

The influence of ultrasound on chicken hatching

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Der Einfluss von Ultraschall auf das Ausschlüpfen von Kücken

1. Introduction

Ultrasound originates as the vibration of an elastic body or a medium and gets spread in the form of wave motion. It is a sound with a frequency of higher than 20 kHz (VAŠKŮ et al., 1984). The ultrasound waves spread in a linear way if the environment is homogeneous (TAKÁČ et al., 1984). In the process of sound perception the high frequency sound wave gets spread in the cochlea of the inner ear on the shorter distance of the membrane basilaris than the lower frequency sound waves (REECE, 1997). During communication some birds produce signals from the range of ultrasound since they are better heard over longer distances (FRANCK, 1985). In general, it could be said that birds more often produce sounds with lower frequency since they are less dampened by various environmental barriers (IĽJIČOV, 1972). The upper boundary of sound perception for chick-

ens is approximately 9 kHz (ZAJANČKOVSKIJ, 1971). According to SLIŠKOVSKAJA (1980), the smaller animals are the higher frequency sounds they are able to perceive and produce. Thus, we can expect that before hatching the chickens communicate with their surroundings by means of ultrasound acoustic signals as well. This is also made possible by the fact that ultrasound penetrates through various biological media very easily (HRAZDÍRA et al., 1983).

The aim of our work was to determine the effect of the application of ultrasound on chicken embryos during incubation.

2. Material and methods

In the experiment, the Rhode Island Red breed eggs from parents aged 38–46 weeks with average weights of 58.00 ±

Zusammenfassung

In der Arbeit wurde der Einfluss künstlichen Ultraschalls auf das Ausschlüpfen der Kücken der Rasse Rhode Island Red untersucht. Die Embryos der Kontrollgruppe wurden während der Bebrütung nicht mit Ultraschall stimuliert. Im Versuch wurden die Embryos von der ersten Stunde der Bebrütung an mit Ultraschall stimuliert, der von einem Signalgeber stammte, welcher eine Frequenz von 30 kHz und eine Stärke von 60 W erzeugte.

Der pathologische Einfluss von Ultraschall wurde speziell an den Embryos mit stark entwickeltem alantochorionischen Blutkreislauf gezeigt. Wir vermuten, dass nach der Verletzung der Allantoidgefäße die Intensität der Oxydationsprozesse abnahm und verursachte, dass sich bei den meisten Embryos Kohlendioxyd anreichte, was den Blut-pH senkte, was wiederum die Geschlechtsdifferenzierung gegenüber den Kontrollgruppen zugunsten der männlichen Tiere beeinflusste.

Schlagworte: Ultraschall, Ausschlüpfen von Kücken, Geschlecht.

Summary

In the work the influence of synthetic ultrasound on the hatching of the Rhode Island Red breed of chicken was investigated. The embryos from the control groups were not ultrasound stimulated during the incubation. In the experiment embryos were, from the first hour of incubation, stimulated by ultrasound generated by the transducer oscillating at the frequency of 30 kHz and the power of 60 W. The pathological influence of ultrasound was demonstrated especially on the embryos with highly developed alantochorionic blood circulation. We suppose that after the violation of allantoid vessels the intensity of oxidation processes decreased and caused that in most of embryos carbon dioxide was accumulated, resulting in the decrease of their blood pH which consequently influenced the sex differentiation in control groups in favour of males.

Key words: ultrasound, hatching, sex, chicken.

0.50 g and 65.00 ± 0.50 g were used. The set eggs were hatched in four incubators of the BIOS MONO 06 type. For ultrasound stimulation the ultrasound generator produced according to our project by the Belančík Co. (Slovak Republic) was applied.

In the first two incubators no ultrasound transducer sonotrode was placed and eggs were not stimulated by a synthetically-made ultrasound. In the first hatchery (1st control group) the eggs with a mean weight of 58.00 ± 0.50 g were hatched while in the second incubator (2nd control group) the weight of eggs was 65.00 ± 0.50 g. In the next two incubators the sonotrodes of the ultrasound transducer oscillating at the frequency of 30 kHz and the power of 60 W were placed already in the first hour of hatching. The ultrasound transducer was ringing in 50 % intervals of effective value; its operation mode was controlled by a microprocessor. In the third hatchery (1st experimental group) ultrasound was applied during incubation for the stimulation of the set eggs weighing 58.00 ± 0.50 g while in the fourth hatchery (2nd experimental group) the synthetic ultrasound stimulated the set eggs 65.00 ± 0.50 g.

During hatching, the following behaviours were observed: beginning of beakclapping, whole group beakclapping time, whole group hatching time, embryonic mortality, hatchability, and egg distribution ratio of the hatched chickens. This was either by an identification drawing of able embryos and fallen chickens or by means of secondary sex signs during the breeding time.

Immediately after the chickens from our experimental groups were hatched, we took blood from their hearts and tested it using the AVL instrument which serves as the control mechanism of the acidobasic balance of blood.

The summed-up results given in the tables were arrived at in seven successive experiments. From these, the basic variation statistic traits were calculated. The results were tested by a Student's t-test.

3. Results and discussion

The chickens first started to beakclap in the control groups of the hatcheries in which no ultrasound was applied on the set eggs (Table 1). In the first control group (C1), this occurred after 474.71 ± 3.03 hours of incubation while in the second control group (C2) it was after 475.79 ± 3.66 incubation hours. Also the beakclapping and hatching times were shorter in the control groups (13.21 ± 0.39 and 13.79 ± 0.49 hours as well as 487.93 ± 3.36 and 490.43 ± 3.25

hours). In the experimental groups with the ultrasound stimulated set eggs the results did not show positive impact of sound stimulation on the chicken embryos (GLAZEV, 1990; VETERÁNY et al., 1998) since the chickens hatched later if compared with the control groups, that is after 492.43 ± 2.49 in the first experimental group (E1) and 492.79 ± 4.22 incubation hours in the second experimental group (E2). Due to the increased embryonic mortality, however, the hatchability in the experimental groups substantially decreased. Differences between experimental and respective control groups as well as those between experimental groups themselves were highly evident ($P \leq 0.01$ and $P \leq 0.001$). As far as the control groups were concerned, a higher hatchability (86.12 ± 3.73 %) was reached in the first control group with the weight of set eggs 58.00 ± 0.50 g while in the second control group with set eggs weighing 65.00 ± 0.50 g, the hatchability was lower (79.73 ± 5.34 %). The results correspond with the results obtained by POLYANICHKIN and VOROKOV (1992) as well as ASUSQOU and OKON (1993) who also observed a higher hatchability of the lower weight set eggs if compared with the higher weight set eggs. A closer look at the embryonic mortality (Table 2) showed that in the experimental groups the highest mortality was among the embryos with developed allantochorionic blood circulation (23.14 ± 4.54 % and 18.88 ± 6.27 %) as well as among those in the reverse position (head in the sharp end of the egg) 9.49 ± 2.54 % and 7.94 ± 2.18 %. The results are highly significant ($P \leq 0.001$) when compared with respective control groups. The above data show that the ultrasound has a stressful effect on chicken hatching (SIEGEL, 1990). The embryonic mortality in the first experimental group was higher than in the second one. We suppose that ultrasound has a more stressful effect on chicken hatching from the lower set eggs. In the case of the higher weight eggs the proportion of individual elements of the egg gets changed especially in favour of the white and shell (BURLEY and VADEHRA, 1989) which results, in our opinion, in a greater sound insulation of the embryo and consequently its weaker perceptiveness to ultrasound coming from the outside. The highest embryonic mortality in the experimental groups was observed in the period up to 14 days of incubation, which corresponds with the findings achieved by WHITEHEAD et al. (1998). In the control groups the highest mortality was observed 3 days before hatching, which is confirmed also by the findings of MINDUR (1985).

The natural proportion of gender of chicken is generally given by the ratio of males to females 1:1 (MÍČEK, 1962; FISININ et al., 1990; HALAJ, 1993). In our experiment, on

Table 1: Indicators of chicken hatching

Tabelle 1: Merkmale des Ausschlüpfens der Kücken

indicators	units	C1 1.st control group	E1 1.st experimental group	C2 2.nd control group	E2 2.nd experimental group
weight of eggs	grams	58.00 ± 0.50	58.00 ± 0.50	65.00 ± 0.50	65.00 ± 0.50
amount of incubated eggs	pieces	161	161	161	161
average number of incubated eggs per each experiment	pieces	23.00 ± 2.31	23.00 ± 2.31	23.00 ± 2.31	23.00 ± 2.31
beginning of beakclapping	hours	474.71 ± 3.03	478.07 ± 2.26	475.79 ± 3.66	479.57 ± 1.79
all group beakclapping time			+++ C1E1		+C2E2
	hours	13.21 ± 0.39	14.36 ± 0.48	13.79 ± 0.49	14.64 ± 0.63
hatching time			+ C1E1		
	hours	487.93 ± 3.36	492.43 ± 2.49	490.43 ± 3.25	492.79 ± 4.22
hatchability			+++C1E1		+++C2E2
	%	86.12 ± 3.73	50.70 ± 4.98	79.73 ± 5.34	63.06 ± 8.01

+P ≤ 0.05

+++ P ≤ 0.001

Table 2: Indicators of mortality at chicken hatching

Tabelle 2: Indikatoren der Sterblichkeit beim Ausschlüpfen der Kücken

Indicators	Units	C1 1-st control group	E1 1-st experimental group	C2 2-nd control group	E2 2-nd experimental group
Infertile eggs	%	0.57 ± 1.51	2.02 ± 3.84	0.00 ± 0.00	1.71 ± 3.15
Dead embryos with developed yolk sac blood circulation	%	1.17 ± 1.99	5.58 ± 3.12	2.51 ± 2.37	1.14 ± 1.95
Dead embryos with alanto-chorionic blood circulation			+++C1E1		+C2E2
	%	1.29 ± 2.21	23.14 ± 4.54	3.17 ± 2.21	18.88 ± 6.27
Dead embryos with unabsorbed yolk sac	%	2.65 ± 2.50	4.25 ± 2.34	3.74 ± 4.07	5.70 ± 2.45
Prolapse of cerebrum	%	0.00 ± 0.00	1.86 ± 2.34	0.00 ± 0.00	0.00 ± 0.00
Dead embryos in the reverse position			+++C1E1		+++C2E2
	%	0.71 ± 1.89	9.49 ± 2.54	1.29 ± 2.21	7.49 ± 2.18
Dead embryos in the irregular position			++C1E1		++C2E2
	%	7.49 ± 2.18	3.82 ± 1.74	8.28 ± 4.75	0.71 ± 1.89
Cyclops	%	0.00 ± 0.00	0.57 ± 1.51	0.71 ± 1.89	0.60 ± 1.58
Shortened upper beak	%	0.00 ± 0.00	0.00 ± 0.00	0.57 ± 1.51	0.71 ± 1.89

+ P ≤ 0.05

++ P ≤ 0.01

+++ P ≤ 0.001

average more males were hatched (88.95 ± 5.02 % in the second experimental group and 88.50 ± 3.79 % in the first experimental group) which is a highly significant result ($P \leq 0.001$) when compared with respective control groups (Table 3). In the control groups with no ultrasound stimulation of the embryos the proportion of males and females was approximately balanced. According to HRUBÝ (1961), the process of final shaping of gender is not influenced only by a genotype composition of the zygote but also by other inner and outer factors. As an example of such factors is the impact of ultrasound from the outside during incubation. The pathological impact of ultrasound is based on a thermal process, mechanical effects and the phenomenon of

cavitation. The chemical impact of ultrasound on blood has been proved as well (VARGA and OBLYVAČ, 1979). The most perceptible to the harmful effects of the ultrasound were the embryos with developed alanto-chorionic blood circulation (the highest mortality). Probably at this stage of the chicken's development, the pathological effect of ultrasound resulted in the damaging of the structure and function of alantoid vessels. Greater damage to cellular formations of alantoid vessels could result in death; lower damage could result only in the violation of metabolism between the embryo and the environment. Biochemical processes going on in the organism of the developing embryo can, under certain conditions, influence the

Table 3: Sex ratio of hatched chicken

Tabelle 3: Geschlechterverhältnis der geschlüpften Kücken

Groups	Total number of identified chickens	Number of identified chicken per experiment	Sex						Number of males per hundred females
			male			female			
	pieces	pieces	pieces	%	blood pH	pieces	%	blood pH	
1-st control group C1	154	21.71 ± 2.43	11.28 ± 2.32	51.79 ± 6.81	7.480 ± 0.01	10.43 ± 1.62	48.21 ± 6.80	7.478 ± 0.012	111.15 ± 31.04
2-nd control group C2	146	20.71 ± 2.36	10.71 ± 2.21	51.37 ± 6.46	7.480 ± 0.01	10.00 ± 1.15	48.63 ± 6.46	7.479 ± 0.006	108.78 ± 28.05
1-st experimental group E1	108	+++C1E1 15.14 ± 2.48	13.43 ± 2.37	+++C1E1 88.50 ± 3.79	7.455 ± 0.005	++C1E1 1.71 ± 0.49	+++ C1E1 11,50 ± 3.79	7.476 ± 0.004	+++C1E1 857.14 ± 328.42
2-nd experimental group E2	121	+C2E2 16.86 ± 2.41	++C2E2 15.00 ± 2.38	+++C2E2 88.95 ± 5.02	7.458 ± 0.006	+++C2E2 1.86 ± 0.90	+++C2E2 11.05 ± 5.02	7.474 ± 0.005	+++ C2E2 1014.29 ± 558.39

pathological composition of sexual cells and gender of the zygote. They can also direct the development of sexual glands in favour of a male or female (ŠREDER, 1957). When the function of alantoid vessels is damaged, the intensity of oxidation processes in embryos is decreased, which, among other things, results in the decrease of blood pH. According to WILCOX (1959), even small changes in blood pH can cause a change of gender. In our experiments, immediately after the chickens from or experimental groups were hatched, we took blood from their hearts and tested it using the AVL instrument, which is generally used for ascertaining the acidobasic balance of blood. With males, we observed that the blood pH measured was within the range of 7.45–7.46, while with females, it was ranging from 7.47–7.48. Our results correspond with the findings of POPIEL and SIKOROWICZ (1955).

The assessment of optimum levels of ultrasound for the decrease of embryonic mortality and the increase in possibilities for influencing the formation of gender of chickens will require further ethological observations.

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