# Developments in incubation: understanding what the chicken embryo needs

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The modern poultry industry is reliant on the large-scale incubation of fertile eggs in hatcheries. Over the last 15 years there have been real changes in our understanding of what the chicken embryo needs during incubation to achieve the best hatch, chick quality and broiler performance.

Better understanding of what is needed has been coupled with improvements in the incubators available and their ability to monitor and control the incubator environment.

Due to the availability of more accurate and reliable sensors and the computer programming tools to use them to their best advantage, hatcheries can now get not only the best hatchability, but also make a big contribution to broiler growth and liveability.

## Learning from history

As recently as 20 years ago we talked of setter programmes solely in terms of air temperature and humidity; now we recognise that it is embryo temperature and egg weight loss that need to be managed to get the best hatch and chick quality.

But these recent developments, and those still to come, are part of a long history of hatcheries and incubation.

Hatcheries have been around for far longer than many people realise; there are written descriptions of systems of artificial incubation used in both Egypt and China dating back over 2000 years.

These early hatcheries operated by burning solid fuel for heat with no thermometers, thermostats or forced ventilation.

The system developed in Egypt is still in use, as reported by FAO in 2009. Eggs hatch around 15% points worse than they would in a multi-stage incubator – embryonic survival can be remarkably resilient.

Artificial incubation stimulated a remarkable amount of research in Europe in the 17th and 18th Centuries. It was mostly focused on devising reliable ways of measuring and delivering a constant temperature; a very early thermostat was reported by 1609, invented to control the temperature in an incubator.

By the end of the 19th Century various patents were taken out in the USA for still air incubators, which could hatch around 500 eggs at a time.

In the first half of the 20th Century incubation and hatchery research focused on responses to air temperature, humidity, to turning angles and frequency and on egg storage conditions. Early models of forced draft incubators were produced just before and after World War I in the USA (Jamesway and Petersime) and in Europe (Pas Reform).

Capacities were tiny by current standards, but the modern hatchery had arrived, giving us the ability to consolidate eggs into large batches and hatch them in ever increasing daily numbers.

## Multi-stage machines

Control systems in these early 20th Century machines were still very basic, offering little flexibility.

By using the machines multi-stage it was possible to use the heat output of older embryos to warm each batch of eggs as they were set, reducing costs and making the whole system a lot more stable. Many hatcheries across the world still use multi-stage setters and get good results.

However, their design can make it difficult to maintain a good standard of hygiene in the incubators, it can be almost impossible to deliver optimal conditions all through incubation, and the older fixed rack machines require a lot of labour.

Temperature and humidity controls improved steadily over the years, as did our understanding of air flow in the machines and ventilation around them.

However, our understanding of the needs

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***Fig. 1. Plot of chick yield versus egg weight loss, showing delayed pull in some machines.***

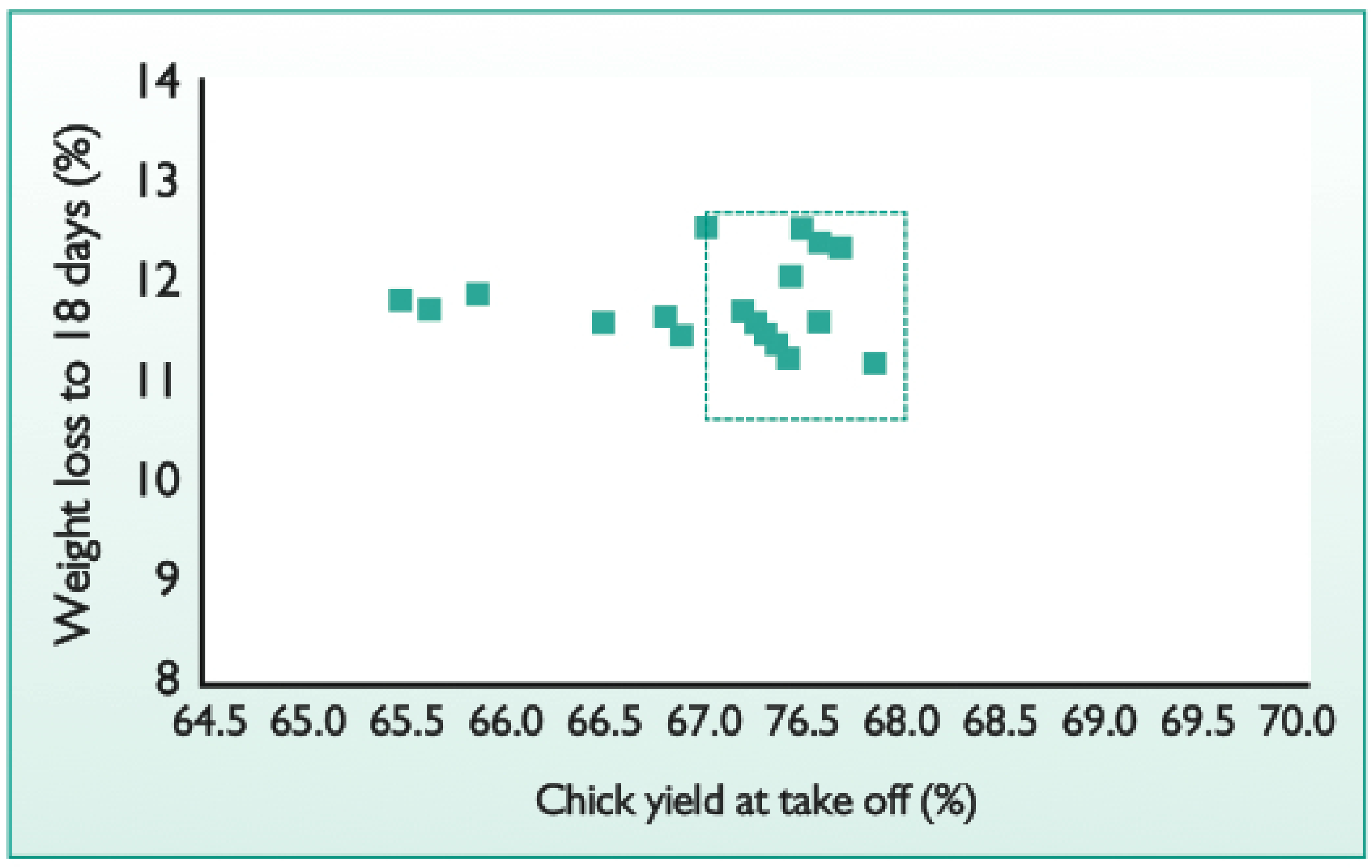
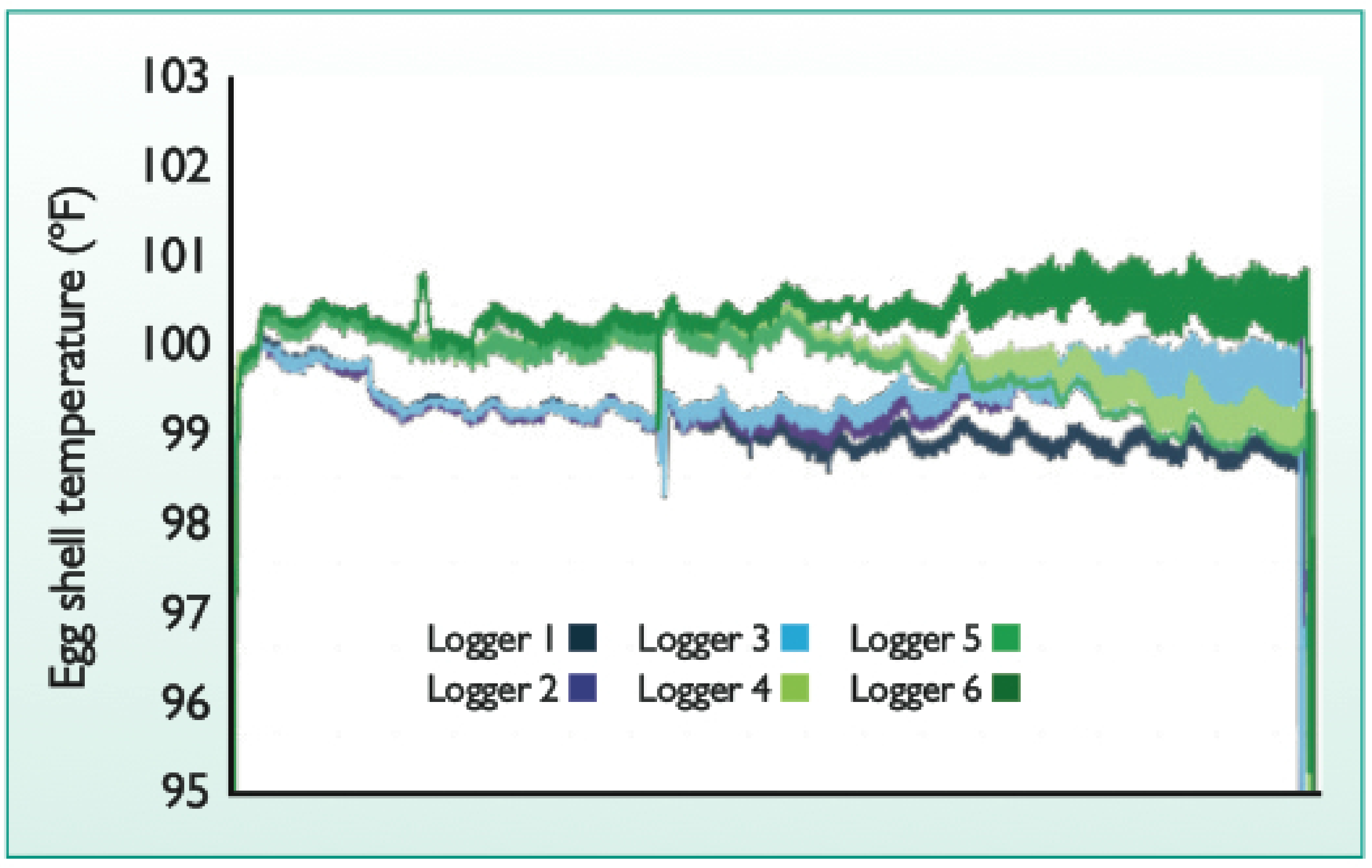



***Fig. 2. Plot of egg shell temperature versus day of incubation showing difference between two setters.***



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of the developing embryo changed relatively little. Individual hatchery managers learned (or didn't learn) the tweaks needed to make the machines they had function in their local conditions and, so long as hatchability was acceptable, left it at that.

There was no perception that conditions experienced in the incubator might have a lasting effect on the hatchling's ability to grow, survive and convert feed to live weight efficiently – except possibly from the more observant broiler farmers who would occasionally express a strong preference as to which hatchery their chicks should come from.

In the late 1970s, the first single-stage incubators appeared. In the UK, Ross Breeders (now Aviagen) opened their first single-stage broiler breeding stock hatchery in 1990. We expected slightly worse hatchability from the new machines than from the fixed-rack multi-stage incubators they replaced. The change was justified on the basis of better hygiene and biosecurity. Andy Hogg in the UK and John Sims in the USA, both working for Ross Breeders (now Aviagen) gradually worked out the practicalities of using sealed incubation in single-stage machines.

They developed a sealed incubation programme that gave even temperatures with high humidity and carbon dioxide levels in early incubation, then dropped the temperature and opened the vents as the embryos started to produce more heat. Hatchability and chick quality both improved. All of the incubator manufacturers now recommend a period of closed or sealed incubation for the first few days in single-stage setters, although opinions differ quite widely as to how long the sealed period needs to be.

## Weigh your eggs

The first big development in our understanding of incubation as it affects the embryo came when an American physiologist, Hermann Rahn, started a programme of research investigating the factors governing how gases passed through the egg shell during incubation.

In the late 1970s, his group was able to show that the amount of water a bird's egg needs to lose between set and internal pipping is a constant proportion of the initial weight – for eggs laid by birds of all sizes, from ostrich to humming bird.

This universal relationship is the reason for the advice we still give our customers, to weigh eggs at the start of incubation and at transfer, and to manage ventilation and humidity to ensure that water loss is optimised. It allowed hatchery managers to make logical adjustments to humidity as the seasons changed and for the first time start to manage the embryos, rather than the incubators (Fig. 1).

In 2001 Sander Lourens published a report in World Poultry, describing the results of an observation in a hatchery in The Netherlands, where he had measured egg surface temperature (EST) at different positions in a large single-stage incubator, and recorded the hatch outcomes of eggs in the same tray. He was able to show that when EST on day 18 exceeded 39°C (102.2°F), chick quality suffered. Above 39.5°C (103.1°F), hatchability was also worse.

The trays where eggs reached these higher temperatures were all ones with restricted airflow, below 0.1m/second. He went on to reproduce the high EST levels on an experimental basis, and was able to show that the eggs incubated under the higher EST treatments hatched less well, with more cull chicks than eggs incubated at a steady 37.8°C (100°F).

This series of trials changed the way we perceive and manage temperature in hatcheries, now focusing on embryo temperature and how it changes over time, rather than just the temperature of the air at the sensor (Fig. 2). From early this century, research in several countries showed that the conditions embryos experience during incubation can affect their liveability, feed conversion and growth long after they hatch.

## Incubation trials

In our incubation trials at Aviagen we now always place the chicks to evaluate early growth and survival rates, plus a full grow out trial to check that conditions which give the best hatchability will also give the best broiler performance.

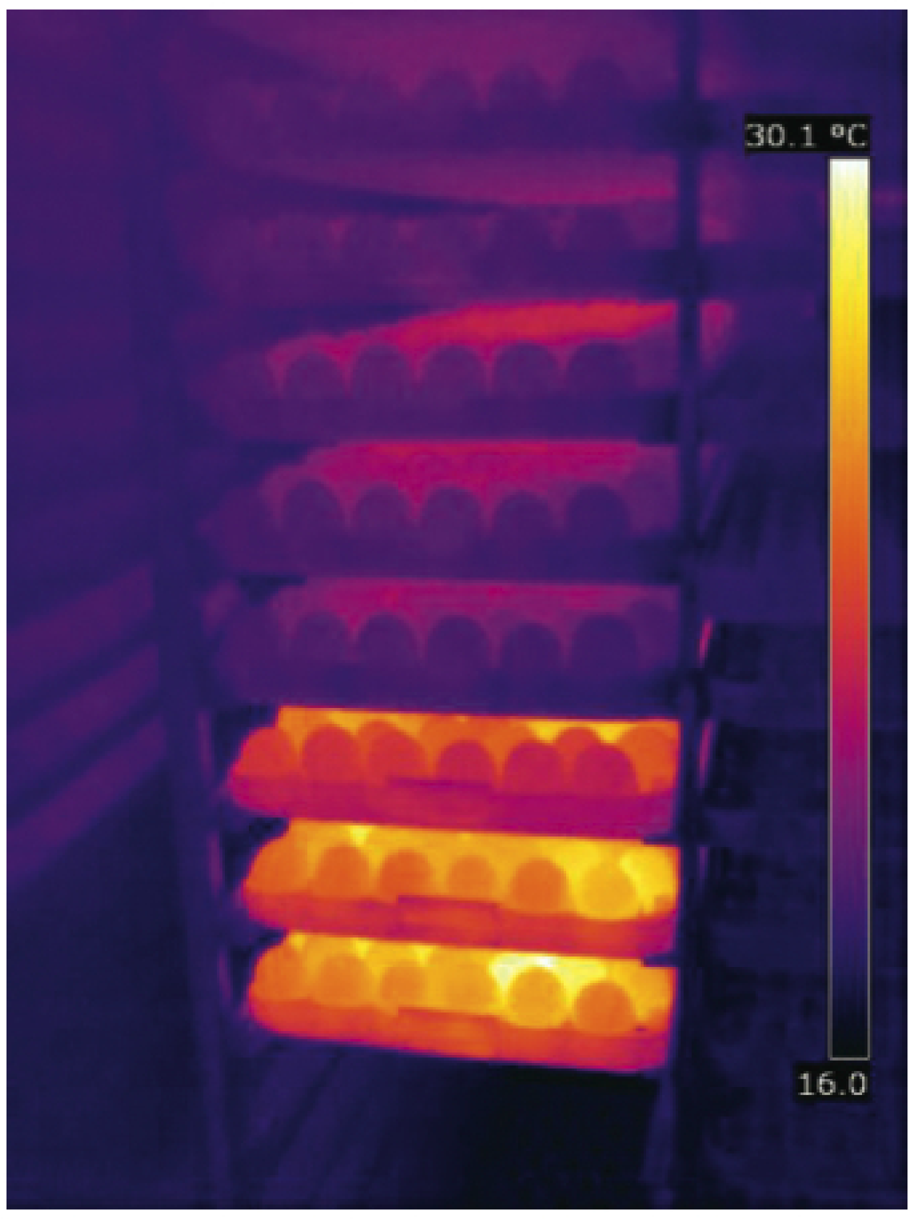
It is notable that despite the selection-driven changes in growth and efficiency after hatch, there seem to have been relatively few changes in incubation traits and requirements as a consequence of selection for broiler performance.

In our trials, the consequences of high EST on different lines are the same regardless of growth rate or breast meat yield. Equally, after decades of selection for broiler growth, broiler lines still take 21 days to hatch, passing the milestones of embryo development on the same days as they always have done.

So what changes might there be still to come? Up until now, most of the focus on optimal water loss and EST has been in the setter, with relatively little attention paid to the last three days in the hatcher.

Traditional hatchers are mostly designed to remove surplus heat, keeping airflow going through closely packed trays while the eggs inside them are changing from embryos to hatchling chicks.

Incubator companies have developed very different approaches to this critical time. One approach is to reduce the stocking density to allow the chicks to hatch at a cooler temperature, and allow them immediate access to food and water.




***Thermal image showing the impact of incorrect loading of an egg buggy in a farm egg store.***

Research has shown both to be beneficial to the individual chick.

The other approach is to use short periods of high temperature and carbon dioxide to try and tighten up the hatch window, to improve chick and broiler uniformity. It will be exciting to see how hatcher design changes in future.

Hatchery hygiene and disinfection remains a challenge, increasingly so as it becomes more difficult to use formalin within local health and safety restrictions. It is perhaps unfortunate that formalin is not only very effective but also very cheap – finding an equally effective alternative that businesses are willing to pay for is a challenge that has still to be met.

The equipment needed to monitor key incubation conditions is steadily becoming smaller, less expensive and more reliable. It is now much more practical to equip a hatchery with suitable, accurate tools to measure the key incubation parameters.

With structured sampling and a simple database, it is possible now to monitor weight loss and EST in every incubator and use the data to cross check calibration and to adjust each machine to deliver optimal conditions. After all, uniformity is important across the day's hatch, not just within each incubator.

Similarly, thermal imaging cameras can now be bought as add-on modules for smart phones, for less than half of the purchase price of the phone itself – they are invaluable for checking egg stores and holding areas.

Like any industry which relies on the application of science, hatcheries are always going to see changes as the science supporting them develops. Depending as hatcheries do on both biology and engineering, it seems unlikely that the pace of change will slow down for a while. ■