The study of the natural chicken brooding in laboratory conditions

E A Andrianov¹, A A Andrianov¹, A N Sudakov¹ and P I Dudin²
¹ Voronezh State Agrarian University named after Emperor Peter the Great, 1 Michurina st., Voronezh, Russia, postcode 394087
² Voronezh State University, 1 Universitetskaya ploshchad, Voronezh, Russia, postcode 394006
E-mail: ansudak@gmail.com

Abstract. The article deals with the preparation for the experiment on long-term monitoring of the temperature of eggs and brooder-hens, the heart rate and the motor activity of the embryos and the motor activity and the behavior of brooder-hens during natural chicken brooding in laboratory conditions. The issues of laboratory premises selection and their internal layout are discussed. We suggest protecting the hardware from dust and excessive humidity by installing it in an isolated chamber in the immediate proximity to the cages with birds. The factors influencing the results of the experiments that involve living animals are analyzed. Some ready-made solutions are suggested to arrange the power supply of the laboratory. We also describe the appropriate components of the hardware set for the monitoring of the controlled parameters.

1. Introduction

The artificial incubation conditions for poultry are based on the observations of the natural brooding. Today we know that the key incubation parameters include temperature, air humidity and composition in the incubation chamber, as well as the frequency and the angle of egg rotation during the incubation [1]. The hatchers where eggs are kept warm by heating up the air in the incubation chamber are the most widely spread ones. In order to maintain the relative humidity of the air at the required level, various types of water evaporators are used. The necessary levels of oxygen and carbon dioxide are maintained by natural draft or forced ventilation of the incubation chamber. Egg rotation is carried out by rolling the eggs or tilting the hatcher pans.

Even though the normal hatchability in industrial farms is at 90% of the fertilized eggs, the recent years have shown an increase in the number of research projects aimed at improving the incubation temperatures [2,3]. This is due to the fact that despite the extensive use of brand-new technologies in artificial brooding, natural brooding is more efficient in terms of hatchability and the quality of the young birds. Another reason for researchers’ growing interest in the impact of the incubation conditions on the further development of birds is the significant increase in the growth rate and a general reduction of the productive life of the poultry. Since broilers today reach the sale weight at the age of 45 days, the embryonal stage of their development comprises up to 33% of their life. Modern research proves that the motor activity of embryos and the incubation temperatures influence the muscle building and the skeleton formation during the embryogenesis, as well as the temperature and distress tolerance of young birds [4,5,6,7]. That being said, the deliberate exposure of the embryos to
these factors during the incubation is nowadays limited to laboratories, i.e. it is not often used in the commercial production of poultry.

There are two ways of promoting a deeper understanding of the embryonal development of birds. The more common one is when the researches study the consequences of the external factor impacts on eggs and embryos’ development during the artificial incubation. A large number of articles have been published that describe the impact of temperature, humidity, air composition and mechanical actions on the morphological, hematological and other properties of embryos, as well as the quality of young birds [8,9,10].

The other way contemplates the study of the mechanisms and parameters of natural brooding, such as birds’ nesting behavior, temperatures in the nest, physiological changes to the body of the brooder, and the properties of the developing embryos [11,12].

The analysis of the data received when studying embryogenesis in natural brooding conditions helps avoid a large number of searching experiments typical of the empirical identification of the best conditions for artificial incubation. Natural brooding provides the best conditions for embryo development because it was shaped by thousands of years of evolution. However, the problems that a researcher faces when studying the naturally brooded embryos can be significant thus making the long-term monitoring of the natural nests a challenge.

This article describes the multifactor monitoring technology for the natural brooding of the dunghill hen (Gallus gallus Linnaeus, 1758) in laboratory conditions that can be accessible for a large number of researches and, hopefully, will help avoid a number of problems typical of conducting experiments with living animals.

2. Materials and Methods
The experiment was carried out in laboratory conditions by the workgroup comprised of specialists from Voronezh State Agricultural University named after Emperor Peter the Great and Voronezh State University. The laboratory is located at the premises of the Galichya Gora natural reserve of Voronezh State University at the following address: Russian Federation, Lipetskaya oblast, Zadonskiy district, Donskoye (52°36'7.34" N, 38°55'43.45" E, altitude: 135 m). The experiment was carried out using 5 hens and 2 roosters, 2 years of age, from the reserve's household. The chickens were kept in cages in the laboratory. The experiment implied long-term monitoring of the following parameters:

1. The eggshell temperature and the body temperature of the brooder.
2. The embryo’s heart rate and motor activity.
3. The motor activity and the behavior of the brooder.

After the experiment, the parents and the young birds were returned back to the household.

3. Results

3.1. Laboratory location
We believe that the selection of the laboratory for the experiment with living animals is the first key question that researchers have to answer. They need to take into consideration the following factors:

1. The type of experiment in question uses animals that generate dust and excessive humidity, which will be kept in close proximity to electronic hardware that can be damaged by those factors.
2. Even though the dunghill hen brooding usually lasts 20-21 days, the experiment might last a few months before completion. The period in which the brooder adapts to the new conditions and begins egg-laying and then brooding can vary depending on an individual bird.
3. Even when the experiment involving living animals is well-prepared for, there can be situations that might lead to its abortion or restart, which may increase the total duration of the research.
4. One must take into account that animals do not take days off or holidays and that the emergency alarm systems used can go off anytime. You will need access to the laboratory on
any day and at any time. If no one keeps watch at the animals around the clock, the remoteness of the laboratory from your house can be crucial: sometimes it only takes a timely adjustment of the egg with the sensor under the brooder to avoid doing the entire work over again.

5. Initially, you will have to spend a lot of time in the laboratory until the equipment will be set and tuned, so you should make sure there are proper ventilation, heating, and lighting, which may affect your working efficiency.

Taking into consideration the aforementioned factors, we chose one of the vacant rooms in an engineering building of the reserve with an area of 20 m² and a separate outside entrance to set up our laboratory. Inside the future laboratory, we assembled a 6 m² chamber made of plastic panels with a ventilation system independent from the main room. The building is located at the reserve's premises and near the homes of the researchers.

3.2. Housing conditions for birds
Since the experiment was carried out in summer, a high temperature inertness of the stone building proved to be an advantage. While the outside temperatures fluctuated between 15 and 35°C, the temperature in the laboratory was 20-25°C.

Due to the small number of birds in the laboratory and the significant shifts of the outside temperature, we deliberately did not use the forced ventilation at all times, but we installed a CO₂ sensor. Further on, we ascertained that when there were no humans in the laboratory, the level of carbon dioxide did not exceed the limit of 500 ppm, but when one of the researchers stayed in for a long time, the level of CO₂ increased up to ≥ 3000 ppm. The problem was solved by connecting a sensor to the intake fan. When the level of CO₂ rose over 600 ppm, the intake fan turned on.

Since the room with the brooders was on the ground floor, the natural lighting was insufficient, and we had to use timer-controlled luminescent lamps.

The birds were kept in cages located in three-piece stacks along the wall. During the laying and before the proper brooding, the hens were kept together with the roosters, but the presence of several animals in a cage was an additional distress factor. The best way of separating brooding birds from the rest, in our opinion, is catching and relocating roosters and those hens who have not started brooding yet. Even though this procedure is a distress-factor for the brooding birds, the brooders returned to their nests within several dozens of minutes in every case.

Water and food were provided to the brooder by automatic feeders and waterers. Large feeders and waterers are more convenient because their content lasts longer. We also noticed that some of the brooders do not leave their nest in order to eat and lose a lot of weight. We solved this problem by placing the feeder as close to the nest as possible so that the hen did not refuse the feeding.

We used complete feeds of the highest quality.

3.3. Laboratory equipment chamber.
We decided to place all of the equipment and computers in a special chamber inside the laboratory in order to promote the comfort of the operator and use the appliances that have low protection against external factors, such as humidity and dust. The proximity of the chamber to the cages allowed us to feed the data cables from the sensors in the nests directly into the chamber. Due to this, we avoided the electronic interfaces and amplifiers which would otherwise be necessary because the signal strength limits the length of cables to be used. Since even the most insignificant temperature fluctuations can adversely impact the accuracy of the temperature sensors using the voltage divider principle, we maintained a stable temperature in the electronic equipment chamber allowing its fluctuations of no more than ±0.5°C. The stable temperature in the chamber was maintained using a simple relay that controlled the electric fan heater.

3.4. Laboratory power supply
The power supply to the laboratory is an issue of its own. A number of appliances are very sensitive to voltage surges caused by the quality of the power (voltage stability, absence of voltage harmonic distortions, etc) in the local supply line that powers the laboratory or the use of high power consumers in the laboratory or in the surrounding rooms. Supply disconnection always leads to serious system failures, if there are no uninterrupted power supplies installed. Since the total power consumed by the laboratory can be over 3 kW and since not all of the consumers require a UPS, we divided the consumers into several groups.

1. Appliances that are insensitive to power quality and not requiring a UPS (heaters).
2. Appliances that are sensitive to power quality but not requiring a UPS (monitors).
3. Appliances that are insensitive to power quality but requiring a UPS (appliances with static power supply units).
4. Appliances that are sensitive to power quality and requiring a UPS (appliances with transformer power supply units).

The first group was connected directly to the supply line. The second group used surge protectors. For the third group, we used household UPSs that do not stabilize the voltage when they are connected to the power supply network and have significant voltage harmonic distortions when operating on their batteries. The fourth group used industrial-grade UPSs that stabilize the voltage when connected to the power supply line and have minimum voltage harmonic distortions when working on their batteries. This scheme provided for a significant reduction of the cost of the equipment necessary for the laboratory to run for an hour in case of a blackout in the incoming power supply network. In case of a longer power disconnection, we anticipated connecting an emergency generator with a gasoline engine.

3.5. Equipment selection

As is the case with many other scientific areas, there are no ready-made equipment sets for the monitoring of natural brooding parameters. Therefore, the problem of selecting necessary control appliances and sensors arises. In our research, we aimed to record the eggshell temperatures, the body temperature of the brooder, the heart rate and the motor activity of the embryo, the motor activity and the behavior of the brooder. There are many technical solutions for recording these parameters, but researches always have to compromise between the cost of the equipment, the quality of the data obtained, and the time inputs (figure 1).

![Figure 1. Dunghill hen eggs with heart rate sensors (left) and thermistors (right).](image-url)
The use of a separate chamber for all electronic components save the sensors themselves allowed us to refuse special protection equipment thus reducing the costs and significantly extending the range of the equipment we could use.

We used high-accuracy compact thermistors connected according to the voltage divider scheme in order to control the eggshell and the brooder body temperature. The changes in voltage were put down by a multichannel recording voltmeter connected to a computer. Its readings can be passed on to MS Excel by the recording voltmeter itself.

We designed our own sensor and amplifier to monitor the embryo’s heart rate and motor activity that recorded the signal received to the PC memory [13]. After the signal has been processed using a fast Fourier transformation in Adobe Audition audio recording software, the researcher gets a visual representation of the embryo’s heart rate dynamics and motor activity rate.

We used an IR motion sensor that was connected to the recording voltmeter as a brooder motor activity sensor. While the majority of the researches use video monitoring to record motor activity, the use of the motion sensor and recording voltmeter system can significantly improve the time necessary to process the data obtained.

In order to study the behavior of the brooders, we used standard video monitoring procedures contemplating the use of a multichannel video recorder with surveillance cameras connected to it (figure 2).

![Figure 2. A brooder on the eggs with embryo heart rate sensors and thermistors. At the top of the photo, you can see a surveillance camera and an IR motion detector.](image)

4. Conclusions
In our research, we explored the methods of the long-term monitoring of natural brooding for dunghill chickens in laboratory conditions and determined the main limiting factors that influence research results.
We ascertained that the use of a separate chamber for measuring devices provides for a significant extension of the range of the equipment that could be used in the laboratory and a reduction of the equipment costs.

The differentiated approach to power supply provided for high-level interference protection of the equipment and eliminated power failures without expensive UPS systems.

The long-term monitoring of natural brooding indicators is easier to be conducted in laboratory conditions because they allow us to monitor the entire brooding process and to fully control the experiment (figure 3).

![Figure 3. The brooder with a chicken from an egg that was in the experiment.](image)

References

[1] Mueller C, Burggren W and Tazawa H 2015 The Physiology of the Avian Embryo Sturkie’s Avian Physiology 12 739

[2] Shinder D, Rusal M, Giloh M and Yahav S 2009 Effect of repetitive acute cold exposures during the last phase of broiler embryogenesis on cold resistance through the life span Poultry science 88 636

[3] Halle I and Tzschentke B 2011 Influence of Temperature Manipulation during the Last 4 Days of Incubation on Hatching Results, Post-Hatching Performance and Adaptability to Warm Growing Conditions in Broiler Chickens The Journal of Poultry Science 48 97
[4] Janisch S, Sharifi A, Wicke M and Krischek C 2015 Changing the incubation temperature during embryonic myogenesis influences the weight performance and meat quality of male and female broilers *Poultry science* 94

[5] Yalcin S, Babacanoğlu E, Güler H C and Akşit M 2010 Effects of incubation temperature on hatching and carcass performance of broilers *World's Poultry Science Journal* 66 87

[6] Alkan S, Karsli T, Karabag K, Galic A and Balcioglu M 2013 The effects of thermal manipulation during early and late embryogenesis on hatchability, hatching weight and body weight in Japanese quails (Coturnix coturnix japonica) *Archiv fur Tierzucht* 56 789

[7] Piestun Y, Harel M, Barak M, Yahav S and Halevy O 2008 Thermal manipulations in late-term chick embryos have immediate and longer effects on myoblast proliferation and skeletal muscle hypertrophy *Journal of applied physiology* 106 233

[8] Bruzual J, Peak S, Brake J and Peebles E 2000 Effects of Relative Humidity During Incubation on Hatchability and Body Weight of Broiler Chicks from Young Breeder Flocks *Poultry science* 79 827

[9] Ipek A, Sahan U, Baycan S and Sozcu A 2014 The effects of different eggshell temperatures on embryonic development, hatchability, chick quality, and first-week broiler *Poultry science* 93 464

[10] Morita V, Boleli I and Oliveira J 2010 Hematological and Incubation Parameters of Chicks from Young Breeders Eggs: Variation with Sex and Incubation Temperature *International Journal of Poultry Science* 9

[11] Shaffer S, Clatterbuck C, Kelsey E, Naiman A, Young L, VanderWerf E, Warzybok P, Bradley R, Jahncke J and Bower G 2014 As the Egg Turns: Monitoring Egg Attendance Behavior in Wild Birds Using Novel Data Logging Technology *PloS one* 9

[12] Andrianov E A, Sudakov A N, Andrianov A A and Skolznev N Y 2019 Non-invasive monitoring of avian embryo heart rate *Journal of Animal Behaviour and Biometeorology* 7 119

[13] Andrianov E A, Sudakov A N, Andrianov A A, Skolznev N Y and Dudin P I 2018 RU, Patent No. 2683513 *Method for determining the temperature regime of agricultural and wild birds eggs incubation*