The importance of light and lux to reproduction

by Ron Meijerhof, senior technical specialist, Hybro BV

Light is extremely important for chickens – and not only to see and find food, water or a nest. The chicken's reproductive system is triggered by light – and to understand how it works, we have to understand the relationship between light and the birds.

● What is light?

Light is a form of electromagnetic radiation, like radio waves or rontgen waves, for example. Wavelengths in the region of 300-800nm (Inm = one millionth of a millimetre) can be seen by the human eye as light. The wavelength determines the colour of light, from violet light at c.300nm, ascending through blue, green, yellow and orange, to the longest visible wavelength of 800nm: red light. White light is the visual effect of combining all colours. Predominantly red/orange coloured light is typically considered 'warm' (candle light), while from bright white to a blue/green hue seems cold and hard.

The intensity of light, wherever it occurs in the spectrum, is measured in 'lux': the amount of electromagnetic radiation received per surface area. Lux is measured irrespective of whether electromagnetic radiation is in the wavelength of blue or red colour. It is purely a measure of the amount of radiation.

● Chickens and light

The chicken's reproductive system is not so much influenced by the light they see, but rather by the light received in the brain. The brain of a chicken contains light sensitive cells, which are known to trigger the reproductive system. These are not so much stimulated by light received through the eye, but rather through the skull.

Warm light (long wavelengths) is most effective at penetrating to the brain. Compare it with music, where the bass (long wavelengths) can be heard easily outside a house or car. Chickens use bright light (short wavelength, high amount of blue/green) to see, but they need red light (long wavelength) for reproduction.

● To use light effectively in chicken houses:

Measure the amount of lux using a luxmeter. The house may well be light enough. But if that light is very bright and there is only a small amount of red colour in it, the birds' may not be sufficiently stimulated to reproduce.

Although 'red' (long wavelength) lamps may not seem very bright to us, the actual lux reading can be surprisingly high. White bright light will seem more intense, but there can, in fact, be less lux. As birds respond to the red wavelengths, white bright light is less effective for reproduction. If we try to provide enough red light with this light source, the increase in total light intensity risks over stimulating the birds' behaviour, resulting in nervousness, stress and pecking.

Because chickens use short wavelength light to see, using predominantly red light may lead to an increase in floor eggs. In rearing, common light bulbs (warm, yellow/orange light) are often used because they can be dimmed easily.

When these birds are transferred to a black-out production house with bright white TL light, total light may increase. But if the amount of red light either decreases or does not increase significantly, the birds' reproductive behaviour is unlikely to be triggered effectively.

● To avoid problems, we must:

- Look not only at lux (light intensity), but also at the colour of the light.
- Ensure that breeders step up especially in the red light fraction coming into production.
- Make sure breeders in production get enough 'warm' light with a high amount of red colour.

Do larger eggs = bigger chicks?

by Ron Meijerhof, senior technical specialist, Hybro BV

In the field we often find that the quality of chicks from older breeder flocks is below the desired standard. Although the chicks are large, there are often problems with viability, yolk sac absorption, unhealed navels and other factors. It is not unusual to see a decreased hatch of fertiles, especially as a result of increased numbers of late deads.

Genetically, the embryos are identical to the embryos produced by the same flock 20 weeks ago. It is, therefore, not unreasonable to expect the embryos to develop more or less in the same way. The decreasing shell quality of older flocks is sometimes thought to be a cause. But even in flocks with good shell quality, we still tend to experience greater problems with chick quality from older breeders.

In fact, a major problem with larger eggs can be found in the actual egg temperature during incubation.

Temperature inside the egg is the result of the balance between heat production and heat loss. Bigger eggs containing larger embryos will produce more heat, simply because there is more embryo mass. Eggs lose heat by transfer from the surface of the shell to the environment, like the radiator in a car. And while larger eggs have more total shell surface, per gram of egg – the shell surface is actually reduced, making it more difficult for the egg to lose heat.

In addition, larger eggs will be packed more tightly in the incubator, especially in a turned position, which has the effect of blocking air flow over the eggs, although a good air flow is one of the most important aspects of cooling the eggs.

For these reasons, larger eggs normally have a higher temperature, especially when the temperature of the machine has been set to cater for an 'average' egg size.

When embryos experience higher temperature, it becomes more difficult for them to convert yolk into body tissue. The yolk residue remains disproportionately large, and the 'real' chick (chick without the yolk) is relatively small. If we weigh the chicks, we do not notice this effect, as we are weighing chicks inclusive of their residual yolk sac.

If we take out the yolk and then weigh the chick, or if we measure the length of the chick as an indicator for its development, the larger eggs will give a greater total chick weight, but much of this is contributed by the yolk. The actual chick is smaller than we expect it to be – sometimes even smaller than from a breeder flock 10 or 20 weeks younger.

In small chicks with large residual yolks, it is more common to see unclosed navels and navel-yolk sac infection, and an increase in late deads, as the high temperatures will kill some of the embryos. Embryos not actually killed will struggle during the final days of incubation, resulting in reduced vitality among the newly hatched chicks.

● Conclusion

Embryos in larger eggs must be exposed to the same temperature as those in smaller eggs. If we incubate all egg sizes at the same machine temperature, larger eggs will have a higher temperature – resulting in a reduced quality.

To control this, adjust the incubation temperature profiles to give the embryos in the larger eggs the same temperature inside the shell as smaller eggs. The objective is to increase heat loss from larger eggs in the second half of the incubation period, either by effecting a greater drop in temperature, or by increasing the air flow over the eggs.

Crocodiles and chickens

by Ron Meijerhof, senior technical specialist, Hybro BV

When we determine gender in the field, for instance when producing breeders or when sexes are reared separately, we expect gender distribution to be roughly 50/50. However, we do sometimes see shifting gender ratio, which can be as skew as 47/53. When this happens, we normally see more females than males hatching, at least in broilers – and to understand why, we need to look more closely at the determination of sex.

In birds, the female determines the gender of her offspring. At the moment the yolk is formed, the sex of the resulting chick is already decided. In mammals, gender is determined by the male, and fixed only after fertilisation.

Reptiles – specifically crocodiles – are even more sophisticated, determining gender according to incubation temperature. In some types of crocodile, incubation at a certain temperature gives 100% males. But if that temperature is reduced by just 2°C, those same eggs will produce 100% females, with a linear distribution of males to females over this 2ºC range. In other types of crocodile, a specific incubation temperature will produce 100% females, while temperatures higher or lower than this will result in more males.

If chickens and crocodiles shared that temperature related gender influencing mechanism, the ability to influence a shift from male to female would certainly be of enormous value. However, as the chicken's sex is determined even before fertilisation of the blastoderm – this is unlikely.

When we do see a shift in sex ratio, this can sometimes be explained by sexing errors, especially if cloaca sexing cannot easily determine gender. In breeders especially, chicks that cannot be decisively sexed will be considered off-sex, reducing the number of sexing errors for the customer – and at the same time influencing the observed male/female ratio.

It does seem, however, that incubation temperature does have some impact. For example, overheating during late-stage incubation can produce a greater number of females. But further investigation of the unhatched eggs will normally reveal the majority of late deads as male. So, if we add the numbers of hatched chicks and late deads together, we usually find that 50/50 ratio between males and females restored. The gender shift in late deads is much more extreme than in hatched chicks, simply because even a shift from 50/50 to 49/51 males/females will produce three times more late dead males than females (based on late deads at 4-5%).

So why do more males than females die late in incubation? One possibility is that males are weaker and more susceptible to sub-optimal conditions than females. This may be true, as we see virtually the same trend in day-old chicks. Or perhaps males produce more heat during incubation than females? Although there is currently no scientific data to support this, we do have some practical evidence.

Per set, males normally hatch several hours earlier than females, which may be due to higher metabolic heat production during incubation, resulting in higher temperatures in-ovo and accelerated growth, compared with the females. If we experiment by setting eggs of exactly the same weight, the hatched males do show more signs of overheating – for example, more yolk sac residue and less development – than females.

This could explain the shift in sex ratio under high temperatures. With increased heat production, there is more likelihood of exceeding maximum temperature. As a result, more males will die late in incubation, while the females are less affected and therefore hatch. Take it one step further, and we could even speculate that the males are perhaps not weaker by nature, but because they are overheated during incubation. This being the case, sexing embryos in the egg – currently in development with in-ovo techniques – could greatly improve the incubation process, by enabling us to create optimum incubation conditions each for males and females.

Right now, we do not have scientific evidence that males do produce more heat than females, or what mechanism may be responsible for that. Further investigation will teach us more about the differences between males and females – and how those differences can help improve processes and productivity in the future. For the time being, if we see a shift from male to female ratios that cannot be explained by sexing errors, the key may lie in overheating. But unlike the crocodile, our chicks are not shifting gender – we are merely seeing a similar effect through the survival of a greater number of females, not in the ratio of male to female overall.

Maximising in-ovo vaccination success

by Ron Meijerhof, senior technical specialist, Hybro BV

In-ovo vaccination by injection, particularly for protection against Marek's disease, is becoming increasingly popular as a time and labour saving method. It delivers vaccines with great accuracy, allowing the embryonic chick to develop its immune response, before being exposed to any threat of disease post-hatch.

However, the process and technique used to administer in-ovo vaccines is critical and determines to a large extent the effectiveness of the method.

Where to deliver the vaccine

To achieve effective in-ovo vaccination, the actual site of injection is of utmost importance. To fully understand that, we have to look at how the embryo is positioned in the egg. The embryo floats in the amnion fluid – the inner sac of the egg – which functions both as a protective shelter and as a source of nutrients, which the embryo absorbs during its development.

Between the amnion and the shell, the allantois functions as a sort of waste bag, storing waste products that are formed during the embryo's growth, including metabolic water. The weight loss of eggs during incubation comes mainly from evaporating this metabolic water through the shell.

Vaccine must be injected deep enough into the egg to be delivered into the amnion fluid, where it can be absorbed by the embryo as it takes up the nutrients contained here. If the vaccine is injected too deep, the needle will hit the developing embryo directly, and although the embryo will be vaccinated, there is a risk of damage to the developing chick. If the vaccine is not injected deeply enough, it will be delivered into the allantois, or waste fluid. This vaccine will not be utilised by the embryo and the vaccination will be ineffective.

Injection

With in-ovo injection, we target the needle to a fixed depth under the shell, positioned for each individual egg. If the embryo is in the correct position, the egg will be injected correctly and the embryo successfully vaccinated. However, the position of the embryo depends on its stage of development. If the embryo is too small, it will not sit high enough in the egg, the needle will not penetrate through the allantoic and the vaccine will be delivered into the allantoic fluid and wasted. If the embryo is too big, the needle will go through the amnion and hit the embryo directly.

Gauging the size of the embryo

The size of an embryo depends mainly on the speed of its development and time since incubation started.

To inject the embryos at the optimum size, we must vaccinate in relation to speed of development. If the embryo is not adequately developed, it is simply a matter of waiting slightly longer before we vaccinate. Speed of development depends on the embryonic temperature inside the egg, which is not equal for each machine, each breed, each egg size and each egg within a machine.

To help identify optimum timing, we can inject the eggs with a dye periodically during incubation, to check where the dye is being delivered. We can also adjust the timing of vaccination by measuring the length of the embryo at 18 days of incubation.

Achieving uniform protection

We often find that the embryonic temperature (inside the egg) is not equal at every spot in the machine. This is dependent on a number of factors, including air temperature, air velocity and the volume and path of water spray, for example.

A spread in embryonic temperature, will indicate a spread in development – and with that, if we do not gauge optimum timing for vaccination, a percentage of the embryos will not be vaccinated correctly and will have no protection when placed in the field, especially when injected relatively early.

To achieve optimum results with in-ovo vaccination, it is therefore, more important to monitor the size of the embryos closely, rather than time elapsed during incubation. To achieve uniform protection, all embryos must be as close to the same stage of development as possible, and of the right size to deliver the vaccine into the amnion.

Brooding: balancing temperature for performance

by Ron Meijerhof, senior technical specialist, Hybro BV

Birds are warm blooded. This means that they have a specific body temperature at which their metabolic processes function at optimum level. For young chicks, optimal body temperature is normally 40°C (104°F) approximately, when measured on or in the cloaca.

This internal body temperature is the result of a balance between the heat produced and the heat lost by the animal. If heat production is higher than heat loss, internal temperature tends to rise. The birds will try to compensate by losing more heat (for instance by panting) or by producing less heat (for instance by eating less). If heat production is lower than heat loss, the birds may huddle together to decrease their heat loss, or consume more food to increase heat production.

The body temperature of adult broilers is often higher than optimum, as they tend to continue eating, even when their body temperature is slightly increased.

● Brooding

When a chick is freshly hatched, its internal heat production is very low. To maintain correct body temperature, chicks need a warm floor (minimum 30°C) and high air temperature (33-35°C), without air movement (draft). If these conditions are not met, the bird's body temperature will drop immediately – and in some cases, very rapidly. In sub-optimal conditions, a day old chick's temperature can drop within one hour or less, from 104°F to 95°F or lower.

We would expect the birds to react immediately, by eating more or huddling together, for example. However, because the thermo-regulatory mechanism is not yet fully developed in young chicks, they are relatively defenceless against reduced temperatures. They will get cold, sit down, use precious energy screaming for their mother, and ultimately become very lethargic. As these birds will not eat and run a high risk of problems with yolk sac absorption and mortality, it is important that we get the brooding conditions right.

Encouraging the birds to be active and to eat will produce body heat as a result of digestion - and their internal body temperature will go up. Once the birds are eating, the risks associated with low body temperature are greatly diminished.

● Fuel prices a factor

With fuel prices currently sky high, it is not unusual to find that, in an attempt to save on fuel costs, houses are not pre-heated as well as they should be before the chicks arrive.

It is logical that this saving is not optimal for the birds, but assuming that bottom line cost savings will compensate for this is often a mistake.

If we fail to pre-heat the house sufficiently, the birds will not achieve optimum body temperature and therefore remain lethargic. They will not eat as quickly or as much as they should, which is counter productive not only for internal heat production, but also for growth. Ultimately, to get them to eat and grow, the ambient temperature in the house will have to be raised, and kept that way for a longer time, which can cost more than was saved by not preheating the house in the first place.

● Food saves fuel

By encouraging birds to eat as soon as possible, their metabolic rate will increase, they will they grow faster and they will produce more heat. This enables us to drop the house temperature more quickly, which in fact we must do or the birds' growth rate will be reduced after a couple of days, in an attempt to prevent overheating.

If we do a bad job in brooding, and only part of the flock starts well, we create an even greater problem. After a couple of days, we must decide whether to keep the temperature up for the non-starting birds, accepting that the well started birds will become overheated and reduce their growth rate, or to drop the temperature and give up on the non-starters.

In all cases, our best and cheapest option is to make full use of the natural by-product of growth – the birds' own heat production – to set them all on the right path for a good start and healthy, rapid growth.

The ABC of Male Behaviour

by Ron Meijerhof, senior technical specialist, Hybro BV

In assessing fertility in a breeder flock, we normally consider factors such as semen quality, bodyweight control, physical condition of the males, foot pad quality, etc. Undoubtedly, these aspects are important. Disease or nutritional factors can influence semen quality. If the males lose bodyweight, they will stop semen production. Overweight males with foot pad injuries will not mate easily. However, there is one more factor of utmost importance.

They have to like each other

For good hatchability, we need successful matings. To achieve this, not only the physical condition of males and females is important, but they must also want to mate. As mating is the final result of a complex sequence of social interaction, we have to look at the behaviour of both males and females.

Male-Female interaction

One of the most important issues is dominancy or pecking order. A male (chicken) must be dominant over a female to be able to mate. At the same time, the female should not be scared of the male and avoid mating.

Male-to-Male interaction

Not all males are equally dominant. Some are higher up in the hierarchy than others. We can divide males into three different groups:

A males: dominant males, highest in the hierarchy, willing to mate and mating.
B males: non-dominant, not high enough in the hierarchy, but want to mate and will try, given the opportunity.
C males: non-dominant, too low in the hierarchy to mate or even consider mating.

This is an arbitrary classification, which helps us to understand what happens in a group of males. All three types will be present in a flock, with the distribution of types A, B and C determined by the condition of the males.

B males will dominate C males, and A males will dominate both B and C males. An A male will try to prevent B males from mating, although the B males will try nonetheless.

Low fertility can mean that there are not enough A males to do all the mating. When there are enough A males - especially when there are a high number of males in a flock – they may be so busy disturbing each other, that successful mating suffers.

Most females will stick for a time with one A male, but some will move from male to male, with some trying to avoid mating by doing so. We recognize this when we set eggs from individual hens, because they produce infertile eggs. We call these females “loose hens”, and their numbers normally increase with the age of the flock. Given the opportunity, B Males will try to mate with these hens and the braver they are, the more successful they will be.

Increase fertility

At first sight, the key to good fertility is a high number of A males in the flock. Removing the ineffective C males will not solve the problem, as by doing this we do not increase the number of A males, we simply decrease the number of C males, which has no impact on fertility as they do not mate in the first place.

Focus on two areas:

Keep the number of active A males high, with fighting kept to a minimum. High stocking density in rearing decreases the percentage of A males, as too many males will face other, more dominant males. Ensuring adequate feed for males in production will help to keep the number of A males up. B males must be active, to mate with “loose hens”. Care in house and feeder design will help force as much movement of the males through the house as possible, so they can find the loose hens.

By looking not only at the physical condition of the males but also at the way they act with the females and towards each other, there is much we can learn much about their mating activity, to improve fertility in the flock.

Incubation ventilation - 1

by Ron Meijerhof, senior technical specialist, Hybro BV

During incubation the embryo absorbs oxygen and produces carbon dioxide, metabolic water and metabolic heat. The eggs need to be turned, and a specific temperature maintained inside the egg, for healthy development. These are the basic principles that underpin incubator design. Most machines have either an electric or a warm water heater, and cold water cooling coils. Machines are set to specific points for temperature and relative humidity (RH). If temperature is too low, the heater comes on. If set temperature is exceeded, cold water is sent to the cooling coils, to remove excess heat. When relative humidity rises above set point, dampers open to increase ventilation. If relative humidity is too low, the sprayer comes into operation to raise it to the required level.

● The function of ventilation

Machines are ventilated to allow oxygen into the incubator and to release carbon dioxide and evaporated water. In conjunction with the cooling coils, ventilation also plays a part in cooling, as exchanging warm air for colder air will have a cooling effect. In effect, the metabolic heat produced by the embryos is partly removed by the cooling coils and partly by ventilation. Many incubators do not have sufficient cooling capacity to be totally independent of ventilated air. If we calculate the ventilation demand of a machine holding 100,000 eggs, simply looking at demand for oxygen and the release of carbon dioxide by the embryos, we expect not more than 250m^3/hr for a single stage machine at day 18 of incubation (approximately 100-150m^3/hr in multi stage). Many machines will in fact ventilate more, simply because temperature exceeds setpoint and the programme requires extra cooling.

● Cooling by evaporation.

When relative humidity is too low, we humidify the air in the machine by spraying water into the air. This spray water must evaporate, which uses energy provided mainly by the eggs in the machine, and therefore has a cooling effect on the eggs. Problems can arise because evaporation tends to occur locally. Eggs positioned close to the ventilator and sprayer get most of the water and will be cooled to a greater extent than those further away. Conversely, those eggs further away from the sprayer will not have to use energy to evaporate sprayed water, and will therefore not be cooled. This means that frequent spraying often leads to non-uniform egg temperature. Eggs close to the sprayer get cold, while eggs placed further away stay warm. The use of water rolls rather than sprayers can minimise this effect, but will not prevent it entirely.

● Ventilation and humidity

It is important to understand that when we ventilate, we often start to humidify as well, because we introduce relatively dry air into the incubator. At 37.5°C and 55% humidity, air holds approximately 22g water per m^3. If the amount of water in the incoming air, combined with the water evaporated from the eggs in the machine, is less than 22g/m^3, the machine will start spraying. We aim to lose approximately 12-14% – roughly 0.6-0.7% per day, or 0.025-0.03% per hour – of water during incubation. So with 100,000 eggs of 60g each in the machine (total 6000kg egg weight), we can expect to lose 1.5-1.8kg of water per hour. When ventilating the machine with 250m^3/hr, the eggs will add 6-7g water to every m^3 of air. If we only ventilate with 125m^3/hr, the eggs will add 12-14g, and if we ventilate 500m^3/hr, the eggs will add 3-3.5 g/m^3. If the machine needs 22g of moisture per m^3 of air and the eggs add 6-7g, then incoming air must carry 15-16g of moisture to prevent the sprayer from operating. Air of 28°C and 65% RH contains approximately 16g water/m^3, so by introducing that into the incubator, the sprayer will not have to operate. If we bring in the same air while the machine ventilates 500m^3/hr, the sprayer must add 3g water per m^3 of air, which means spraying 1.5 litres per hour. If the machine ventilates less, humidity in the machine will rise too much, and the dampers open, or the eggs will not lose enough moisture (egg weight). As spraying delivers evaporative cooling, the amount of air ventilated and the temperature and relative humidity of the air used will have significant impact on the cooling of the machine, both directly by air temperature, but also indirectly by the amount of spraying that the machine will deliver as a result.

Incubation ventilation - 2

by Ron Meijerhof, senior technical specialist, Hybro BV

● Ventilation by carbon dioxide

Nowadays, many machines are ventilated based on carbon dioxide levels. The carbon dioxide level in the machine is set at a certain amount, for instance at 4000 ppm (outside air contains about 300-350 ppm) and when the level in the machine gets higher, the dampers open and the machine starts to ventilate. Although it is still not totally clear what the effect of either high or low carbon dioxide is on the development of the embryo, we can at least estimate what happens with the temperature and humidity. Ventilation of the machine will force the carbon dioxide level down, as the air in the machine will be replaced with air only containing 300 ppm carbon dioxide. If we ventilate based on a high level of carbon dioxide, we close the machine more, if we set our ventilation on a low level of carbon dioxide we open up the dampers more. If we look at the influence that ventilation has on spraying, it means that a high level of carbon dioxide automatically leads to a low spraying in the machine. Low levels of carbon dioxide requires more ventilation, more relative dry air coming in and less moisture of the eggs per m^3 of air, and the sprayer will come in more. The only way to avoid this, to keep the amount of spraying constant in the machines, is to bring in more moisture in the air that enters the machine if we ventilate more. That would mean that we have to adjust the moisture amount of the air in the setter room if we change the carbon dioxide requirements in the machine. As this is not practically feasible, we have to accept and realise that the level of carbon dioxide that we use as set point in our machines will influence the amount of spraying in the machine.

● Embryo vs eggs

One other thing we have to realise is that the source of carbon dioxide and of evaporated water from the eggs is not equal, although both come from the eggs in the machine. All eggs in the machine evaporate water, regardless of whether they are fertile or not. However, only the living embryos in the machine produce carbon dioxide. This means that if we ventilate on carbon dioxide, we have to take the fertility into account as well, or we will mess up the humidity and consequently the temperature. If our fertility is low, we have a low level of carbon dioxide production, and to reach the same level of carbon dioxide in the machine, we have to close up the machine more. This means that the relative humidity in the machine will go up, and the sprayer will come in less. If we put the limits on ventilation for humidity rather high in the machine, we might find that the eggs did not lose enough water at the end of incubation, because the dampers did not open enough to get rid of the metabolic water. If the fertility is high, there is a high level of carbon dioxide in the machine, the dampers will open, take in more fresh, cold, dry air and the machine will start spraying water.

● What do we do in the field

As ventilating on carbon dioxide can have an influence on the humidity, the amount of spraying and therefore on the temperature distribution of the eggs, we have to be careful with simply putting a standard carbon dioxide level for ventilation. We have to realise that the level of fertility by itself already has an influence on it. We have to make sure that our carbon dioxide level does not influence our temperature distribution and our moisture loss, so we have to check if the sprayer comes in more or less in the way we expect, if the temperature distribution of the eggs is within our limits of expectation and if the eggs have lost enough moisture loss at the end of incubation. If we foresee that the moisture loss is not adequate (minimum should be 10%), we have to allow a lower carbon dioxide level to force the machine to open the dampers and remove the water. If the dampers are opening too much and the machine sprays more then we want, we might choose for a higher level of carbon dioxide level, or a higher amount of moisture in the incoming air. As we do not fully understand the dangers of high carbon dioxide levels on the embryo, the last one might be a better option.

We have talked mainly about single stage machines, as we can influence our settings there. If we work with multi stage machines, our choices are much more limited, but we still have to consider these things.