the large end of the egg.
<i>Albumen</i>	Egg white
<i>Avian</i>	Relating to, or characteristic of birds.
<i>Blastoderm</i>	A fertilized egg cell, which has started to divide into more cells developing into an embryo.
<i>Broiler breeder</i>	Breeding hens kept for laying eggs to produce broilers.
<i>Broiler</i>	Chickens reared for meat production.
<i>Brooding</i>	Rearing young chicks during the first weeks, when they need to be kept warm.
<i>Chalazae</i>	The two whitish cords attached to the yolk of an egg, which hold the yolk in the centre of the albumen.
<i>Chick</i>	A young bird about to be hatched or newly hatched
<i>Chick tooth</i>	The tiny, horny projection on the top of the chick's beak, which it uses to peck holes in the shell when hatching.
<i>Cloaca</i>	The vent or common opening in birds through which the digestive, urinary, and reproductive tracts empty.
<i>Cockerel</i>	A male chicken usually less than 18 months old or male turkey less than 12 months old.
<i>Down</i>	Soft, fine, hair-like feathers on young birds.
<i>Embryo</i>	The early stage in development of the chick within the egg.
<i>Embryology</i>	The study of the formation and development of embryos.
<i>Fertilization</i>	The union of a male reproductive cell and a female reproductive cell.
<i>Fowl</i>	General term for birds often used for domestic chickens.

<i>Germ cell</i>	Microscopic reproductive cell of a female; the female germ cell
<i>Grower (poultry)</i>	Chicken between a chick and a pullet before it starts to lay eggs, usually up to 18-20 weeks old.
<i>Guinea fowl</i>	Pheasant-like bird from Africa raised for eggs, meat and feathers (<i>Numida meleagris</i>).
<i>Hatching</i>	Production of day-old chicks from an egg.
<i>Humidity</i>	Moisture in the air.
<i>Incubation</i>	The process of applying heat to eggs causing them to hatch. <i>Natural incubation</i> is incubation by a (brooding) hen. <i>Artificial incubation</i> is incubation in an (electric) incubator
<i>Laying hen/layer</i>	Chicken kept for egg production.
<i>Oocyte</i>	Ovum, see below.
<i>Ovary</i>	The female organ that holds the true eggs cells and produces the yolks.
<i>Oviduct</i>	The female bird organ in which the albumen, shell membranes, and shell around the yolk forms.
<i>Ovulation</i>	The release of a true egg or ovum from a follicle in the ovary.
<i>Ovum</i>	The female germ cell or true egg
<i>Pip</i>	To break through or peck holes in the shell by the chick.
<i>Poultry</i>	Domesticated birds (fowl) kept for meat or egg production. Includes chickens, turkeys, geese (singular = goose) and ducks.
<i>Pullet</i>	A female chicken in its first egg-laying year between 20 weeks and 18 months old. A young layer.
<i>Shell membrane</i>	Each egg has 2 thin membranes. The inner membrane encloses the egg white or albumen, the outer is lining the inside of the egg shell. The 2 membranes are closely joined together except at the blunt end of the egg where they separate and so the airspace is formed. The membranes are permeable for gasses like oxygen but not for germs).

<i>Sperm</i>	The microscopic reproductive cell of a male: the male germ cell.
<i>Spread legs</i>	Spread-legs is a condition in which the hip joints of the young chick become dislocated because of a slippery floor. The condition is nearly always fatal.
<i>Turkeys</i>	Large poultry species kept for the production of meat.
<i>Uterus</i>	The section of the oviduct next to the isthmus that secretes a portion of the albumen and all of the shell and shell pigment.
<i>Vagina</i>	The final section of the oviduct connected to the cloaca.
<i>Vent</i>	The external opening in poultry through which passes all waste material and eggs.