Optimising hatcher conditions 89

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by Maciej Kolanczyk, Senior Hatchery Specialist, Pas Reform Hatchery Technologies

Hatching is the last part of the incubation cycle and optimal conditions in the hatcher are essential for best hatch results.

Whether a single or multistage incubation system is used, the hatcher is always a single stage machine. Eggs can be transferred from setter to the hatcher between the 15th and 19th day of the cycle, the optimum being days 18-19. Regardless of when the transfer is done, the total incubation time will not change.

A hatcher is a small cabinet, usually loaded to full capacity with eggs, all in their last incubation phase. The embryos as well as the hatched chicks require a lot of cooling and fresh air. As the baskets hamper the air circulation more than the setter trays, a high airflow helps to create a uniform environment. An efficient cooling system and a good supply of fresh air that reaches all parts of the hatcher are therefore necessary for the chicks to survive.

The hatching process consists of three periods:

- Period 1: before pipping.
- Period 2: from beginning of pipping until peak humidity.
- Period 3: after peak humidity.

Period 1 is simply an extension of the incubation process in the setter. The set points can be fixed, and typical values are: 40-55% relative humidity (RH), 97.5-98.5°F temperature, 0.4-0.5% CO_2. The actual values depend on the breed, design of the hatcher and local conditions. During period 2 the leading parameter to be watched in the hatcher is the RH. This is the best indication of when pipping has begun and when hatching is complete. It can be followed by simply watching the graphs, if these are available. Pipping and hatching take several hours. During the process, a hatcher – even if all eggs are very uniform – will contain ready chicks and still closed eggs.
As the hatchlings are wet, the RH raises spontaneously (period 2), reaches its maximum and starts dropping after the last chicks have hatched and dried off (period 3).

The time between the first and the last chicks hatching is called the 'hatch window'. It can last between 12 and 40 hours, depending on the uniformity of the load (age of the flock, storage time), egg prewarming and the uniformity of conditions in the setter. As short a hatch window as possible is desirable. The maximum RH value reached depends on the rate at which the chicks are hatching and the amount of ventilation. Many chicks hatching at the same time can push the RH up as high as 85%.

Once the RH peak is clearly over, which will be indicated by a 3-5% reduction in humidity, the initially selected set points can be adjusted. A very slow reduction of temperature (by 0.2-0.3°F) followed by more intensive ventilation helps to keep the chicks in a comfort zone. The final temperature is usually around 97.0°F and the final CO_2 set point 0.25%.

The aim is a comfortable environment in the hatcher with sufficient fresh air. The best way to judge the conditions is to closely watch the chicks themselves. When they are comfortable they will be calm and silent, and sleep much of the time.

Advice

- Load the machine in a way that provides the most uniform and effective air distribution and flow. This will differ depending on the design of the hatcher.
- Do not open the hatcher during the hatching process unless really necessary.
- Aim for optimum fresh air supply; follow the machine supplier's recommendation.
- If operating manually:
  - Keep the set points fixed until period 3.
  - Correct them very slowly after RH peak.
  - Make sure after RH peak that RH does not drop below 55%.
  - Observe the chicks' behaviour (noise, panting) – and respond. ■

Eggshell mottling and incubation results

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by Lotte Hebbink, Incubation Specialist, Pas Reform Hatchery Technologies

Candling eggs not only provides information on whether there is an embryo inside; it is also a way to detect abnormalities in the eggshell. Hairline cracks are an obvious example of this, but somewhat less known are the small translucent spots on the eggshell, often referred to as 'eggshell mottling'. Eggshell mottling occurs in different degrees, from several translucent spots to almost total coverage of the whole eggshell (Fig. 1).

Cause

Eggshell is composed primarily of calcium carbonate crystals (calcite), which are organised in columns. The eggshell pores are located between these columns. The organisation of the calcite columns, and therefore ultimately eggshell strength, is dependent on the protein matrix in the eggshell. Stress and disease in a hen negatively affect the synthesis of this protein matrix, which is reflected in the structure of the calcite columns. When the columns are disorganised, moisture accumulates in the spaces between, and these appear as translucent spots when the egg has dried after laying (Talbot and Tyler, 1973).

Effect on incubation results

Pas Reform did a study to find out if eggshell mottling affects incubation results. 1313 fertile eggs from three different flocks of the same age and breed were all individually tracked and traced during incubation. Different parameters were recorded, including individual egg weight loss, eggshell mottling and eggshell colour. Hatching was also recorded for each egg, and for the non-hatched eggs a break-out analysis was performed to identify the underlying cause.

A relationship was found between weight loss, hatchability and the degree of eggshell mottling (Fig. 2). The more severe the mottling, the higher the average weight loss and the lower the hatch of fertiles.

Moreover, the variation in individual egg weight loss was larger for the more heavily mottled eggs. More research should be done on eggs from other breeds and different flock ages to confirm the relationships found in this study.

Advice

- Consider adding eggshell mottling to your egg quality protocol. Use a candling table or flashlight to check the degree of eggshell mottling for different breeds and flock ages.
- Mottling can increase with flock age, but is also related to stress and disease. Consult your supplier if eggshell mottling is more frequent than usual.
- If you have a heavily mottled batch of eggs, consider checking whether the weight loss on day 18 is not higher than optimal. ■

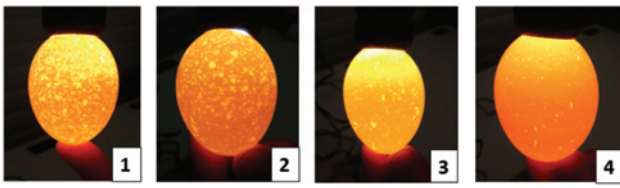

Fig. 1. Degree of eggshell mottling revealed using a flashlight. Category 1 is heavily mottled, 4 is least mottled.

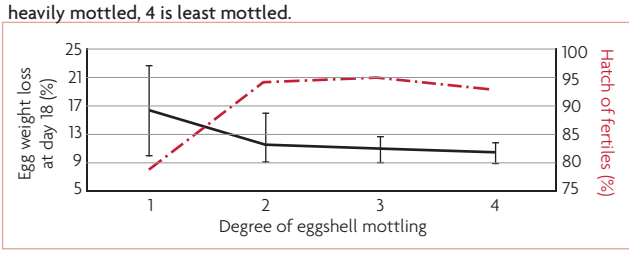

Fig. 2. Relationship between eggshell mottling and weight loss and hatch of fertiles (n=1313). Error bars represent the standard deviation.

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How chick quality is affected by navel development

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by Dr Marleen Boerjan, Pas Reform Academy, Pas Reform Hatchery Technologies

The hatchery manager takes all possible measures to ensure that incubation results in the highest number of first class chicks. The aim is to have boxes ready for transport to the farm which contain a known number of first class chicks with bright eyes, clean beaks, closed and clean navels, and bellies that feel soft and supple. The chicks' clean, closed navels are not immediately visible because of the long and shiny down that covers them.

It is even possible that in these batches of first class chicken there might be chicks with minor navel problems, for example a small scab (‹3mm) of dried blood, or a string of dried yolk stalk. Sticky, wet down is a sign of a leaky, unhealed navel. Chicks with these minor navel problems grow more slowly and broilers have lower weight at slaughter age compared to chicks with a clean and closed navel.

How the navel develops

In the embryo the navel (umbilicus) and yolk sac, including the yolk stalk, develop in synchrony with the small intestine and body wall.

From embryonic age day 16-19, the small intestine (umbilical loop) is retracted into the growing body wall leaving, at day 19, a ring-like muscle called the umbilicus (= the future navel). The rhythmic contractions of the umbilicus muscles then draw the large (approximately 5g) yolk sac into the body cavity leaving a direct connection to the small intestine via the yolk stalk. By day 20 the entire yolk sac has been retracted into the body cavity and the navel closes, with the yolk sac loosely attached to the navel area as part of the internal body wall.

Finally, after hatching, the connection between the yolk stalk and the small intestine develops, becoming Meckel's diverticulum: an appendix in the small gut which forms a part of the gut associated immune functions (GALT = Gut-Associated Lymphoid Tissue).

Causes of navel abnormalities

As the description above shows, the retraction of the small intestine followed by the yolk sac and the formation of the final body wall is a synchronised and complex process which can be easily disrupted.

Minor navel abnormalities can occur when the small intestine and yolk sac do not develop synchronously. There are a number of possible causes of asynchronous development:

- Too high temperatures from day 17.
- Too high or too low egg weight loss.
- Eggs from old flocks.
- Incorrect egg storage conditions (too long or too high temperature).

Longer incubation times as a result of lower incubation temperatures and optimum egg weight loss can be a measure to overcome poor navel quality.

Advice

- Depending on hatchery specific protocol, randomly select 500 chicks from hatcher baskets or 500 saleable chicks from the transport boxes.
- Determine the number of chicks in the batch with clean and thus healed navels (= excellent quality/ first class chicks).
- Analyse whether the differences between batches in number of top quality chicks might be attributed to:
  - Flock age.
  - Conditions on the breeder farm.
  - Incubation program: temperature and/or weight loss.
  - Storage conditions (length, temperature or heat treatment during storage).
- Use your hatchery reference data to compare the outcome of the analysis. If necessary, take action to reduce the number of chicks with minor navel problems.
- Be aware that hens' reproduction physiology changes as they age. Optimum breeder management can reduce the ageing influence on egg and chick quality. ■

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A service from Pas Reform Hatchery Technologies

Efficient data management in the hatchery

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Optimising hatchery performance requires good data management. Data can be stored in various ways, ranging from simple Excel sheets to sophisticated data management software. It is also not uncommon for a large part of the hatchery's data to still only be on paper. This is a pity, because this data is much more valuable for analysis when it is digitally stored in the right way.

Basic data entries

Here we look at the most basic hatchery data collection. We assume that in each hatchery for each batch of eggs the following is known:

- Flock number, farm, house number, flock age, breed.
- Egg production date.
- Arrival date in the hatchery.
- Setting and hatch date.
- Number of eggs set.
- Number of clears detected during candling.
- Number of saleable chicks (and ideally also number of culled chicks).

These data can be used to calculate hatch results, such as hatchability of eggs set and hatch of transfer. The data is often recorded on separate pages for each hatch day. This might be a great way to report daily production, but it does not allow for deeper analysis such as identification of the best breeder farms, effect of flock age and egg storage time on hatchability, hatchery performance compared to the previous year, comparison of incubation programs, and so on. One has to flip through endless pages and it is difficult to obtain a good overview of historical data.

Design data sheets

Hatchery data sheets that are generated on a daily and/or weekly basis usually have a dual purpose: they serve as data entry tables and as reports. In addition, data from different hatchery production processes and calculations are put together on one page to obtain a summarising table. Although this may seem efficient, it actually makes data management unnecessarily complex. When preparing these data for analysis you will encounter problems such as multiple data

repetitions with differences in detail level, copy/paste errors and non-uniform data entries.

It is more convenient to separate basic data entry tables from daily or weekly summary reports. In a basic entry table, amounts (e.g. number of clears; number of saleable chicks) and dates (e.g. laying date; setting date) are used instead of calculations (%). A separate report should contain calculations, e.g. hatch of eggs set, days of egg storage, % first week mortality, and these can be generated daily or on request. Ideally, for quick analysis using a program such as Excel, data entries should be made in one large continuous file instead of a new file for each hatching day.

Link files together

Very often data is scattered over several files, for example a table with data collected in the hatchery and another table with data concerning first week mortality on the farm. Keep these data in separate files, but use one or two common columns to link the two tables together. A practical way to do this is by using the columns 'Hatch date' and 'Flock ID' in both tables.

Advice

- Make the names of the data fields consistent when using different files with overlapping data.
- Do not combine basic data entries and daily production reports in one table.
- Use amounts and dates when entering data; do not enter calculations directly.
- For simple analysis you can use Excel Pivot Tables or Graphs. ■

For the full article, including two example tables, visit www.pasreform.com/en/knowledge

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Uniformity requires accurate climate data

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In modern hatcheries, climate data are collected from various sensors installed in incubators and hatchery rooms, and from handheld measuring instruments. The performance of the sensors is crucial for continuous production of batches of first-class day-old chicks.

Maintenance of sensors, including cleaning filters and calibration, is of great importance. Calibration means comparing read-outs from the sensor with read-outs from a certified standard. As long as hatchability and chick quality meet expectations hatchery managers can rely on their team for maintenance and sensor calibration. However, to be able to interpret data correctly, the hatchery manager needs information on data collection procedures and on the level of reliability of the data delivered.

Standard information required for data interpretation:

- **Sensor accuracy** is reflected in the 'quality' of the data measured. Accuracy is an expression of the difference (error) between the measured value and true value. Since we cannot know the 'true value' precisely, accuracy is presented as a range of values.

- **Precision, or repeatability**, is a value ascribed to a sensor. It describes the spread in data on a standard object measured under standardised conditions. In practice this means that you calculate, for example, the average and standard deviation of egg shell temperature (n=10) of one egg, measured with an infrared ear thermometer. To do so, you need to have at least 10 measurements taken from the same spot on the egg shell.

- **Random errors** occur and may be due to precision limitations of the instruments OR conditions not being standardised throughout measurement.

- **A stable sensor** remains constant over time or shows low drift as it ages.

- A sensor is **calibrated** if its read-outs have been compared, under similar conditions, to read-outs from a **standard** sensor whose accuracy is 10 times higher. The standard sensor has a certificate of calibration provided by an institution that is certified to calibrate sensors and instruments.

- **Reference values** (or range of values) are numerical data collected under normal/standard conditions, measured using calibrated sensors of known precision and stability. Reference data can be (1) determined (mean + standard deviation) from climate data collected in the hatchery or (2) provided by breeder companies, for example average EST (Egg Shell Temperatures) for incubation or set points for RH to achieve optimum hatchability and chick quality.

In conclusion, a stable sensor of high repeatability is the best choice if you need to collect reliable data on a routine basis.

Sensors must be calibrated regularly by a certified institution. A sensor or measuring instrument must be replaced if its deviation from the calibrated sensor is unacceptable (as defined by hatchery management).

Advice

- Clean sensors and protection filters before taking any measurements.
- Realise that accurate and stable instruments are essential if your aim is to perform statistical analysis of data collected over longer periods.
- Contact your incubator supplier for advice on how to maintain and calibrate incubator sensors.
- Ensure a certified institution calibrates your sensor and measuring instruments regularly.
- Be aware that the read-out from your reliable instrument may differ from read-outs from other brands of instruments, for example those used by colleague hatchery managers. Instruments with high levels of accuracy deliver read-outs that can be shared and compared among hatchery managers. ■

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Does the external climate matter? 94

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The optimum climate parameters for embryo development – temperature, humidity, and the balance between oxygen supply and carbon dioxide release from the incubator – are the same regardless of the climate zone in which a hatchery operates, up to an altitude of 1,200 metres.

Developing embryos produce CO_2 and heat, and moisture evaporates from the eggs. Much of the heat produced is collected by the water-cooling system and the rest is removed, together with the excess moisture and CO_2, through ventilation. Used air is replaced by fresh air.

The purpose of ventilation is to provide fresh air and to remove waste products. In addition, fresh air, which is usually drier and cooler than the air inside the incubator, lowers the humidity and absorbs some of the heat produced by the embryos. Ideally, the air exchange is balanced so that the incubator's internal humidifiers, heaters and coolers simply have a corrective function and work only when necessary.

Modern incubators are technically able to fully control their internal microclimate. These systems are designed to maintain or restore the climate quickly after a machine has stopped or started, or if climate parameters deviate from the set points. It is preferable, however, not to have to activate the systems because intensive heating, cooling or humidifying destabilise the uniformity of the internal microclimate. It is a question of balancing the need for fresh air with the need to maintain a stable internal microclimate.

If fresh air were taken directly from outside the building, its parameters would reflect the local conditions: the season and daily fluctuations in temperature and humidity. Even in a moderate climate zone, temperatures can vary by up to 50°C throughout the year, and daytime and night time temperatures can fluctuate by 20-30°C. Likewise, humidity can vary substantially over 24 hours, depending on the weather conditions.

These fluctuations in the fresh air parameters represent a challenge for incubators. In order to achieve the desired set points, intensive heating, cooling and humidifying would have to take place, but this would reduce the uniformity of conditions inside the cabinet.

To overcome this problem, air entering the incubator must be preconditioned. The optimum temperature range is 21-27°C and RH range 50-60%. Creating these stable parameters requires an Air Handling Unit (AHU). Preconditioning is a costly process and therefore prepared air should be valued.

In practice, to lower the influence of the outside climate conditions, fresh air comes either from a room inside the hatchery building or a specialised air preparation room that can supply preconditioned air hygienically and economically. The air in either of these places should be seen as a precious resource, which must not be wasted. It should be carefully stored and protected, and only the necessary amount used. A setter with space for 100,000 eggs needs an average of 400-500m^3 of fresh air per hour. So, a hatchery with many incubators will need a multiple of this amount of fresh air. If you do have a system that provides regulated air, however, the outside climate does not matter. Easy to say but difficult and not cheap to do.

Advice:

- Make sure the capacity of your AHU is sufficient for your incubators.
- Maintenance of the AHU is important: keep filters clean and dry, revise motors and mechanical parts regularly.
- Do not waste air that has been preconditioned to the optimum parameters. Keep all hatchery doors closed.
- Use CO_2 controllers to monitor the ventilation rate. Make sure incubators take only as much air as really necessary to keep air fresh enough. ■

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Air cell up when setting eggs! 95

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It is important to pay attention to the orientation of the eggs when placing them on setter trays as this has quite an impact on hatch results, both in terms of hatchability and chick quality. Air cell up is the way to go!

The embryo lies on the surface of the yolk and is connected to the latebra ('white yolk'), which is located in the centre of the yolk. The water-rich latebra has a lower specific gravity than the lipid-rich yolk and according to the laws of physics, the embryo will always move to the top of the egg, no matter which way the egg is placed on the setter tray.

By about day 14 the developing embryo lies on top of the yolk sac. It then turns so it lies lengthwise in the egg and by day 18 the embryo's head is under the right wing with the beak pointing upwards, ready to pierce the air cell (internal pipping) and inflate the lungs prior to finally emerging from the egg. But what if the air cell is out of reach of the embryo?

The air cell is situated at the blunt end between the shell membrane and the egg membrane. When eggs are set accidentally sharp-end-up, the head of the embryo is at the opposite end from the air cell and internal pipping is impossible. It is very difficult for the embryo to hatch in this position because it is fully dependent on the limited oxygen supply through the chorioallantoic membrane, and because the shell is stronger at the sharp end and there is less space for pipping and moving around. Unsuccessful embryos can be recognised during break-out of hatch residue by their legs being near the air cell; however not all eggs that are incubated sharp-end-up fail to hatch.

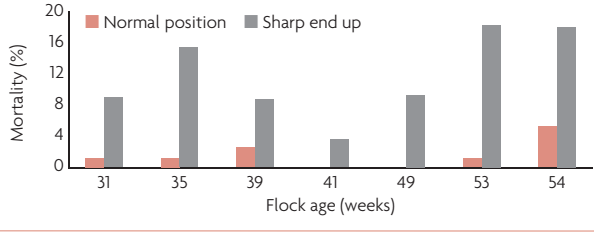
A customer in Turkey carried out an experiment in 2016 using different breeds and flock ages. 300 eggs were set sharp-end-up and 300 eggs in the normal position. This resulted in 12.7-21.0% lower hatch of fertile, mostly due to a difference in late mortality (see Fig. 1).

Moreover, among the eggs that had been incubated sharp-end-up there were more culled chicks. When sharp-end-up incubation is combined with in-ovo vaccination, the results are even more dramatic. A small-scale experiment conducted by a customer in Hungary in 2019 with 162 eggs per treatment resulted in 93 saleable chicks from sharp-end-up incubated eggs. When eggs in this position were also in-ovo vaccinated, only 39 saleable chicks were obtained. The control group (sharp-end-down and in-ovo vaccination) showed normal hatch results.

Advice:

- Be aware that if 10% of eggs are accidentally set sharp-end-up hatchability will be up to 2% lower.
- Train staff in breeder farm and hatchery to set eggs with air cell up (sharp-end-down/blunt-end-up).
- Use a candling light in a darkened room to make air cell visible if in doubt.
- Consider automated sharp-end-down setting, especially when doing in-ovo vaccination.
- Pay more attention to egg orientation if you notice the 'legs near air cell' sign during break-out of hatch residue.

Fig. 1. Embryo mortality 19-21 days for eggs incubated in normal position vs eggs incubated sharp-end up.



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Fertile or not? 96

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Fertilisation marks the beginning of a new life but is by no means a guarantee of a long life, as the journey is full of obstacles. Stress, genetic factors, diseases or nutritional deficiencies may all kill the embryo before the egg is laid.

The newly laid egg is then exposed to another set of risks: the conditions under which it cools down from the hen's body temperature to the ambient conditions in the nest, the time this takes, mechanical factors, chemicals, infections and even disinfection are all hurdles to overcome. After that comes storage, transport and the start of incubation – not always conducive to survival.

These kinds of very early mortality are almost impossible to identify in a standard, industrial way – by candling. As a consequence, the 'clears' category contains both eggs that are truly infertile and those that contain early-dead embryos. The only way to distinguish truly infertile from early-dead eggs is by breaking them out for analysis. However, to diagnose accurately and thus choose the correct solution, it is essential to be able to distinguish between these two groups.

The presence of a tiny ring on the surface of the yolk, just 3-4mm in diameter – visible immediately after oviposition – allows the egg to be classified as fertilised. The embryo continues to develop as the egg cools down. During an optimum cooling time – six hours – it will grow to a diameter of about 5mm and become storage resistant. This is stage XII-XIII, when the ring is still small and its centre is clearly yellow.

The colour of the yolk surrounding the embryo remains unchanged. Too slow cooling, or high storage or transport temperatures cause the embryo to develop more. An increased diameter of the ring, its centre filled up with white cells, and a pale yolk zone surrounding the embryo indicate continued development and absorption of water from the albumen. These embryos have developed beyond the storage-resistant stage and will probably die if placed in the low temperatures used for storage.

Life continues, and the start of incubation brings further changes. After just 24 hours, the pale-yellow yolk zone surrounds the embryo. After 48 hours, that zone has increased, and a small island of blood vessels can be seen with a magnifying glass or under the microscope. By 60 hours, the vessels have developed and soon a blood ring can be seen with the naked eye.

The development of the vessels is a reliable indication that the egg is fertile. But be careful: traces of blood found in an egg that has not been incubated are not necessarily a reliable sign of 'life'. Meat or blood spots – released in the hen's oviduct – can be found even in infertile table eggs.

Analysis of 'clears', done by candling at 7-10 days, provides reliable information. Candling earlier than this makes no sense. Changes in yolk colour, or cloudy yolk in an apparently 'clear egg' can be interpreted as an expression of very early mortality.

The more advanced phases such as 'blood ring' or 'black eye' leave no doubts. If a break-out is done later on – for example at transfer – indicators of very early mortality are less visible and mistakes are easier to make, as the yolk membrane becomes weak and breaks easily.

Advice:

- Practice distinguishing between 'fertile or not' on fresh eggs that have not yet been incubated.
- Check the stage of embryo development by measuring diameter and assessing appearance when eggs arrive. Use this information to decide on cooling, on-farm storage and transport.
- If % of 'clears' is cause for doubt, shift candling to days 7-10 to get a clearer picture.

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