RESISTANCE OF CHICKEN EMBRYOS TO MECHANICAL DISTURBANCES [1]

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INTRODUCTION

The effect of mechanical shock on eggs during incubation has long been a matter of speculation. The idea is prevalent that a sudden jar or vibrations of the earth such as are caused by earthquakes, dynamite explosions, claps of thunder, or even the passing of trains, affect hatchability. Little or no concrete evidence has been presented to support or to disprove this idea although reliable information would be valuable from a practical, as well as a scientific, standpoint. If developing embryos are more easily killed at one age than another, the hatcheryman could avoid unnecessary handling of the eggs at a critical time, and thereby increase the chances for improving the hatch.

The very extensive literature on the susceptibility of the embryo and its parts to various external agents has been summarized by Hyman.[2] Most of this literature has to do with the origin of terata and contains the results of qualitative experiments with very young embryos or with eggs subjected to various external forces prior to incubation. The opinion is generally accepted that all harmful agents produce similar effects when applied at similar times to the whole embryo and that they affect those parts of the embryo that are developing most rapidly. Since development in earlier stages usually proceeds more rapidly than in later stages, it is generally held that the younger embryos will be most affected by a given force. However, quantitative data on the susceptibility of the embryo at successive stages of incubation and data for later stages are very meager. In this paper quantitative data are presented showing the resistance of the embryo at different stages of development to various forces applied externally to the egg.

MATERIALS AND METHODS

Eggs obtained from a flock of White Leghorns at the National Agricultural Research Center, Beltsville, Md., in 1934, were used for these experiments. The eggs were carefully selected to eliminate, as far as possible, variations due to the breeding and the management of the adult birds and the storage conditions of the eggs previous to incubation.

All the experimental eggs, including the controls, were incubated in a force-draft cabinet-type machine operated at 99.9° F. with a wet-bulb reading of 85°. The eggs were racked in the trays, large end up, and were turned four times daily.

[1] Received for publication September 24, 1937; issued March, 1938.

[2] HYMAN, L. H. THE METABOLIC GRADIENTS OF VERTEBRATE EMBRYOS. III. THE CHICK. Biol. Bull. 52: 1–38, illus. 1927.

Susceptibility of the embryos, at different stages of development, to mechanical shock was tested by applying force to the egg in different ways: (1) By placing eggs in a shaking machine, (2) by centrifuging, (3) by striking the eggs against the operator's hand, and (4) by placing them near blasts of dynamite. In order that only strong embryos would be used, the eggs were removed from the incubator and candled just prior to treatment by one of the foregoing methods. After treatment they were again placed in the machine, where they were left for 3 days before they were again removed and candled. All eggs containing dead embryos were broken and the embryos classified as to time of death.

EXPERIMENTAL RESULTS

EFFECT OF SHAKING

Each day during incubation, two groups of eggs containing embryos of known ages were placed in a mechanical shaking machine and treated for 7 minutes. This machine was driven by an electric motor

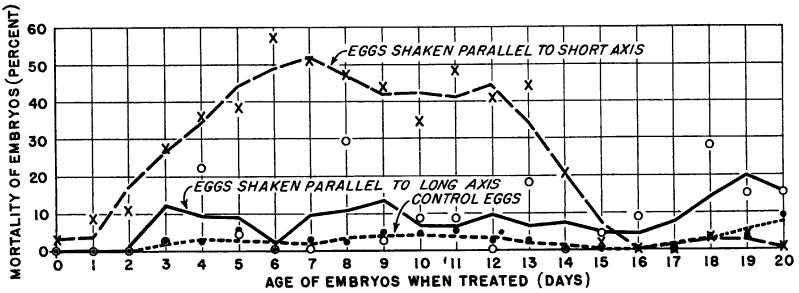

FIGURE 1.—Mortality among embryos in eggs shaken daily for 7 minutes in a mechanical shaker.

at the rate of 229 oscillations per minute through a distance of 3 inches. One group of eggs was so placed in the machine that they were shaken in a direction parallel to the short axis of the egg. The second group was so placed that the direction of force was exerted parallel to the long axis of the egg. During the entire incubation period the test involved 1,252 eggs in the first group, 708 eggs in the second group, and 350 eggs in the control group. The percentage of mortality, showing the effect of this particular type of shock on the embryos at various stages of development, is shown in figure 1

Each point was obtained by dividing the number of deaths which occurred within 72 hours after treatment by the number of live embryos treated. The curves have been smoothed by the three-point method of moving averages. The figure shows that eggs shaken parallel to the short axis of the egg were affected more severely than those shaken parallel to the long axis. In both groups, affected embryos usually died within 72 hours after treatment as a result of rupture of the yolk sac or hemorrhage caused by disruption of the chorio-allantois from the overlying shell membrane. There was little or no delayed mortality and no apparent teratogenic response to treatment at any point in the incubation period. In the eggs shaken parallel to the short axis, mortality attributable to treatment increased rapidly to the fourth day, where it remained within a range

of 30 to 50 percent most of the time until the thirteenth day and then rapidly decreased to zero. In the other treated group, however, the percentage of mortality was rather constant during this period.

EFFECT OF CENTRIFUGING

During each day of the incubation period, two groups of eggs containing embryos of known ages were placed in a centrifuge. One group of eggs, totaling 1,263 at the beginning of this phase of the experiment, was placed in the centrifuge cups blunt end foremost so that the direction of force would be exerted against the large end of the eggs. The second group of eggs, numbering 1,304, was placed pointed end foremost in the centrifuge cups. The eggs were centrifuged for 1 minute, during which time the maximum force exerted on a 2-ounce egg was 1,732 dynes and the average force 710 dynes. After treatment the eggs were removed from the centrifuge and replaced in the incubator, where they remained for 3 days before they were candled and eggs containing dead embryos removed. In

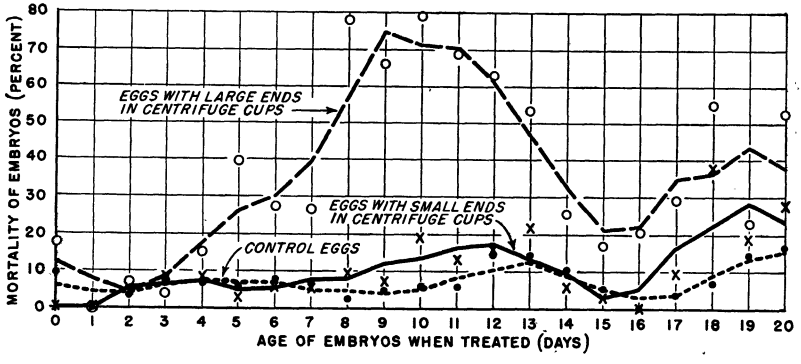

FIGURE 2.—Mortality among embryos in eggs centrifuged for 1 minute.

this phase of the experiment, 850 eggs were used in the control group. The percentage of mortality attributable to treatment on successive days of incubation is shown in figure 2. As in the case of eggs treated in the mechanical shaker, the percentage of mortality was calculated from the number of deaths occurring during a period of 72 hours after treatment. The mortality curves shown in figure 2 have been smoothed by the three-point method of moving averages. The curves are similar to those of eggs that were shaken, in that mortality was much heavier in one of the groups and the heaviest mortality occurred approximately at the same period of incubation.

The effect of treatment in neither group placed in the centrifuge was apparent during the first 3 days of incubation. After that time there was a sharp rise in mortality among embryos in eggs on which force was exerted on the blunt end, the trend line reaching a maximum of 74.0 percent on the ninth day of incubation, gradually receding until it reached 20.5 percent on the fifteenth day, then again rising to an average of about 34.4 percent for the remainder of the incubation period. This same general trend is noticeable but to a far less degree in the group centrifuged with the force exerted on the small end of the egg.

The major cause of death among embryos of both centrifuged groups was found to be broken yolk sacs and ruptured blood vessels of the chorion and the allantois. In these groups of eggs, and especially in the group centrifuged with the large end in the cup, tremulous air cells were produced. Those embryos that survived the treatment showed no ill effects, and in most cases the air cell became fixed again when the chorion and allantois came in contact with the shell membrane. It appears that tremulous air cells are a result of adverse conditions affecting eggs and causing high mortality of the contained embryos and are not the direct cause.

EFFECT OF JARRING

Susceptibility of embryos to mechanical shock was tested by jarring eggs at successive stages of incubation. Each day a group of eggs containing live embryos was removed from the incubator and subdivided into two groups. The blunt ends of one lot of eggs were

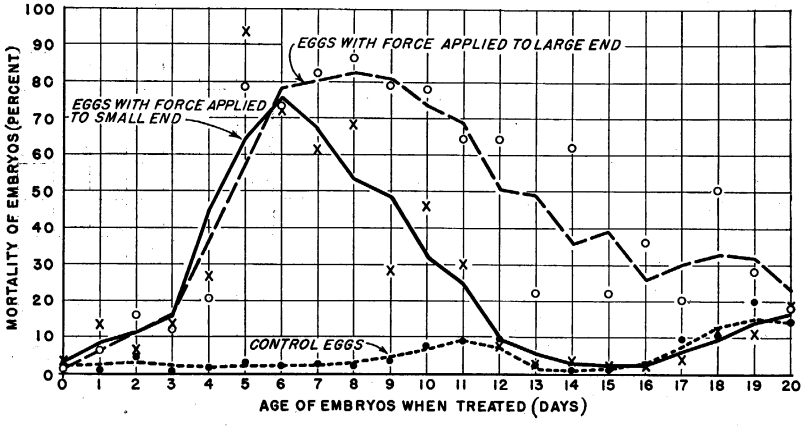

FIGURE 3.—Mortality among embryos in eggs which were jarred against operator's hand.

struck three times against the palm of the operator's hand. The other group was treated in the same manner except that the pointed ends were struck against the operator's hand. In many cases the force was sufficient, especially in the group struck on the blunt end, to produce tremulous air cells in the eggs. During the entire experiment the test involved 1,020 eggs in the first group, 990 in the second group, and 1,163 in the control group. The mortality resulting from the different methods of treatment is shown in figure 3. As in the case of eggs treated in the centrifuge, the points shown on the graph are the percentages of embryos that were killed within 72 hours after treatment. The curves shown have been smoothed by the three-point method of moving averages. It will be noted that the mortality was heavier in the group of embryos in which force was applied on the large end of the egg. This finding is in agreement with that of Knox and Olsen,[3] who found that eggs, when struck on the large end before incubation, failed to hatch as well as either the controls or the group struck on the small end of the egg.

[3] KNOX, C. W., and OLSEN, M. W. THE EFFECT OF TREMULOUS AIR CELLS UPON THE HATCHABILITY OF EGGS. Poultry Sci. 15: 345-348. 1936.

EFFECT OF EXPOSURE TO DYNAMITE BLASTS

Groups of eggs containing embryos of the ages shown in figure 4 were placed near areas where tree stumps were being blasted. The charges of dynamite placed under the stumps ranged from 3 to 28 sticks of 20-percent gelatin dynamite. In this phase of the experiment, 755 eggs were subjected to this type of shock and 623 were used as controls. The former were candled just prior to treatment and then racked, small end uppermost, in an incubator tray and carried to the area where the blasting was being done. The eggs, with the exception of the groups treated on the eighth, ninth, and fourteenth days, were placed within 5 feet of a stump to be blasted and the tray tilted in such a position that the force of the concussion would be exerted on the large end of the egg. To insure against damage from falling objects, the tray of eggs was covered with an empty incubator tray and then was partly buried in the red clay soil. The treatment was so severe that in many cases 20 to 30 percent of the shells of the treated eggs were broken.

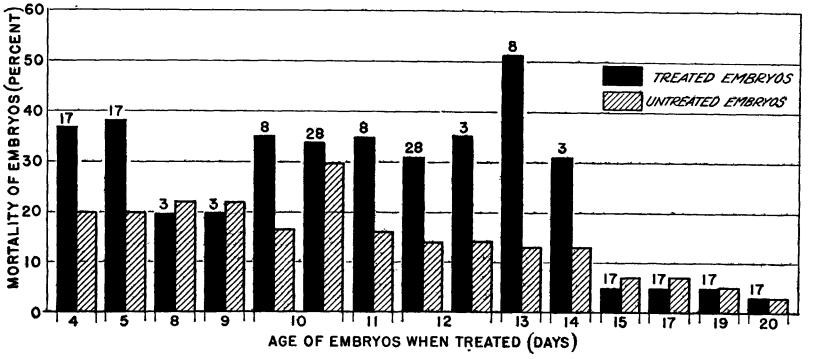

FIGURE 4.—Mortality among embryos in eggs subjected to shock from various sized charges of 20-percent gelatin dynamite. (Numbers at top of bars indicate number of half-pound sticks of dynamite used).

The eggs in the groups treated on the eighth, ninth, and fourteenth days of incubation were racked, large end up, in the incubator trays and the tray placed upon the surface of the ground. Directly over the eggs and within 1 foot of them three sticks of 20-percent dynamite were suspended and discharged. This was done to discover whether the shock transmitted through the air to the eggs was as severe as when transmitted through the ground.

After treatment all the eggs were carried back to the laboratory, where they were candled and those having broken shells were removed. The remainder were replaced in the incubator. The maximum time any group of eggs was out of the incubator during treatment was 30 minutes. The percentage of mortality of embryos in eggs that were not broken when subjected to this type of shock is shown in figure 4. The relative size of charges of dynamite used in each treated group is also indicated. Figure 4 shows the same general effect of this type of mechanical shock as was found in eggs which were shaken, jarred, or centrifuged. In the experiment with dynamite, however, the effect of the shock was cumulative and not so noticeable in mortality during the 72 hours following treatment as at the end of

the incubation period. The percentage mortality shown in figure 4, therefore, is the total mortality from time of treatment to end of incubation. However, this figure in general shows the same susceptible period to mechanical shock, with the exception of the 8- and 9-day points, as shown in the other treated groups, that is, from the fourth to the fifteenth day of incubation. Embryos in eggs subjected to shock on or after 15 days of incubation showed little or no effect due to treatment. The shock on the eighth, ninth, and fourteenth days, as previously pointed out, was transmitted to the eggs through the air instead of through the ground as in the case of the other treated groups. The charges of dynamite used to produce the shock at these points were smaller than those used on the other days of incubation. Either or both of these factors may help to explain the apparent discrepancy in the data.

SUMMARY AND CONCLUSIONS

The data presented show that chicken embryos can be killed by mechanical disturbances caused by jarring, centrifuging, or concussion of the air or ground. In addition, it is shown that embryos are more affected by mechanical shock from the fourth to the fifteenth day than at any other period during incubation. Mortality among embryos was caused chiefly by broken yolk sacs and ruptured blood vessels. In many cases, tremulous air cells were produced by the different treatments, especially when the force was applied at the blunt end of the egg, and in such cases mortality was heavy. The tremulous air cells, in eggs where the embryos survived the treatment, became fixed when the allantois attached again to the shell membrane.

From the results of this experiment, it is recommended that hatching eggs during the period from the fourth to fifteenth day be handled as gently as possible and that they be candled on or after the fifteenth day where this is practicable.