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Changes in swan goose (*Anser cygnoides*) hatchability due to application of a tridimensional silicon layer on eggshells and vertical egg setting during incubation

WACŁAW SUMARA[1], MICHAŁ PATRZAŁEK[2], BARTOSZ BOJARSKI[1], MIECZYSŁAW SAJEWICZ[3], MAGDALENA TRELA[1], MARCIN W. LIS[1]
[1] Faculty of Animal Science, University of Agriculture in Krakow
[2] ICB Pharma Jaworzno
[3] Faculty of Mathematics, Physics and Chemistry, University of Silesia

Abstract: *Changes in swan goose* (Anser cygnoides) *hatchability due to application of a tridimensional silicon layer on eggshells and vertical egg setting during incubation*. Goose egg incubation technology differs from the procedure used for chickens: eggs are washed before putting into an incubator and set horizontally due to their big size. However, the effects of the washing procedure and egg arrangement in the context of the hatchability and quality of goslings has not yet been extensively researched. The current study revealed that positioning eggs vertically facilitated hatching, and application of a silicon layer reduced hatching time. The results indicate that covering swan goose (*Anser cygnoides*) eggshells with a tridimensional silicon layer before incubation of wet-cleaned eggs can improve hatchability.

Key words: embryo pathology, egg incubation, artificial shell layer

INTRODUCTION

In Poland, swan goose (*Anser cygnoides*) has less economic value than the white Italian goose (*Anser anser* f. *domestica*), but it is becoming a common bird in agrotouristic breeding. Moreover, this species shows better reproductive performance (egg number, fertilization, and hatchability) than the white Italian goose (Bednarczyk and Rosiński 1999).

The protocol of artificial incubation of goose eggs includes washing and horizontal setting on incubation trays. The washing procedure is for sanitization because many saprophytic microorganisms and sometimes also pathogenic ones (*Escherichia*, *Salmonella* and *Enterobacter*) can occur on the eggshells, but this also results in loss of the cuticle layer. The procedure increases the water vapor conductance of eggshells (Deeming 1987) and the risk of entry of pathogenic microorganisms (Wellman-Labadie et al. 2008). Thus, it seems that the reconstruction of some kind of eggshell layer could improve hatchability. Siloxanes (silicones) constitute a group of low molecular weight compounds, organosilicon oligomers and polymers. These are commonly considered to be nontoxic to humans and the environment (or toxic to a very limited extent), therefore they are often an integral part of innovative methods of treatment, health care, and nursing (Mojsiewicz-Pieńkowska and Krenczkowska 2018). According to the Stöber mechanism, organomodified siloxanes applied on solid surfaces create a 3D Immobilizing Polymeric Network Structure (3D IPNS) (Han et al. 2017) because the silicone layer coating the biomaterial reduces bacterial cell adhesion (Erol 2018, Sankaran et al. 2019). More importantly, the bacteriostatic prosperities of 3D IPNS are based on a purely physical mechanism of action which precludes the development of drug-resistant microorganisms.

Goose egg incubation technology assumes that they are set horizontally on incubation trays, not vertically as in the case of hen eggs. It cannot be ruled out that this may be a reason for embryo malposition (van den Ven et al. 2011), which potentially leads to a severe reduction in hatchability.

The aim of the study was to determine the influence on swan goose hatchability and the quality of goslings of covering eggs with a tridimensional silicon layer, and setting position.

MATERIAL AND METHODS

Animals and experimental design

The experimental material was 52 eggs of swan goose (*Anser cygnoides*) parental stock (two males and eight females). The eggs, which weighed 182.2 ±13.84 g (mean ±*SD*), were stored for 2–10 days, wet cleaned and disinfected in 1% $KMnO_4$ water solution (temperature solution 37–38°C for 15–30 s) in a ROTOMAID 100 egg cleaner (Interhatch, UK) and randomly divided into four equinumerous groups. Half of the eggs were dipped (for 15 s) in a 1% water solution of DERGALL® (ICB Pharma Jaworzno, Poland) to cover their shells with a silicon layer; the second group was not treated. On incubator trays, one group of eggs was set horizontally, and the other group was set vertically; they were then incubated in an Ova-Easy Advance (Brinsea, USA) incubator. Incubation parameters were: temperature 37.8 ±0.1°C, relative humidity 60 ± 5% for days of incubation (E) from first to 26th (E1–E26), and 37.0 ±0.1°C and 75 ±5% from E27 to E32. The eggs were cooled outside the incubator (22°C, 20 min) from E10 and also sprayed with water from E16. Eggshell temperature (EST) was monitored with a FLIR i7 thermovision camera (according to the protocol described by Lis et al. 2011). During the incubation, the eggs were candled using a Powerlux Ovoscope at E8 and E26 to remove unfertilized eggs and those with dead embryos. The hatching process was monitored at six-hour intervals from incubation period of 576–768 h. All unhatched eggs and those rejected at candling were subjected to embryopathological analysis that involved identification of the developmental stages at the time of death (Badowski 2007). The weight of the eggs (before incubation and at E26) and of newly hatched goslings was determined to 0.1 g accuracy. After hatching, the zone of eggshell piping and the appearance of the chorioallantois membrane were evaluated according to Lis et al. (2001).

Statistical analysis

The hatching results were analyzed using a *Z*-test, while all other parameters were analyzed with a two-way ANOVA followed by Tukey's post hoc test. The statistical procedures were performed using Sigma-Stat 2.03 (SPSS Science Software Ltd., USA). The obtained results were presented as means and standard deviation (±*SD*) and considered significant at $P < 0.05$.

RESULTS AND DISCUSSION

In poultry production the biological value of eggs and external factors determined by the incubation technology are crucial. Because modern poultry production is conducted on a mass scale, even a slight improvement in hatchability and/or chick quality produces tangible economic benefits.

The hatchability of the goslings from fertilized eggs incubated horizontally and covered with a silicone layer was 42.3% lower than the equivalent group without the layer (the table). Death of embryos in this group occurred during the second half of incubation, which could indicate gas exchange disturbances (Tullet 1990, Meir and Ar 1996). A similar phenomenon was not observed in the case of vertically set eggs. Egg position in the

TABLE. The weight of the incubated eggs and the hatchability results of swan goose (*Anser cygnoides*)

Silicon layer		absent		present	
Egg set position		horizontal	vertical	horizontal	vertical
Egg weight (g)		179.3 ±5.54	179.6 ±3.55	185.8 ±3.73	190.7 ±6.79
Set eggs (*n*)		13	13	13	13
Embryonated eggs (*n*)		13	10	12	12
Dead embryos (*n*)	incubation period E1–E15	1	0	2	0
	incubation period E16–E32	0	1	4	2
Nanomelia cases (*n*)		0	2	0	1
Hatchability	goslings (*n*)	12	7	6	9
	embryonated eggs (%)	92.3	70.0	50.0	75.0
Gosling weight (g)		122.3 ±12.11	118.7^{a} ±5.19	123.9 ±11.42	131.5^{a} ±7.41
Gosling to egg weight proportion (%)		68.2 ±2.24	66.1^{a} ±1.09	66.1^{b} ±3.24	69.0^{ab} ±2.09
Moment of external pipping (hour of incubation)		714.8^{ab} ±14.89	699.1^{ac} ±5.37	699.7^{bd} ±5.68	721.1^{cd} ±13.71
Moment of hatching (hour of incubation)		739.0^{ab} ±12.66	726.0^{acd} ±13.66	718.0^{bce} ±0.00	736.7^{de} ±14.00
Time of hatching (h)		24.2^{ab} ±12.27	26.9^{cd} ±13.09	18.3^{ac} ±5.68	15.6^{bd} ±3.24
Shell pipping zone		4.6^{ab} ±1.84	5.1^{a} ±0.75	4.8 ±1.60	5.2^{b} ±0.67
Chorioallantois evaluation		3.5 ±1.08	3.0 ±0.82	3.0 ±0.71	3.5 ±0.76

Values in rows marked with the same letters differ significantly at $P < 0.05$.

setter during the first stage of incubation is critical for the formation of the air chamber and the optimum embryo position for hatching. In addition, the position of the egg in the tray can affect gas exchange through the shell during incubation (Moraes et al. 2008, van de Ven et al 2011, Boleli et al 2016). In this way, the decreased hatchability of ostrich eggs incubated horizontally is explained (Schalkwyk et al. 2000).

The main reason of mortality in these groups was nanomelia. This malformation seems to be induced by genetic factors (Romanoff and Romanoff 1972), not the experimental procedures applied. Moreover, no cases of malposition were noticed in this experiment, but the individuals developed in vertically set eggs pipped the shell closer to the big end. Thus, the vertical position seems to be more desirable than the horizontal one.

The recorded eggshell temperature increased during incubation in each group (results not shown) and exceeded the air temperature in the incubator (machine temperature, MT) on E15. This corresponds to the phase of goose embryo development during which the chorioallantois membrane (CAM) is completely closed off (Kucharska-Gaca 2018). The CAM is then the only embryonic respiratory organ (Romanoff 1960), which thus leads to an increase of metabolic rate (Ar et al. 1987). The heat production of goose embryos on E27–E28 was already so high that the recorded difference between EST and MT in this study was more than 1°C. This phenomenon is analogous to those known in the case of chicken incubation (Hulet et al. 2007, Lis et al. 2011). All hatched goslings were high quality (good activity, completely closed and clean navel). The biggest relative weight of goslings was recorded in individuals from vertically set eggs treated with DERGALL. This may be a result of the water vapour conductance limitation caused by the experimental procedure as well as the size of the eggs (Visschedijk et al. 1985, Deeming 1987). The hatching time was generally shorter in the groups treated with the tested silicon preparation. The presence of this layer may lead to an increase of CO_2 concentration in the air cell. An increase of this gas content is known to be a strong hatching stimulant (Tullet 1990, Tong et al. 2015).

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Streszczenie: *Zmiany w wylęgowości gęsi garbonose* (Anser cygnoides) *spowodowane pokryciem skorupy jaj przestrzenna powłoką silikonową i pionowym ułożeniem jaj podczas inkubacji.* Technologia inkubacji jaj gęsi różni się od stosowanej u kur, m.in. tym, że jaja są myte przed umieszczeniem w inkubatorze i układane poziomo na tacach lęgowych. Wpływ tych czynników na wyniki lęgów nie został jak dotąd dostatecznie zbadany. Niniejsze badania wykazały, że pionowe położenie jaj ułatwiało wykluwanie się gąsiąt, zastosowanie warstwy silikonowej doprowadziło do skrócenia czasu wylęgu. Wskazuje to, że pokrycie jaj mytych w wodnych roztworach dezynfekcyjnych trójwymiarową powłoką silikonową może poprawiać wyniki lęgów gęsi garbonosej.

Słowa kluczowe: embriopatologia, inkubacja jaj, sztuczna powłoka na skorupie

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Authors' address:
Marcin W. Lis
Katedra Zoologii i Dobrostanu Zwierząt
Wydział Hodowli i Biologii Zwierząt
Uniwersytet Rolniczy im. Hugona Kołłątaja
w Krakowie
al. Mickiewicza 24/28, 30-059 Kraków
Poland
e-mail: rzlis@cyf-kr.edu.pl