

Effect of Abnormal Incubating Temperature on Chick Behavior

W. C. GUNTHER, Valparaiso University

Introduction

Through the years many investigators have been interested in the effects of temperature on the development of chicks. Classically, Féré (2) studied the effects of temperature on the stages of development in chick eggs. Edwards (1) determined the physiological zero of chick eggs. In more recent times, attention has been centered on specific incubation temperatures and their effects on development and hatchability. (5).

Harrison and Klein (4) incubated eggs at 25° C for 2 to 15 days. Various abnormalities and degenerative phenomena developed in the embryos. These authors noted that when embryos (among which were anomalous forms) were returned to the optimum incubation temperatures, many continued to develop normally. For what length of time normal development went on was not stated. Apparently no attempts were made to hatch the eggs, and no neural tube anomalies were reported.

Harrison (3) followed the in vitro development of embryos after exposure to lowered temperatures in ovo. Various anomalies were reported. Again no attempt was made to determine the effects of altered temperature on the behavior of chicks hatched from such eggs.

Many works could be cited concerning physiological mechanisms in development (8; 9; 10). The research reported herein is preliminary to a proposed extended investigation covering the effects of altered incubating temperatures on the brain and on the behavior of chicks hatched under these circumstances. This report concerns some aspects of behavior and of gross appearance of chicks hatched from eggs which had undergone abnormal incubating temperatures.

Materials and Methods

Ninety-six fertile chick eggs were incubated under the following conditions (all temperatures in this paper are reported as centigrade):

Nine eggs incubated at 37.5° for 22-23 days (normal controls)

Nine eggs incubated for 12 days at 25°, then placed in normal temperature incubator

Nine eggs incubated for 11 days at 25°, then placed in normal temperature incubator

Nine eggs incubated for 12 days at 34°, then placed in normal temperature incubator

Nine eggs incubated for 11 days at 34°, then placed in normal temperature incubator

Nine eggs incubated for 10 days at 41°, then placed in normal temperature incubator

Nine eggs incubated for 5 days at 41°, then placed in normal temperature incubator

Nine eggs incubated at normal temperature for 5 days, then placed in 10° incubator for 24 hours and returned to normal temperature incubator

Nine eggs incubated at normal temperature for 4 days, then placed in 10° incubator for 24 hours and returned to normal temperature incubator

Seven eggs incubated at normal temperature for 5 days, then placed in 1° incubator for 24 hours and returned to normal temperature incubator

Eight eggs incubated at normal temperature for 4 days, then placed in 1° incubator for 24 hours and returned to normal temperature incubator

Three homemade incubators with wafer thermostats were utilized for the 41-, 34-, and 25-degree lots. A Montgomery Ward Standard Forced Air 416-egg incubator provided the normal temperature for the eggs. An ordinary refrigerator, carefully calibrated, was utilized for the 10- and 1-degree lots. The newly-hatched chicks were color coded and then placed in a 100-chick capacity battery brooder. Standard starter mash (Purina) was fed to the birds.

The appearance of the birds was noted daily. The ability of seemingly abnormal birds to eat, drink, walk, and right themselves was compared with that of normal birds. The experiment was concluded when the birds were about six weeks of age.

Results

All eggs in the control group hatched in 23 days, and were normal in all respects.

Six of the eggs incubated at 25° for 11 and 12 days and then placed in the normal temperature incubator hatched in 37 days. This is in itself rather remarkable. Full-term but recently dead embryos were in the remaining 12 eggs. Apparently these unhatched chicks did not have enough energy to open the eggs. The six chicks hatched were in fair physical condition, but failed to match the size of the normal chicks by the time the experiment was terminated. The six chicks could peck normally, but appeared to be rather lethargic. Where the normal birds would run for their food, these would slowly make their way toward the feeding troughs. Coordination appeared to be consistent with their degree of lethargy. They did exhibit a rather precocious feather development.

Of the 12 eggs hatched in 23, 24, and 26 days at 34° (for 11 and 12 days and then placed in normal incubator), 4 were crippled badly in both feet, had very poor coordination, and were completely unable to eat and drink. The remaining chicks in this group appeared normal. Six eggs failed to hatch.

Eggs incubated at 41° for 10 days failed to hatch. Seven out of 9 incubated for 5 days at 41° hatched. Of this group, one was crippled badly in both feet, lacked coordination, and couldn't eat or drink. One was normal in appearance, but pecked only at food under its body and

in so doing would flop over on its back. When on its back it could right itself only with the greatest difficulty. A third bird was normal in appearance but could not peck, eat, or drink. Its head was cocked and the chick lacked coordination. The other 4 were normal.

Nine out of 18 eggs incubated at 10° for 24 hours hatched. Of these, 2 chicks were badly crippled in both feet, lacked coordination, and couldn't eat or drink. One bird was crippled in the right foot, which extended at a right angle as it walked along. In this bird, however, coordination appeared to be good. The remaining six chicks appeared normal.

No eggs hatched at incubating temperatures of 1° for 24 hours.

Discussion

The positive results obtained in this pilot experiment encourage further investigation into the nature of these abnormalities. The question to be considered is whether the different temperatures exerted a direct effect on the nervous system of the chick and so produced the anomalies, or whether these effects were exerted directly on the muscles.

When the results of Harrison's (3) experiment are taken into consideration, it might very well be inferred that the effects of temperature on development in these chicks are of neural origin. Harrison's low-temperature embryos had various brain and neural tube abnormalities. Furthermore, it does not seem likely that muscular malformation alone could produce lethargy, inability to eat or drink, and lack of coordination. Some of the chicks even had symptoms closely resembling human mental retardation.

It is interesting to note that chicks hatched from eggs incubated at below-normal temperatures had the same abnormalities as those hatched at above-normal temperatures. Apparently lower temperatures have as deleterious effects as higher temperatures. This is consistent with the findings of Romijn and Lokhorst (6, 7) that chick embryos show a poikilothermia until hatched. A gradually increasing homothermia then develops until the chick is about 7 days old, after which the bird is typically homothermic. Thus, any effect of altered incubation temperatures on the embryo could be similar at higher and lower temperatures if homothermia were not a critical factor in the embryonic chick.

Several important aspects involving the effects of environmental stress on development should now be investigated.

It seems desirable to incubate eggs on a trial and error basis at temperatures other than those already used. Of course, it is also necessary to incubate more eggs at the temperatures already used. Once incubating temperatures which will give consistent results in producing anomalous conditions in young birds are established, attention can be directed toward learning what metabolic mechanisms are involved in producing these abnormalities. Study of these mechanisms will involve the cyto- and histo-chemical treatment of embryonic and adult neural tissues, including the observation of reducing enzyme systems. It is also highly probable that the activity of respiratory and certain other

enzyme systems can be measured by means of the Warburg apparatus. Once the metabolic pathways are established, attention can be directed toward preventive or corrective measures.

Summary

Ninety-six chick eggs were incubated under various conditions of abnormal temperatures.

Eggs subjected to either higher or lower than normal temperatures for varying periods of time during incubation produced chicks with abnormal physical development which appeared to be of neural origin. Some chicks showed signs of mental retardation, very similar to that observed in humans.

Further inquiry into the nature of these abnormalities is necessary, along with investigation of the metabolic pathways involved.

Literature Cited

1. EDWARDS, C. L. 1902. The physiological zero and the index of development for the egg of the domestic fowl, *Gallus domesticus*. Am. Journ. Physiol. **VI**:351-397.
2. FÉRÉ, CH. 1894. Note sur l'influence de la température sur l'incubation de l'oeuf de poule. Journ. de l'anatomie et de la physiologie, Paris, T. **XXX**:155-161.
3. HARRISON, JOHN R. 1957. Morphogenesis of chick embryo in vitro after exposure to lowered temperatures in ovo. Physiol. Zool. **30**(3):187-197.
4. HARRISON, JOHN R. and IRVING KLEIN. 1954. Effect of lowered incubation temperature on the growth and differentiation of the chick embryo. Biol. Bull. **106**(1):48-59.
5. MORENG, ROBERT E. and REECE L. BRYANT. 1956. The resistance of the chick embryo to low temperature exposure. Poultry Sci. **35**:753-757.
6. ROMIJN, C. and W. LOKHORST. 1955. Chemical heat regulation in the chicken embryo. Poultry Sci. **34**:649-654.
7. ———— 1956. The caloric equilibrium of the chicken embryo. Poultry Sci. **35**:829-834.
8. SPRATT, N. T., JR. 1950. Nutritional requirements of the early chick embryo. III. The metabolic basis of morphogenesis and differentiation as revealed by the use of inhibitors. Biol. Bull. **99**:120-135.
9. ———— 1951. Demonstration of spacial and temporal patterns of reducing enzyme systems in early chick blastoderms by neotetrazolium chloride, potassium tellurite and methylene blue. Anat. Rec. **109**:384-385.
10. ———— 1951. Effects of starvation on development and on reducing enzyme activities of early chick blastoderms. Anat. Rec. **111**:553-554.