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Influence of temperature stimulation during the last 6 days of incubation on hatching results and later performance in Pekin ducks

Einfluss einer Temperaturstimulierung während der letzten 6 Bruttage auf das Schlupfergebnis und die spätere Entwicklung von Pekingenten

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Introduction

In Germany per capita consumption of poultry meat was 16 kg in the year 2000 and rose up to 18 kg in 2007. Per capita consumption of 0.9 kg meat originated from ducks in 2000 and 1.0 kg in 2007, respectively (Böttcher and Schmidt, 2009). The American breed of Pekin duck takes a dominant position within duck meat production in Germany. The Pekin duck or Long Island duck (*Anas platyrhynchos domestica*, or *Anas peking*) was bred from the wild Mallard in South East Asia. This fast growing duck has the ability to achieve a body weight of 3.34 kg (male)/3.06 kg (female) by a feed intake of 8.18 kg/7.98 kg after a 7-week fattening period (NRC, 1994). Pekin ducks reach maximum daily weight gain at 24–26 days of age. But the body parts of the ducks don't grow at the same growing rate, thus the maximum breast meat growth is reached at 38–40 days of age (Gramzow, 2005).

Recent research shows that incubation climate may have a long-lasting influence on poultry performance (e.g., Collin et al., 2007; Hulet et al., 2007; Piestun et al., 2008; Tzschentke and Halle, 2009; Shinder et al., 2011). The most important climatic incubation factor is the incubation temperature (Decuypere and Michels, 1992). Changes of only 1°C from the optimum have a major impact, for instance, on hatching results in turkeys (French, 1994), but the strength of this influence depends on the time frame used and the duration of changes in incubation temperature during embryogenesis (French, 2000).

Further, during 'critical periods,' incubation climate may cause long-lasting changes in the perinatal epigenetic programming of respective body functions ('imprinting of physiological control systems', Tzschentke and Plagemann, 2006). In poultry, for instance, at the end of incubation, long-term alterations in incubation temperature may induce prenatal epigenetic temperature adaptation, which results in a long-lasting cold or warm adaptation during post-hatching development (Tzschentke, 2007, 2008). Another important fact is that the development of body functions starts early during embryogenesis (Tzschentke 2007). Environmental input is necessary for early consolidation and maturation of body functions, so that finally, environmental stimulation could improve these processes ('training effect', Nichelmann and Tzschentke, 2002). Obviously, the last days of incubation are optimal for application of thermal manipulation with long-lasting implications. In this period the thermoregulatory system and related adaptive systems are well developed (Tzschentke 2007) so that side effects by temperature manipulations will be not expected.

In our previous study in broiler chicks we showed that short-term warm stimulation (prenatal „temperature training") during the last days of incubation prior to hatching improves hatchability and post-hatching performance until age of slaughter (Tzschentke and Halle, 2009). In this study, the mean daily feed intake of the male broilers, for instance, was higher from the first day on in comparison to the control group. Finally, compared with the control the short-term warm stimulated male chicks reached a 2.9% higher final body weight at slaughter. The feed conversion of the short-term temperature stimulated male but also female broilers was statistically better in comparison to the non-stimulated group. But also short-term cold-stimulation might have a positive effect on the later development in poultry. Short-term cold load during late embryogenesis significantly reduced the ascites development rate in broiler chicks by 26% without negative effects on poultry farming parameters. (Shinder et al., 2011).

So far, different incubation programs for poultry do not include such daily variations of incubation temperature, especially during final incubation, which might stimulate the development of different body functions and may increase the robustness (overall adaptability of the animals to stress factors, e.g. environmental changes, social factors). Modern poultry production requires robust birds that grow uniformly and efficiently (see also Boerjan, 2010). Efficient birds are resistant to stressful conditions. These birds use only small amounts of nutrients for the maintenance of basic physiological functions, e.g. controlling of body temperature. Finally, more feed energy is available for performance.

Therefore, the following study was carried out to investigate our hypothesis that short-term variation in incubation temperature during the last days of incubation can improve hatching results and have long-lasting effect on performance, also in Pekin ducks. The aim of the study was to make a complex investigation of the influence of a mild short term change in incubation temperature at the end of incubation (Day 23 up to hatching) on hatchability; secondary sex ratio, and quality of the hatched ducklings, as well as performance of a large sample of males and

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females of a high yielding duck breed until age of slaughter. In this regard our main objective was to find out if thermal manipulation during the end of incubation has a different influence on performance until slaughter age in male and female Pekin ducks.

Materials and methods

In 3 incubation trials a total of 1730 eggs of the Pekin duck strain were incubated from Days 1 up to 22 under normal incubation temperature (37.6°C). Usual cooling for duck eggs was carried out 10 min every 12 hours for days 7–14 and 20 min every 12 hours from day 14 on. Thereby all trays was pulled out (room environmental temperature of 20°C) and water spayed over the eggs. For this incubation period in each trial one incubator with 15 trays for a maximum of 110 eggs was used. In all trials, from Day 23 up to hatching (Day 28) the eggs were sorted in two hatch incubators with different temperature programs. The temperature was always 37.0–37.2°C (control) in one hatch incubator. In the second hatch incubator, the temperature was increased by 1°C over standard (38.0–38.2°C) (short-term warm stimulation; Trial 1) and reduced by 1°C below standard (36.0–36.2°C) (short-term cold stimulation; Trials 2 and 3) for 2 hours daily.

In the Incubation Trials 2 and 3, a random sampling of ducklings was analysed by the Pasgar©score (vitality, navel, legs, beak, and belly). The highest duckling quality has a score of 10 and one point is subtracted for each abnormality recorded in one of the above-mentioned five criteria (www.pasreform.com). In Trial 3, the one-day-old ducklings were also sorted by sex.

The 1-day-old ducklings from the three trials were used for a subsequent growing trial. In the Growing Trials 1 and 2, a total of 192 unsexed ducklings from every hatch incubator were randomly distributed in treatments with 6 ducks per pen and 16 pens per group. In Growing Trial 3, a total of 36 male and 36 female ducklings from each incubator were randomly distributed in treatments with 6 ducks per pen and 12 pens (6 male, 6 female) per group (1-Control, 2-short-term cold stimulated). The duration of the growing trials was 49 days. Ducks were kept according to the temperature-regime (Day 1: 30–32°C, 5: 24°C, 9: 20°C, 14: 15°C, up day 15 to day 49: 14°C) and to the light-regime (Days 1–7: 24 h, 8–14: 20 h, 15–49: 14 h light) of ducks. Pelleted feed (Table 1) and water were provided for *ad libitum* consumption. In the Growing Trial 1 ducks were fed with one unchanged diet (Day 1–49), in Trial 2 and 3 ducks were fed with a starter diet (Day 1–21) and then with a fattening diet (Day 22–49). Body weight was recorded for each duck individually at Days 1, 21 and 49 of age. Feed was weighed back weekly on a pen-basis. In the Growing Trial 3 one bird per pen, representing the mean body weight of ducks of this pen, was slaughtered at the end of the trial (6 male/6 female per group) to determine carcass composition. Weights of total breast meat (without skin), breast skin, complete right leg, liver, heart, gizzard, spleen and sum of abdominal and visceral fat were individually recorded. All parts were expressed as percentage of body weight. Breast meat of slaughtered ducks was analyzed with Near Infrared Transmission Spectroscopy. That is a rapid method for evaluation of intramuscular fat and moisture content in Pekin ducks (Köhler et al., 1995). The content of crude protein of breast meat was calculated.

Data from growing trials were analysed according to the one-way design of analysis of variance (GLM procedure): $y_i = \mu + a_i + e_i$ y_i = performance parameters of ducks, μ = mean, a_i = hatch incubator (temperature regime), e_i = error term. Means were compared by Student-Newman-Keuls Test ($P \leq 0.05$). All statistics were carried out using SAS operating system, Version 9.1 (SAS Institute Inc., 2002/03).

Table 1. Ingredient composition and analysed and calculated nutrients of the diets – Trial 1–3
Zusammensetzung der Futtermischungen und kalkulierte und analysierte Inhaltsstoffe – Versuch 1–3

Trial	1	2 and 3	
Age of days	1–49	1–21	22–49
Wheat, g/kg	150.0	150.0	400.0
Corn, g/kg	480.8	480.8	316.3
Soya bean meal, g/kg	299.8	299.8	212.8
Soya oil, g/kg	24.9	24.9	29.4
Di-calcium-phosphate, g/kg	19.6	19.6	17.6
Calcium carbonate, g/kg	7.7	7.7	6.7
Sodium chloride, g/kg	3.4	3.4	3.5
DL-methionine, g/kg	2.0	2.0	2.1
L-lysine-HCl, g/kg	1.6	1.6	1.6
Threonine, g/kg	0.2	0.2	–
Premix[1], g/kg	10.0	10.0	10
Dry matter[2], g/kg	893	889/877[4]	883/881[4]
Crude protein[2], g/kg	202	183/174	158/162
ME, MJ/kg[3]	12.0	12.3/12.0	12.5/12.2
Lysine[3], g/kg	11.5	11.5	9.6
Methionine + Cystine[3], g/kg	8.5	8.5	8.0

[1] Vitamin-mineral premix provided per kg of diet: Fe, 32 mg; Cu, 12 mg; Zn, 80 mg; Mn, 100 mg; Se, 0.4 mg; I, 1.6 mg; Co, 0.64 mg; Vitamin A, 12000 IE; Vitamin D_3, 3500 IE; Vitamin E, 40 mg; menadion, 4.5 mg; thiamine, 2.5 mg; riboflavin, 8 mg; pyridoxine, 6 mg; cobalamin, 32 µg; nicotinic acid, 45 mg; pantothenic acid, 15 mg; folic acid, 1.2 mg; biotin, 50 µg; choline chloride, 550 mg
[2] Analysed values [3] Calculated values (WPSA, 1985) [4] Trial 2/Trial 3

Results

The results of the Incubation Trial 1 (Table 2) showed that short-term warm stimulation (6 days, daily 2 h, +1°C) reduced the percentage of hatched ducklings from 86.6% in the control group to 83.7% in the short-term warm stimulation group. In contrast, the short-term cold stimulation (6 days, daily 2 h, −1°C) did not change the hatching results. Furthermore, it could be seen in the hatching from the short-term cold stimulated group (Incubation Trial 3) that the ratio of hatched female to male ducklings shifted in favour of the female ducks. The factor to evaluate the vitality of the hatched ducklings (Pasgar©score) was above 9.7 in the control group and 9.0 in the short-term cold stimulated group in Trial 2, equally good for female and male ducklings and not affected by temperature treatment in the Incubation Trial 3.

During the 1st and the 2nd Growing Trial two ducks died in the first group and three or four ducks, respectively, died in the second group. None of the ducks died in Growing Trial 3.

In Growing Trial 1 (Table 3), feed intake of the ducks from the short-term warm stimulated group was significantly lower during the first three weeks (Days 1–21) than for the ducks of the control group. As a result, the ducks in the control group reached a daily body weight gain of 61.4 ± 2.0 g and a body weight of 1349 ± 111 g at day 21, which was statistically significantly higher than for the short-term warm stimulated group (59.8 ± 2.2 and 1316 ± 117, respectively). The final body weight was similar between the two groups at the end of the growing period (3541 ± 299/3516 ± 333 g per duck).

In Growing Trial 2 (Table 4), feed intake of the ducks from the short-term cold stimulated group was slightly higher compared to the control during the first growing period (Days 1–12). The outcome of this was a significantly higher body weight gain in the first three weeks and a 2% higher body weight at day 21. The feed to gain ratio was similar between the control and treated group in the first three weeks and also over the total growing period.

In Growing Trial 3 (Table 5), feed intake was different between control and treatment as well as between male and female ducks. The highest feed intake was found in male ducks from control group and female birds from short-term cold stimulated group in the first three weeks as well as in the mean overall trial duration. The male ducklings of the short-term cold stimulated group had the significantly highest body weight at the day of hatch. The daily body weight gain of 75.9 ± 1.4/77.1 ± 2.3 g (control/short-term cold stimulated group) was significantly higher in males of both groups than in females (69.3 ± 1.9/70.8 ± 2.2 g). Similar results were found regarding the final body weight (males 3773 ± 228/3832 ± 393 g; females 3449 ± 297/3526 ± 298 g). In females the daily body weight gain and finally the body weight could be improved by short-term cold stimulation. But only in the first growing period from Day 1 up to Day 21 was it significant. The feed to gain ratio of the male ducks from the short-term cold stimulated group was significantly improved in comparison to the females of the same group, as well as the male and female animals of the control group.

Slaughtering of six male and female ducks after the 49th day of life (Table 6) showed statistical differences within sexes in the gizzard. Male ducks of control group showed a higher heart weight than the females from the short-term cold stimulated group. The weight and the percentage of abdominal and visceral fat were significantly higher in female ducks from short-term cold stimulated group compared to the males of the same group.

Analysing the nutrients in the fresh breast matter (Table 7) resulted in a significantly reduced water content in female ducks from the short-term cold stimulated group and the highest crude fat and crude protein content in these animals. The male and the female ducks from the short-term cold stimulated group reached significantly higher crude protein content in the breast meat compared to ducks of same sex from the control group.

Discussion

Short-term warm stimulation reduced the hatching rate but also the post-hatching performance, especially in the first growing period (Days 1–21). Feed intake, body weight gain up to Day 21 and, finally, the body weight at Day 21 were statistically significantly reduced. During the final growing phase up to age of slaughter (Day 49) no statistically significant differences in performance parameters were observed between the control and short-term warm stimulated group. It could be a sign that short-term mild warm incubation in Pekin ducks at the end of incubation has no long-lasting effect on physiology and performance or that

Table 2. Results of incubation Trials 1–3 (Trial 1 – unfertilised eggs = 5.1%, two times to candle eggs – 29 embryos died; Trial 2 – unfertilised eggs = 10.9%, two times to candle eggs – 42 embryos died; Trial 3 – 32 unfertilised eggs = 5.4%, two times to candle eggs – 15 embryos died)
Ergebnisse der Brutversuche – 1–3

Trial	Incubated eggs			Hatch incubator, number of eggs		Hatched living ducklings, %		Pasgar©score	
	N	Fertile eggs	Egg weight	Control N	6 days, 2 h, +1°C[1)] 6 days, 2 h, −1°C[2)] N	Control	6 days, 2 h, +1°C[1)] 6 days, 2 h, −1°C[2)]	Control	6 days, 2 h, +1°C[1)] 6 days, 2 h, −1°C[2)]
		%	g			Male/female	Male/female	Male/female	Male/female
1	570	94.9	90.8	254	258	86.6	83.7	–	–
2	570	89.1	88.6	233	233	85.4	86.3	9.7	9.0
3	590	94.6	91.2	272	271	88.2 53.3/46.7	88.2 50.2/49.8	10/10	10/9.9

[1)] Trial 1: 1 – Control, 2 – short-term warm stimulated (6 days, 2 h, +1°C) [2)] Trial 2: 1 – Control, 2 – short-term cold stimulated (6 days, 2 h, −1°C) and Trial 3: 1 – Control, 2 – short-term cold stimulated (6 days, 2 h, −1°C)

Table 3. Performance features of ducks (n = 192/group) – Trial 1 (Mean, SD)
Leistungsmerkmale der Enten (n = 192/Gruppe) – Versuch 1 (Mittelwerte, SD)

Treatments Age, days	1[1)]	2[1)]
Feed intake, g/duck/day		
1–21	98.2 a ± 4.6	95.3 b ± 4.1
22–49	240 ± 12.4	239 ± 14.4
1–49	179 ± 8.4	177 ± 9.4
Body weight gain, g/duck/day		
1–21	61.4 a ± 2.0	59.8 b ± 2.2
22–49	78.3 ± 4.3	79.1 ± 4.0
1–49	71.1 ± 2.8	70.8 ± 2.9
Feed to gain ratio, kg/kg		
1–21	1.60 ± 0.05	1.59 ± 0.04
22–49	3.07 ± 0.17	3.02 ± 0.17
1–49	2.53 ± 0.11	2.50 ± 0.12
Body weight, g/duck		
1	59 ± 2	60 ± 2
21	1349 a ± 111	1316 b ± 117
49	3541 ± 299	3516 ± 333

a; b; – Means with different letters differ significantly within rows
[1)] 1 – Control, 2 – short-term warm stimulated (6 days, 2 h, +1°C)

Table 4. Performance features of ducks (n = 192/group) – Trial 2 (Mean, SD)
Leistungsmerkmale der Enten (n = 192/Gruppe) – Versuch 2 (Mittelwerte, SD)

Treatments Age, days	1[1)]	2[1)]
Feed intake, g/duck/day		
1–21	101 ± 4.5	103 ± 4.6
22–49	252 ± 18.3	252 ± 15.7
1–49	187 ± 9.8	188 ± 10.2
Body weight gain, g/duck/day		
1–21	65.7 b ± 2.6	67.1 a ± 2.6
22–49	78.5 ± 3.9	79.9 ± 4.0
1–49	73.0 ± 2.7	74.4 ± 3.0
Feed to gain ratio, kg/kg		
1–21	1.54 ± 0.05	1.53 ± 0.05
22–49	3.19 ± 0.26	3.16 ± 0.14
1–49	2.58 ± 0.18	2.53 ± 0.08
Body weight, g/duck		
1	54 ± 2	55 ± 2
21	1380 b ± 122	1408 a ± 114
49	3586 ± 293	3647 ± 328

a; b; – Means with different letters differ significantly within rows
[1)] 1 – Control, 2 – short-term cold stimulated (6 days, 2 h, –1°C)

Table 5. Performance features of ducks (n = 72/group/sex) – Trial 3 (Mean, SD)
Leistungsmerkmale der Enten (n = 72/Gruppe/Geschlecht) – Versuch 3 (Mittelwerte, SD)

Treatments Age, days	1[1)]		2[1)]	
	Male ducks	Female ducks	Male ducks	Female ducks
Feed intake, g/duck/day				
1–21	111 a ± 3.0	103 c ± 1.8	105 bc ± 3.4	109 ab ± 5.2
22–49	262 ± 10.4	244 ± 11.1	242 ± 12.6	259 ± 17.2
1–49	197 a ± 6.8	183 b ± 6.4	183 b ± 6.9	195 ab ± 11.7
Body weight gain, g/duck/day				
1–21	68.8 a ± 1.8	63.3 b ± 1.5	67.6 a ± 2.0	66.3 a ± 3.1
22–49	81.3 a ± 2.7	73.7 b ± 3.9	84.2 a ± 4.5	74.2 b ± 2.8
1–49	75.9 a ± 1.4	69.3 b ± 1.9	77.1 a ± 2.3	70.8 b ± 2.2
Feed to gain ratio, kg/kg				
1–21	1.61 a ± 0.04	1.62 a ± 0.04	1.55 b ± 0.02	1.64 a ± 0.02
22–49	3.23 a ± 0.20	3.32 a ± 0.18	2.88 b ± 0.15	3.49 a ± 0.19
1–49	2.60 b ± 0.11	2.65 ab ± 0.08	2.38 c ± 0.09	2.74 a ± 0.10
Body weight, g/duck				
1	54 b ± 2	55 b ± 2	58 a ± 3	56 b ± 2
21	1498 a ± 131	1386 b ± 111	1476 a ± 108	1448 a ± 152
49	3773 a ± 228	3449 b ± 297	3832 a ± 393	3526 b ± 298

a; b; c; – Means with different letters differ significantly within rows
[1)] 1 – Control, 2 – short-term cold stimulated (6 days, 2 h, –1°C)

Table 6. Carcass (% of body weight), carcass composition (% of carcass weight) and muscle and organ weight (g) of ducks (n = 6/group/sex) – Trial 3 (Mean, SD)
Schlachtkörper (% der Lebendmasse), Schlachtkörperzusammensetzung (% des Schlachtkörpers) und Muskel- und Organmasse (g) der Enten (n = 6/Gruppe/Geschlecht) – Versuch 3 (Mittelwerte, SD)

Treatments	1[1)]		2[1)]	
	Male ducks	Female ducks	Male ducks	Female ducks
Carcass, %	67.6 ± 0.9	69.0 ± 1.6	68.3 ± 1.4	68.9 ± 1.6
Breast skin, %	5.4 ± 0.9	6.3 ± 1.8	5.7 ± 1.3	7.3 ± 1.0
Breast meat, g	401 ± 33	369 ± 102	384 ± 59	380 ± 48
Breast meat, %	15.6 ± 1.0	15.2 ± 3.7	14.7 ± 1.6	15.3 ± 2.0
Legs, g	487 ± 30	473 ± 30	483 ± 23	463 ± 20
Legs, %	19.0 ± 1.7	19.6 ± 0.8	19.3 ± 0.8	18.6 ± 0.9
Liver, g	67.5 ± 4.5	66.3 ± 3.9	73.8 ± 12.1	71,2 ± 5.0
Heart, g	21.4 a ± 2.0	20.1 ab ± 0.5	19.5 ab ± 2.2	18.5 b ± 1.2
Gizzard, g	129 a ± 6.4	94.7 c ± 14.9	115 b ± 8.9	99.2 c ± 9.7
Spleen, g	2.7 ± 1.1	2.5 ± 0.6	2.8 ± 0.6	2.0 ± 0.6
Fat, g	41.3 ab ± 13.1	44.4 ab ± 13.9	34.7 b ± 6.3	54.2 a ± 12.0
Fat, %	1.6 ab ± 0.4	1.8 ab ± 0.5	1.4 b ± 0.3	2.2 a ± 0.4

a; b; – Means with different letters differ significantly within rows
[1)] 1 – Control, 2 – short-term cold stimulated (6 days, 2 h, –1°C)

Table 7. Content of water, protein and fat in the fresh matter of the breast meat – Trial 3 (%, n = 6/group/sex) (Mean, SD)
Gehalt an Wasser, Protein und Fett in der Frischsubstanz des Brustfleisches – Versuch 3 (%, n = 6/Gruppe/Geschlecht) (Mittelwerte, SD)

Treatments	1[1)]		2[1)]	
	Male ducks	Female ducks	Male ducks	Female ducks
Water	76.9 a ± 0.6	76.6 a ± 0.3	76.0 a ± 0.9	75.1 b ± 0.7
Crude fat	1.2 ab ± 0.3	1.0 b ± 0.0	1.3 ab ± 0.2	1.5 a ± 0.2
Crude Protein	21.9 c ± 0.4	22.4 bc ± 0.3	22.7 ab ± 0.8	23.3 a ± 0.6

a; b; c; – Means with different letters differ significantly within rows
[1)] 1 – Control, 2 – short-term cold stimulated (6 days, 2 h, –1°C)

the prenatally induced changes were masked by cross adaptation induced by the actual environmental conditions (Janke and Tzschentke, 2010). In our previous experiments on chronic and short-term mild warm stimulation in broiler chicks, we found a reduction in feed intake and final body weight after chronic warm incubation (1°C over standard, continuously during the last 4 days of incubation) and under warm growing conditions (continuously 32°C) only (Halle and Tzschentke, 2011). Further, this result was exclusively found in male broiler chicks. Our interpretation was that a significantly lower food intake leads to a decrease in body heat production, which finally minimizes the thermal strain of these birds and could be a sign of improved heat adaptation. However, chronic warm incubation did not influence production parameters under the normal growing regime. Furthermore, a short-term warm stimulation (1°C over standard for 2 h daily) improved performance parameters up to slaughter age and this exclusively in male chicks. The opposite result was found in the current study in Pekin ducks. In comparison with galliform species, anseriform species, like the Pekin duck, are characterized by a higher precocial status (McNabb and Olson, 1996). Muscovy duck hatchlings, for instance, have a higher heat production capacity under cold load than chicks of a similar age, which enables the ducklings to already stabilise their body temperature in a narrow temperature range on the 1st post-hatching day (Tzschentke and Nichelmann, 1999). Also the early development of central nervous thermoregulatory mechanisms is different between ducks and chickens. Qualitative changes in the neuronal hypothalamic thermosensitivity from the „juvenile“ to the „adult“ type, for instance, occurred in Muscovy ducks around Day 10 (Tzschentke and Basta, 2000) and in chickens around Day 30 of post-hatching (Sallagundala et al., 2006). It is not to be assumed that such developmental differences occur only after hatching. In late-term Muscovy duck embryos, for instance, the neuronal hypothalamic thermosensitivity is not different from that after hatching (Tzschentke, 2007). However, extensive comparative studies on embryonic development of physiological systems of chicks and ducks are rare. Finally, we can only assume that in late-term Pekin duck embryos, an increase in incubation temperature of 1°C over 2 h per day could be a heat stress because of their higher precocial level.

On the other hand chicken and duck embryos show different development of warm or cold defence mechanisms. Bird embryos increase heat loss with an increase in the blood flow of the chorioallantoic vessels, when the incubation temperature is increasing, and save heat by decrease in the blood flow, when the incubation temperature is decreasing (Tzschentke, 2007). In chicken embryos such adaptive reactions were found after Day 19 of incubation when incubation temperature was increasing or decreas-

ing from the normal level. In younger embryos, cooling or warming induced non-adaptive (paradoxical) reactions (increase and decrease in blood flow independent of the applied temperature change). In Muscovy duck embryos an adaptive reaction was only found after cooling from Day 31 up to hatching. Warming induced paradoxical reactions during the whole incubation time. Similar results were found after short-term cooling or warming when neuronal mechanisms were analysed. Expression of nitric oxide synthase, which also acts as a mediator in the neuronal network controlling body temperature (e.g., COLEONE et al., 2009), was stimulated exclusively by short-term cold-stimulation from Day 20 up to hatching (TZSCHENTKE and DUNAI, 2011). But short-term temperature stimulation during the same time window induced paradoxical reactions up to Day 33 of incubation. These examples show that possibly short-term cold experiences might preferentially stimulate physiological mechanisms in ducks.

A common practice in duck incubation is to cool and/or to spray with water duck eggs during incubation periodically. One idea behind this is to simulate natural incubation, which improves hatchability in ducks (NARAHARI et al., 1991; HARUN et al., 2001). The impact on the embryo's physiology is still little investigated. In practice a high variation of cooling methods is used. Generally, first cooling starts after 5–7 days of incubation and finished before the hatching period starts. In our incubation trials this common practice was also used (see Method). The goal of prenatal temperature stimulation, which we used in this study, obviously is different to this common cooling method. In the actual study short-term cold stimulation was applied during the last days of incubation until the ducks hatched. With this method we will train the well-developed body functions during their critical developmental period, which have long-lasting effects on post-hatching performance and possibly the robustness in poultry.

In our study short-term cold load shows a stimulating effect on performance of Pekin Hatchability was not negatively influenced. Interestingly, the secondary sex ratio was changed in favour of female ducklings, but the male one-day-old ducklings had a significantly higher body weight compared to the male ducklings of the control group. In our previous study in broiler chicks after short-term warm load (1°C over standard for 2 h daily) the secondary sex-ratio shifted in favour of male chickens (TZSCHENTKE and HALLE, 2009), but the body weight of the one-day-old male chicks was not different between the control group and the short-term temperature stimulated group. However, to answer the question why short-term temperature stimulation has a significant impact on secondary sex-ratio during final incubation needs further investigation. Similar to the results from the study in warm stimulated broiler chicks (TZSCHENTKE and HALLE, 2009), in Pekin ducks short-term cold temperature stimulation during the last days of incubation improved performance parameters up to the age of slaughter. The main difference between the investigated species was that this stimulation was achieved in ducks by a 1°C decrease and in broiler chicks by a 1°C increase in incubation temperature from the normal level. Parameters like feed intake, body weight gain, body weight and feed to gain ratio were improved and this improvement was sex-specific. In Growing Trial 2 (without sex sorting) short-term cold stimulation had no influence on feed intake. But, in Growing Trial 3 (with sex sorting) it could be demonstrated that short-term cold stimulation had an opposing influence on feed intake in male and female ducks; in male ducks feed intake was decreased and in female ducks increased, especially in the first growing period (Day 1–21). Body weight gain in the same growing period and body weight on Day 21 were statistically significantly higher in the short-term cold stimulated group in Growing Trial 2. Similar results were obtained in Growing Trial 3, but the statistically significant increase in both parameters was found exclusively in female ducks. On the other hand, short-term cold stimulation improved feed to gain ratio during the whole growing period exclusively in male ducks. An influence of embryonic short-term temperature manipulation in muscle development (improved satellite cell proliferation and differentiation) was described in galliforme species after short-term heat load during different developmental periods (early incubation stages, MALTBY et al., 2004; late-term embryos between Days 16 and 18 of incubation, HALEVY et al., 2006a, b).

It is not to be excluded, that also short-term cold experience might induce stimulation in muscle development with long-lasting effects on body weight development. However, an influence of embryonic short-term cold stimulation on feed intake and feed to gain ratio could also be caused by long-lasting changes in the regulatory properties of the hypothalamic neuronal mechanisms involved in regulation of metabolism and/or molecular mechanisms of the peripheral metabolism. In Muscovy ducklings, for instance, such changes in the cold induced metabolism were found exclusively after cold-experience (DUCHAMP et al., 1992; TOYOMIZU et al., 2002; TEULIER et al., 2010).

Additionally, nutrient composition of breast meat was influenced by prenatal short-term cold load. Especially the crude protein content in the breast meat was improved and this in both sexes. Parallel to the protein content, the fat content in the breast meat was influenced. The higher fat storage could also be obtained in the proportion in breast skin. The economically most important criterion is the breast muscle yield which was high and comparable with other studies on growing Pekin ducks (TIMMLER and JEROCH, 1999; BONS, 2000; BONS et al., 2002) but not significantly different between sexes and groups.

In conclusion, an incubation temperature profile including short-term temperature stimulation during the last days of embryonic development can be of high relevance for improving poultry performance including meat quality. Obviously each poultry species (breed and line) needs specific „temperature training" programs, which should be based on basic physiological research. While in broiler chicks warm stimulation (TZSCHENTKE and HALLE, 2009) improved performance, in Pekin ducks cold stimulation was the preferred method with long-lasting effects. Moreover, this manipulation induces specific effects in female and male poultry. It has to be note, that the used cold-stimulation in this study is different to this common cooling method, which was also applied during an earlier stage of incubation. In the actual study short-term cold stimulation was used during the last days of incubation until the ducks hatched. With this method we will train the well-developed body functions during their critical developmental period, which have long-lasting effects on post-hatching performance and possibly the robustness in poultry.

Summary

In three incubation trials and three growing trials the influence of temperature manipulation at the end of incubation on hatching results and performance in Pekin ducks was investigated for 49 days. A total of 1730 eggs (Pekin duck) were incubated from Days 1 to 22 under normal incubation conditions (37.6°C) and then sorted into two hatch incubators (37.0–37.2°C: control; 38.0–38.2°C, 2 hours daily: short-term warm stimulation – Trial 1; 36.0–36.2°C, 2 hours daily:

short-term cold stimulation – Trial 2 and 3). In Trial 3, 1-day old ducklings were selected by sex. In Trial 2 and 3 duckling quality was analysed in a random sample using the Pasgar©score. In growth Trial 1 and 2, a total of 192 unsexed ducks from each incubator and in Trial 3, 36 male and 36 female ducks from each incubator, were used for a 49-d fattening period.

The short-term warm stimulation reduced the percentage of hatched ducklings. The short-term cold stimulation did not change the hatching results. Further, under these incubation conditions the ratio of hatched female to male ducks shifted in favour of the female ducks. In the control group and the short-term cold stimulated group the Pasgar©score was between 9 and 10. In the first subsequent duck growth trial, the mean daily feed intake and weight gain for the short-term warm stimulated ducks was statistically lower than for the control group in the first three weeks. In Growing Trial 2 (without sex sorting) short-term cold stimulation had no influence on feed intake. But, in Growing Trial 3 (with sex sorting), it could be demonstrated that short-term cold stimulation had an opposing influence on feed intake in male and female ducks; in male ducks feed intake was decreased and in female ducks increased, especially in the first growing period (Day 1–21). Body weight gain in the same growing period and body weight on Day 21 were statistically significantly higher in the short-term cold stimulated group in Growing Trial 2. Similar results were obtained in Growing Trial 3, but the statistically significant increase in both parameters was exclusively found in female ducks. On the other hand, short-term cold stimulation improved feed to gain ratio during the whole growing period exclusively in male ducks. The male and the female ducks from short-term stimulated group reached statistically higher crude protein content in the breast meat compared to ducks of same sex from the control group at the end of the trial.

Key words

Pekin duck, incubation temperature, hatchability, duckling quality, feed intake, daily weight gain, crude protein

Zusammenfassung

Einfluss einer Temperaturstimulierung während der letzten 6 Bruttage auf das Schlupfergebnis und die spätere Entwicklung von Pekingenten

In drei Brut- und drei Wachstumsversuchen wurde der Einfluss einer Änderung der Bruttemperatur am Ende der Brut auf das Schlupfergebnis und die Entwicklung von Pekingenten untersucht. Dazu wurden insgesamt 1730 Bruteier (Pekingente) vom 1. bis 22. Tag unter normalen Brutbedingungen (37,6^{0}C) gebrütet und dann in zwei Schlupfbrüter (37,0–37,2°C: Kontrolle; 38,0–38,2°C für 2 täglich Stunden: Kurzzeitige Wärmestimulierung – Versuch 1 oder 36,0–36,2°C für 2 täglich Stunden: Kurzzeitige Kältestimulierung – Versuch 2 und 3) aufgeteilt. Im Versuch 3 wurden die frisch geschlüpften Entenküken geschlechtssortiert. Im Versuch 2 und 3 wurde die Vitalität der Entenküken mittels des Pasgar©score ermittelt. In den Wachstumsversuchen 1 und 2 wurden insgesamt 192 unsortierte Entenküken und in Versuch 3 je 36 männliche und 36 weibliche Enten aus jedem Schlupfbrüter über einen Zeitraum von 49 Tagen gemästet.

Die kurzzeitige Wärmestimulierung reduzierte den Anteil an geschlüpften Entenküken. Die kurzzeitige Kältestimulierung veränderte nicht das Schlupfergebnis. Unter diesen Brutbedingungen verschob sich das Verhältnis weiblicher zu männlichen Enten zu Gunsten der weiblichen Tiere. In der Kontrollgruppe und der Gruppe mit kurzzeitiger Kältestimulierung lag der Pasgar©score zwischen 9 und 10. Im sich anschließenden ersten Wachstumsversuch waren die mittlere tägliche Futteraufnahme und die Lebendmassezunahme der Gruppe mit kurzzeitiger Wärmestimulierung signifikant niedriger als die der Kontrolle in den ersten 3 Lebenswochen. Im zweiten Wachstumsversuch (nicht geschlechtssortiert) wurde die mittlere tägliche Futteraufnahme durch Kältestimulation nicht statistisch signifikant beeinflusst. Im dritten Wachstumsversuch (mit Geschlechtssortierung) hatte die kurzzeitige Kältestimulation einen unterschiedlichen Einfluss auf die Futteraufnahme männlicher und weiblicher Tiere: bei männlichen Enten wurde sie verringert und bei weiblichen Enten erhöht. Im zweiten Wachstumsversuch führte die Kältestimulation zu einer statistisch gesicherten erhöhten Wachstumsrate (Tag 1–21) und Körpermasse am 21. Lebenstag. Aus dem 3. Wachstumsversuch geht hervor and dass diese Verbesserung ausschließlich für weibliche Tiere zutraf. Andererseits verwerteten die kurzzeitig kältestimulierten männlichen Enten das aufgenommene Futter statistisch gesichert besser als die männlichen und weiblichen Enten der anderen Gruppen. Die kurzzeitige Kältestimulierung im Schlupfbrüter führte zu einem statistisch gesicherten höheren Proteingehalt im Brustfleisch bei den Enten beider Geschlechter im Vergleich zu den Enten der Kontrollgruppe gleichen Geschlechts.

Stichworte

Pekingente, Bruttemperatur, Schlupf, Entenkükenqualität, Futteraufnahme, tägliche Lebendmassezunahme, Rohprotein

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