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HATCHERY

Genetic progress inspires cha

Genetic changes in broiler and layer breeds have an effect on incubation conditions. Traditional setpoints must be reviewed, whereby scientific research and new technologies provide the tools to better match the needs of the modern breeds.

By Dr Marleen Boerjan, *Pas Reform Hatchery Technologies, Zeddam, The Netherlands*

Standards for successful commercial incubation were defined during the first half of the 20th century. In 1969, Harry Lundy reviewed the data available at that time on artificial incubation, to publish *The fertility and hatchability of Hen's eggs* (Carter, TC and Freeman BM, eds, Edinburgh (1969) 143-176). To this day, Lundy's review is widely regarded as the definitive reference for the design of incubators, as well as incubation setpoints for temperature, humidity and ventilation.

As one of the world's leading hatchery technology companies, Pas Reform has, through the research, training and consultation activities of it's academy worldwide, recognised the need to update this important reference work, in order to meet the needs of the embryos of today's modern poultry breeds. For that reason we looked at the impact of advances in modern poultry genetics in relation to the application of Lundy's standards in single stage incubation, with the emphasis on air and embryo temperature.

Incubation and chick quality

The poultry industry has undergone major changes since Lundy wrote his review in the late sixties. Genetic selection and highly developed management practices have greatly improved the efficiency of meat and egg production. In modern broilers for example, the growing chick spends half the time on the farm than it did a little over 26 years ago, with the rearing period having decreased since then from 84 days to just 42 today. In the seventies, chicks spent 20% of their total lifespan, from egg to slaughterhouse, in the incubator. The modern broiler chick now spends 33% of its life in an incubator climate. It is therefore obvious that the impact of incubation conditions on the growing embryo and chick are fundamental to the growth performance and feed conversion ratios of modern broilers – and as such, should not be neglected as an important factor in determining commercial breed performance.

North Holland Blue

Embryonic management change

It is not just the proportion of lifetime spent in the incubator that has changed. With genetic progress, the diversification of egg types has also increased dramatically over the past 30 years. Within this diversification, specific egg producing and meat producing industry needs have emerged, induced by extreme selection pressure. While high egg production is the defining genetic factor for the former, the latter demands fast growth complemented by low feed conversion rates. And further, within the broiler (meat-type) breeds alone, selection for breast meat yield and percentage of abdominal fat, for example, have shaped the management needs of the broiler breeder industry specifically.

In the farm environment, the most obvious difference between layer hens and broilers is the difference in their respective growth rates. Layer hen chicks reach a weight of 500g at 42 days, while broiler chicks grow to over four times that weight, around 2300g, in the same period.

These differences are equally evident in the embryonic phase. Pal (2002) showed that genetic selection for growth not only influenced growth at the farm, but also the growth and body composition of the embryo in the second week of incubation. Clum (1995) went further, to show that different growth patterns are associated with changes in the pattern of embryonic reallocation between tissue types. For example, higher growth rates are associated with decreases in bone, feather and brain mass. And in quail, selection for high postnatal growth rate is accompanied by a more rapid early development of the digestive organs. Metabolic disorders like ascites also find their origin in the embryonic phase.

Broilers and layers

In separate experiments, we have found that at 40 hours, broiler embryos and layer embryos were both in stage 10 of the Hamburger and Hamilton standards[1], while at 48 hours of incubation, broiler embryos were in stage 13 and layer embryos had only developed to stage 12. These results indicated that the higher growth rate of broiler embryos is in evidence before the blood ring stage at 80 hours of incubation. What becomes critically important as a factor for successful incubation, is that fundamentally, different growth rates result in different levels of heat production between layer and broiler breeds. This makes it impossible to combine the incubation of eggs from a layer strain and a broiler strain under the same conditions in one incubator.

A

It is also clear that within broiler breeds, as selection for increasingly high breast meat yields and low percentages of abdominal fat continues, this further diversification will lead to still greater variability in the development and growth of broiler embryos and, consequently to breed specific incubation programmes.

Growth and metabolic heat

The rate of embryonic as well as post-natal growth (growth at the farm) is determined by the rate of bio-synthesis of tissue, which depends on the availability of nutrients and oxygen. A strong physiological relationship exists between the rate of bio-synthesis and metabolic heat production. In trials conducted in collaboration with the Humboldt University in Berlin, Pas Reform has shown that at day 18, metabolic heat production, based on oxygen consumption, is about 26% higher for Ross 308, for example, when compared to a white leghorn breed (*Table 1*).

Metabolic heat production in the modern broiler breeds Ross 308 and Ross 508, is about 20% higher than the metabolic heat produced by the North Holland Blue, a traditional meat producing breed that was common in commercial poultry production when Lundy produced his review in the sixties (*Table 1*). The higher metabolic heat production of modern broilers as compared to a slower growing breed, is the result of higher growth potential. It is interesting that, at all time points measured, the Ross 508 embryo produced slightly – though not significantly - less metabolic heat. This was a surprise, given that there

nges in incubator technology

B

The developing embryo: variation between the heart structures of a layer embryo(A) and a broiler embryo(B) at 40 hours of incubation. In studies conducted by Pas Reform genetic selection for growth has shown not only to influence growth after hatching, but also to influence the growth patterns of embryonic heart structures. Here we see that in the broiler embryo (B) the ventricle (marked *) is dilated, compared to the ventricle in the layer embryo (A).

Table 1 - Metabolic heat production (W/1000 eggs) of a modern layer hen breed and broiler breed compared to heat production (W/1000 eggs) produced by the North Holland Blue breed (traditional)

Day of incubation	Metabolic heat production W per 1000 eggs Ross 308*	Ross 508*	White leghorn*	Traditional**
17	151.2	160.2	133.2	130
18	156.6	149.4	130.2	137
19	164.4	160.8	127.2	124
20	252.0	239.4	130.8	169

* Janke, Tzschenktke and Boerjan (2004) Abstract World's Poultry Congress Istanbul Turkey, June 2004. ** Romijn C and Lokhorst W (1960) Foetal heat production in the fowl. J. of Physiology 150:239-249.

Table 2 - Setpoints for temperature recommended for single stage incubation of a brown layer and a broiler breed

Day of incubation	Embryonic age (hr)	Average egg shell temperature		Setpoint of temperatures in Pas Reform incubator			
				Layer		Broiler	
		°C	°F	°C	°F	°C	°F
1	0	37.8	100.0	38.0	100.4	38.0	100.4
4	72	37.8	100.0	37.9	100.2	37.7	99.9
7	144	37.8	100.0	37.8	100.0	37.7	99.9
10	216	37.8	100.0	37.8	100.0	37.6	99.8
13	288	37.8	100.0	37.6	99.7	37.3	99.2
16	360	38.3	100.9	37.4	99.4	36.8	98.3
19	432	38.8	101.8	36.9	98.5	36.4	97.5

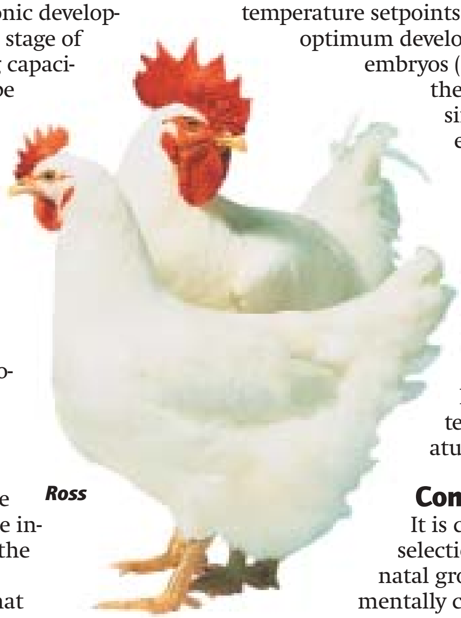
is a common belief today that breast meat producing breeds like the Ross 508 produce more metabolic heat during incubation. However, Pas Reforms results seem to indicate that high heat production by a broiler embryo is determined more by high growth rate than breast meat yield.

Incubating modern breeds

For incubator manufacturers today, the challenge is to design incubators that can support optimum embryonic development for each egg at each stage of development. The heating capacity of the incubator must be sufficient to initiate embryonic development in every egg placed in the incubator. Genetic selection has not only had an impact on production traits, but has also resulted in larger eggs with a decreased percentage of yolk volume. The greater volume of eggs produced by modern breeds means that a greater volume of eggs must be warmed – and therefore the heating capacity of the modern incubator must be increased in comparison to the older incubators.

It is a well known fact that metabolic heat production increases as the embryo grows. The cooling capacity of the incubator must therefore be sufficient to remove the heat produced by the older embryos, as the higher metabolic heat production of modern broiler embryos increases the risk of overheating. To avoid this, incubation setpoints are adjusted such that the embryo temperature[2] is always maintained at the correct level.

In order to ensure optimum conditions for the growing broiler embryo in a commercial single stage incubator, setpoints for temperature are lower, compared to the temperature setpoints needed for the optimum development of layer embryos (*Table 2*). Further, the increased diversification of broiler breeds increasingly requires the development of breed specific incubation programs, whereby the eggshell temperature can be used as a leading parameter for the temperature setpoint.



Ross

Conclusions

It is clear that genetic selection for high postnatal growth has fundamentally changed the pattern of embryonic development and rates of biosynthesis (=growth), resulting in higher metabolic heat production that must be carefully managed in the incubator environment to optimise hatchability and uniformity. In addition: for the optimum support of embryonic development, the incubator must have sufficient heating and cooling capacity. Optimum eggshell temperature for highest chick quality can vary between breeds, because of inherent variations in the embryo and egg characteristics of different breeds bred for either meat or egg producing purposes.

Since the hatchery is the first and formative stage of broiler's life, breeder companies that support the hatchery with optimum eggshell temperature advice for each stage of development will deliver stronger, more breed-representative results. In this respect, to achieve the most efficient and productive poultry production both for the broiler and egg laying sectors, the incubator industry and breeder companies are well advised in their use of co-operative research, to share knowledge and explore the needs of the growing embryo. ■

Note:
[1] *Hamburger and Hamilton standards relate to a series of normal stages in the development of the chick embryo. The Hamburger and Hamilton standards are used by embryologists to describe the embryonic stages of different breeds.* [2] *Because the temperature of the embryo cannot be measured without damage to the egg, the temperature of the eggshell is used as a reference for embryo temperature.*