The effect of magnetic field on hatchability of Japanese quail eggs

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ABSTRACT: The effect of environmental conditions on hatching indices of poultry eggs is sufficiently important that new methods for their improvement are sought, among others through exposing the eggs during hatching to an artificially generated magnetic field of variable frequency. Hatching eggs in this study came from Pharaoh quail in the 4th month of laying. The flock was kept under optimum microclimate conditions and fed a complete feed mix containing 21% total protein and 11.7 MJ ME. The eggs (n = 150), after weighing, were divided into 3 groups equal in respect of numbers: control (I) and two experimental (II and III). The eggs of group II and III were exposed to the action of variable magnetic field of the same intensity but different times of application. The highest percentage of dead embryos during incubation in relation to fertilised eggs was found in control group (11.36%), while the smallest was from group II (4.17%). The highest value of hatching indices calculated in relation to fertilised eggs was found in group II (91.6%), while the smallest was in group III (83.7%) with 86.3% in control group. The results point to the possibility of increasing egg hatchability indices through the use of additional variable magnetic field. The chicks hatched from eggs exposed to the action of this experimental agent had similar body weight. The average weight of one-day-old chicks ranged from 7.82 g (group II) to 8.05 g (group III). In the last week of rearing, mean body weight in both sexes was similar and ranged from 168 (group I) to 172 g (group III) in males, and from 186 g (group I) to 199 g (group III) in females; these differences were not statistically significant. The females of group III reached sexual maturity at 41 days, this being one and three days (non-significantly) earlier than birds in group I and II.

Keywords: Japanese quail; egg; hatchability; magnetic field

Living organisms are continually submitted to environmental impacts and they in turn exert an influence on the environment surrounding them, creating thus a functional biological unity. The knowledge of these animal-environment relationships has been the basis for developing modern methods of keeping animals, with the influence of environmental conditions being modified by humans in the case of livestock. In recent years, some attention in scientific research has been paid to the effect of electromagnetic and magnetic fields on living organisms from the aspect of using them in health issues and for improvement of physiological indices, and maybe production ones as well (Janowski et al., 1996; Niedziółka and Janowski, 1996b; Tombarkiewicz, 1996; Głogowski, 1999; Veterany and Hluchy, 2001; Toman et al., 2002). The processes related to reproduction are among the most important spheres on which investigations should be focused. Observations on the impact of magnetic field on embryogenesis in poultry are of great interest as it takes place outside the native organism.

The effect of environmental conditions on hatching indices of poultry eggs is sufficiently important that new methods for their improvement are sought through exposing the eggs during hatching, among others, to biological and chemical preparations as well as to X rays (Borzemska et al., 1995; Gawęcka, 1995; Pudynowska et al., 1998). Attempts have also been made to stimulate embryonic development with the aid of the colour of light (Chełmońska et al., 2000) and sound and ultrasound (Veterany et al., 1998, 2000). The effect of artificially generated electromagnetic field of low frequency on chick embryos was examined, among others, by Berman (1990), Bednarczyk et al. (1993), Niedziółka and Janowski (1996a,b), Niedziółka and Lis (1998), and Lis (2000). The results of such studies are ambiguous and recurrently controversial mainly because different induction frequencies and intensities as well as different times of exposure to the effect of these fields were used. Studies have also been conducted on the effect of magnetic and electromagnetic fields on seeds and plants. The effects of these studies also point to difficulties to establish clearly the influence of these fields on plants, in particular with large differences in applied doses (Drobig, 1988; Pietruszewski, 1995).

In the light of the above, it seemed purposeful to undertake a study on the effect of variable magnetic field on hatching indices of quail eggs.

MATERIAL AND METHODS

The experiment was conducted at the Department of Poultry and Breeding of the Agricultural University in Szczecin. The study involved 150 eggs from the breeding stock of Japanese quails, variety of Pharaoh, in the 4^{th} month of laying. The stock was kept under optimum microclimate conditions and a light regime of 17 hours of light and 7 hours of dark (17L:7D). The feeding was based on a complete feed mix containing 21% total protein and 11.7 MJ ME designed for adult birds at this stage of life (Feeding Norms for Poultry, 1996).

The eggs for hatching were collected over a period of 7 days, sorted by selecting those weighing 11.0–12.5 g and stored in a blackened store-room at 16°C and 65% relative humidity. Before setting the eggs into incubator, they were divided into three groups: control (I) and experimental (II and III). Egg incubation was carried out in a cabinet-type apparatus according to the technique specific to this poultry species. During incubation, egg weight was measured on days 3, 5, 7, 10, 12 and 14. On the same days, the eggs of group II and III were exposed to stimulation with a variable magnetic field for 12 minutes with the aid of Viofor JPS magnetostimulator by placing them in an applicator connected to the apparatus controller. The eggs of group II were exposed to the action of additional modulated magnetic field using programme M2, in which the magnetic field strength during application increased stepwise by 12 seconds from an induction value of 0.5 to 4 μT, then it rapidly decreased to 0.5 μT, the process being repeated cyclically until the end of exposure. In group III, programme M3 was used, in which magnetic induction increased over a period of two minutes from 0.5 to 4 μT, and for the next eight minutes it remained at the level of 4 μT, then during the next two minutes it decreased gradually to 0.5 μT. In both experimental groups, the action of ionic cyclotron resonance (programme P2) was used. The eggs of the control group were also removed from the incubator after 12 minutes.

After the incubation process was completed, biological analysis of hatching was done by calculating hatchability indices and the percentage of post-hatching losses. Healthy hatched chicks of each group were weighed individually and reared to the 6th week of life in the three groups, being a continuation of the experimental groups. During the rearing period, the quail were kept under controlled microclimate conditions, being fed in the respective growth stages with complete feed mixes of nutritive value conforming to Feeding Norms for Poultry (1996). During the growth period, weekly body weights of chicks were measured. Up to three weeks of age the mean body weight for both sexes was reported since it was difficult to determine the sex of the young birds (no sex-related differences in the plumage). However, from the fourth week of age, the males and females were weighed separately in each group, and the mean weight for both sexes was calculated.

The survivability of chicks was measured, and the time of reaching sexual maturity was established (the age at which 10% of the birds in the group started laying). The results were analysed statistically using one-factor analysis of variance and Duncan's test.

RESULTS AND DISCUSSION

The average egg weight before incubation was equalised in all groups and ranged from 11.19 g (group II) to 11.26 g (group III), being within the standard limits accepted for quail (Shanawany, 1994). Egg weight losses during the 14-day period in the hatcher (Table 1) were significantly higher in the control group (1.13 g, which accounts for 10.08% of the egg weight before setting) than in

Table 1. Egg weight losses during incubation ($\overline{x}$ ± SD)

Specification		Group		
		I	II	III
Egg weight before setting	(g)	11.21 ± 0.75	11.19 ± 0.64	11.26 ± 0.69
On incubation day 14	(g)	10.08 ± 0.80	10.28 ± 0.79	10.33 ± 0.81
Egg weight losses	(g)	1.13^a ± 0.14	0.91^b ± 0.12	0.93^b ± 0.12
	(%)	10.08^a ± 0.83	8.13^b ± 0.48	8.26^b ± 0.51
Daily losses	(g)	0.081^a ± 0.006	0.065^b ± 0.004	0.066^b ± 0.005
	(%)	0.72^a ± 0.24	0.58^b ± 0.15	0.59^b ± 0.17

^{a,b}means in the rows marked with different letters differ significantly($P \leq 0.05$)

experimental groups II and III, where weight losses were similar being 0.91 and 0.93 g, respectively. The highest daily losses were thus recorded in the control group (0.72%) and they were significantly greater than those noted in the experimental groups.

The daily losses in egg weight in this experiment were similar to the standard limits for hen eggs (0.60–0.70%). No equivalent standards for weight losses in quail eggs have been published until now.

The number of infertile eggs varied between treatments even though the eggs for each treatment were randomly chosen from the 150 eggs available. Most unfertilised eggs were found in group III (7 out of 50 eggs), being 14% of the eggs set for incubation, whereas in groups I and II the losses related to infertility were 2.0 and 10.0% less, respectively (Table 2). The proportion of infertile eggs is one of the indices that inform about the condition of the parental flock, but because this is unlikely to undergo modification during incubation, the objective assessment of the effect of additional magnetic field on hatching results should be made on the fertile eggs only. In this experiment, the fertilisation rate was over 30% higher than that obtained by Reddish et al. (1996) when mating quails of different age, as well as by several per cent higher than that given by Tarasewicz (1998) for studies on Pharaoh quails.

The highest percentage of dead embryos during incubation in relation to fertilised eggs (Table 2) was found in the control group (11.36%), with the lowest in group II (4.17%). The hatching losses, in the form of weak chicks, (Table 2) were highest in group III (9.3%), this being 4.76 and 5.13% higher than in groups I and II, respectively.

The highest value of hatching indices calculated in relation to fertilised eggs was found in group II (91.6%), while the lowest was in group III

Table 2. Fertilisation and hatchability indices

Specification		Group		
		I	II	III
Eggs				
– set	(n)	50.00	50.00	50.00
– unfertilised	(n)	6.00	2.00	7.00
	(%)	12.00	4.00	14.00
Fertilisation rate	(%)	88.00	96.00	86.00
Dead embryos	(n)	5.00	2.00	3.00
	(%)	11.36	4.17	6.98
Unhatched, crippled and weak chicks	(n)	2.00	2.00	4.00
	(%)	4.54	4.17	9.30
– healthy hatched	(n)	38.00	44.00	36.00
Hatchability from	(%)			
– fertilised eggs		86.30	91.60	83.70
– set eggs		76.50	88.00	72.00

Table 3. Body weight of quail (g) ($\bar{x}$ ± SD)

Age (in days)	Group		
	I	II	III
1	$7.88^a \pm 0.58$	$7.82^a \pm 0.70$	$8.05^a \pm 0.51$
7	$23.24^a \pm 3.12$	$25.44^b \pm 3.27$	$26.26^b \pm 3.09$
14	$57.55^a \pm 5.25$	$57.69^a \pm 5.48$	$61.96^b \pm 5.26$
21	$97.70^{ab} \pm 7.52$	$90.94^a \pm 8.78$	$101.44^b \pm 8.38$
28 males	$123.81^a \pm 8.56$	$125.29^a \pm 10.33$	$134.28^b \pm 9.90$
females	$121.80^a \pm 10.18$	$127.08^a \pm 11.36$	$139.85^b \pm 10.93$
35 males	$156.94^a \pm 8.6$	$161.90^a \pm 14.85$	$161\ 10^a \pm 11.85$
females	$153.15^a \pm 17.66$	$168.92^b \pm 12.66$	$166.00^b \pm 12.23$
42 males	$169.50^a \pm 8.80$	$168.00^a \pm 14.66$	$171.50^a \pm 11.38$
females	$186.07^a \pm 22.88$	$193.72^a \pm 16.09$	$199.25^a \pm 13.1$
Sexual maturity	42	44	41

^{a,b}means in the rows marked with different letters differ significantly ($P \leq 0.05$)

(83.7%) with 86.3% in the control group (Table 2). In many experiments, the impacts of magnetic field on biological objects were different. For example Bednarczyk et al. (1993) found no improvement in hatchability with an artificially generated electromagnetic (EM) field of low frequency on chick embryos whereas Niedziółka and Janowski (1996a,b) found a delay in the hatching time of chicks under the influence of artificial EM field. Veterany and Hluchy (2001) and Toman et al. (2002) reported that hatchability of hen eggs subjected to a magnetic field during storage prior to setting was increased, but hatchability of eggs treated with a magnetic field during incubation was decreased. Cox et al. (1993) did not find any developmental anomalies after treating hen eggs with a magnetic field of 50 Hz and 10 μT in the first 52 hours of incubation. Coulton and Barker (1991) stated that the effects attributed to the action of magnetic field might be a derivative of disturbances in hatching parameters. Terol and Panchon (1995), who used a magnetic field of 50 and 60 Hz and 0.2 and 3.2 μT on quail eggs, observed damage to the nervous system, in particular to its cranial section. Some authors believe that negative effects of additional magnetic field, in relation to hen eggs, are limited to the first 24 or 48 hours of incubation, i.e. to the beginning of embryo gastrulation. This accounts for perturbations in the secretion and structure of glycosoaminoglycans, which are pre-gastrulation initiators, with the developmental response of the embryo depending, among others, on the magnetic field induction (Martin, 1988; Ubeda et al. 1995). On the other hand, Camerton et al. (1993) did not exclude the influence of magnetic field on the expression of genes responsible for apoptosis. According to Lis (2000) the intensity of apoptosis process may depend on the magnetic field induction value. The field with higher induction may cause considerable stimulation of apoptosis processes and dying of weak hen embryos during 48 hours of incubation, while with lower induction value the embryos with minute anomalies have a chance of further growth. Formicki and Winnicki (1998), using the magnetic field of 1 to 5 μT on fish embryos, obtained higher incubation results and heavier and longer larvae in relation to the control group with prolonged incubation time.

The average weight of one-day-old chicks (Table 3) was similar in all groups and ranged from 7.82 g (group II) to 8.05 g (group III). The weight of the chick as a proportion of egg weight before setting was between 69.9 and 71.5%. Veictsteinas et al. (1996) and Lis (2000) found no effect of magnetic field on the weight of one-day-old hen chicks, whereas Piera et al. (1992) reported an increase in this weight.

Significantly higher body weights were measured in birds of group III (101 g) at 21 days these being approximately 4 and 10 g higher than those in group I and II, respectively. This difference in body weight of birds in favour of group III was maintained up to the 4th week of their life, being significantly higher both in females and males in relation to the other groups. On day 35, the body weight of males of group III was significantly higher than that of the control group. In the last week of rearing, mean body weight in both sexes was similar and ranged from 168 (group II) to 172 g (group III) in males, and from 186 g (group I) to 199 g (group III) in females, none of these differences being statistically significant.

The quail of group III reached sexual maturity on day 41, this being one and three days insignificantly earlier than birds in group I and II, respectively. In previous studies on Pharaoh quails, females reached sexual maturity between 42 and 49 days (Tarasewicz, 1998; Tarasewicz et al., 2004).

CONCLUSIONS

1. The lowest percentage of losses during incubation was found out in group II, where eggs were exposed to the action of additional magnetic field in programme M2.
2. The highest values of hatching indices calculated in relation to fertilized eggs were found in group II, where the magnetic field strength increased cyclically during application every 12 seconds from 0.5 to 4 μT, then it decreased to 0.5 μT, and the process was repeated until the end of exposure.
3. In the post-embryonic period, quail of group III with programme M3 had insignificantly higher body weights at 42 day and reached sexual maturity insignificantly earlier than quail in the other treatments.

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