A METHOD FOR RECORDING THE RESPIRATORY AND HATCHING MOVEMENTS OF THE CHICK EMBRYO

By C. M. DAWES

Department of Physiology, Royal Veterinary College, London NW1 0TU

(Received 8 August 1975)

SUMMARY

1. An artificial air space was made in the narrow end of the pipped egg by separating the shell membranes from the shell.
2. The respiratory and hatching movements of the embryo set up pressure changes within the artificial air space and these were recorded up until the moment when the chick emerged from the shell.
3. Random movements appeared to be inhibited during the period of hatching.
4. The ways in which the presence of the artificial air space might affect the embryo have been discussed.

INTRODUCTION

The egg shell of the domestic fowl is lined by two shell membranes which are closely applied to each other except in the broad end of the egg where they are separated by an air space. About 20–30 h before hatching, the beak of the embryo penetrates the membranes which lie between it and the air space, and the embryo then begins to breathe. About 10 h later, a crack is made in the shell overlying the air space. This event (pipping) is followed by a period of about 10–20 h before the chick hatches, and during this time the crack in the shell may become enlarged to form a pip-hole.

The event of hatching, or climax, lasts for a period of about 50 min (Oppenheim, 1973). During climax, the embryo moves its body in a highly co-ordinated manner about once every 10–12 s (Hamburger & Oppenheim, 1967; Kovach, 1970; Bakhuis, 1974). Each burst of activity lasts about 1–3 s (Oppenheim, 1973) and consists of a cracking phase in which the shell is pierced by a vigorous backward movement of the head and beak, followed by a turning phase in which the body of the embryo rotates within the egg (Bakhuis, 1974). After about two-thirds of the circumference of the shell have been perforated by these movements, the embryo pushes the shell apart and emerges from the egg (Oppenheim, 1973).

The movements of the embryo set up pressure changes within the air space of the egg which can be used to record the pattern of respiration (Romijn & Roos, 1938; Romijn, 1948; Windle, Scharpenberg & Steele, 1938; Vince & Salter, 1967). The pressure changes cease after the pip-hole has been formed (Romijn & Roos, 1938; Romijn, 1948). It is possible to obtain recordings of both respiratory and climax...
movements during the period between pipping and emergence by selecting one of the minority of eggs in which the embryo has pipped the shell away from the air space (Dawes, 1973; 1975); but many of the embryos which by-pass the air space have their heads in the small ends of the eggs and would be classified as malpositioned (Romanoff, 1972). By making an artificial air space in the narrow end of the egg, recording can be made from a normally pipped egg.

MATERIALS AND METHODS

Fertile eggs of the domestic fowl (White Leghorn) were incubated at 39.4 °C in a ‘still air’ incubator and were turned twice daily according to normal practice. Six pipped eggs were selected for these experiments. In each egg, the movements of the head and chest wall of the embryo could be clearly seen through the pip-hole and the embryo could be heard squeaking, indicating that pulmonary ventilation had begun. After removing the egg from the incubator, a small hole, about 2 mm in diameter, was drilled through the shell at the extreme end of its narrow pole. A blunt seeker was introduced into this hole so that the shell membranes could be pressed away from the shell to form an artificial air space with a volume of up to about 0.3 cc. A short length of plastic tubing was passed through the hole so that it protruded slightly into the air space. The tubing was then sealed into position using epoxy cement. The preparation is illustrated in Fig. 1. The tubing was connected to a Mercury pressure transducer (Type M3), the output of which was recorded upon a Devices Recorder. The pressure changes which corresponded to the various movements of the embryo were identified by comparing the recording with the movements of the embryo as seen through the pip-hole. An electric lamp was used to illuminate the pip-hole and to maintain the egg at the same temperature as that of the incubator while the recordings were made. In three of the eggs, the pressure changes were recorded up until the moment when the chick emerged from the egg. The other eggs were returned to the incubator before hatching activities began.

RESULTS

Pressure changes which corresponded to the respiratory movements of the embryo during the last few hours before hatching were obtained for each of the six eggs
Recording the movements of the chick embryo

Fig. 2. Record of pressure changes in the artificial air space of a pipped egg. The record began about 72 min before the chick emerged from the egg. Variations in pressure which corresponded to a random movement (R) and a head thrust (C) are indicated in the top trace. The onset of climax is characterized by a marked increase in head thrust activity (trace d).

used in this study. A representative trace is shown in Figs. 2 and 3. The recording began about 72 min before the chick emerged from the egg. At first, the major component of the trace was respiratory, with the embryo breathing at a rate of about 60–65 breaths/min (Fig. 2a, b, c). Superimposed on this respiratory pattern were: (1) brief, irregular changes in pressure which were often accompanied by random movements of the embryo, (2) relatively large changes in pressure which usually coincided with a thrust of the head and beak of the embryo in a backward direction against the shell, and (3) slow fluctuations in pressure which were sometimes rhythmic (Fig. 2b) but did not appear to be related to any movements which could be seen through the pip-hole. At about 47 min before emergence, there was a marked increase in the head thrust activity of the embryo (Fig. 2d) and, after a period in which these movements varied in frequency, they were maintained at a rate of about 5/min until the moment of emergence (Figs. 2, 3). The respiratory frequency of the embryo increased as the time of emergence was approached (Figs. 2, 3) and there appeared to be a marked increase in the amplitude of respiration during the 5 min period preceding emergence (Fig. 3). The pressure changes in the air space ceased immediately after the embryo had emerged from the egg; the brief fluctuations which occurred later were due to the chick moving the egg as it attempted to stand (Fig. 3).

In the two other eggs in which hatching was recorded, climax lasted about 42 and 63 min and the traces for both eggs were very similar to those shown in Figs. 2 and 3. In the three remaining eggs, the patterns of pressure changes were similar to those shown in Fig. 2a throughout the period of recording.

All the embryos appeared to hatch normally and the artificial air space was found to be intact in each egg after the chick had left the shell.
Fig. 3. Record of pressure changes in the artificial air space of a pipped egg. The record is continuous with Fig. 2. The pressure changes ceased immediately after the chick emerged from the shell; the two bursts of pressure changes which occurred later were due to the chick moving the egg as it attempted to stand (bottom trace).

DISCUSSION

The hatching movements of the embryo within the intact egg can be monitored by placing the egg on a piezoelectric transducer (Salter, 1966; Kovach, Callies & Hartzell, 1970). Alternatively, the egg can be placed on a device in which the displacements of the egg move a coil over a magnet and induce an electric current within the coil (Corner & Bakhuis, 1969; Corner, Bakhuis & van Wingerden, 1973). In the method described in the present study, hatching activity can be recorded against a background of the respiratory pattern of the embryo but it is necessary to remove a small part of the shell from the narrow pole of the egg (Fig. 1). This procedure may affect the embryo in at least two ways.

Firstly, there may be a change in the rate at which gases are exchanged between the environment of the egg and the chorioallantois which lies just beneath the inner shell membrane. This effect is likely to be negligible when recordings are made at the end of the period of incubation; after the egg has been pipped there is a gradual decline in the exchange of gases across the shell while the lungs take over as the principal respiratory organ of the embryo (Visschedijk, 1968) and the major blood vessels of the chorioallantois become closed off from the body of the embryo just before or within 15 min after the onset of climax (Hamburger & Oppenheim, 1967).

Secondly, there may be some interference with the mechanical aspects of hatching. During each climax movement, the tarsal joints of the embryo are pushed against the narrow pole of the egg and this helps to keep the embryo in position while the shell is pierced by the beak (Bakhuis, 1974). In each of the eggs used in the present work, the parts of the shell membranes which line the artificial air space were found
Recording the movements of the chick embryo

383

do be intact after the chick had emerged from the egg. It therefore appears that
either the force exerted by the tarsal joints is not sufficient to tear the membranes or
that the tarsal joints never reach them.

The relatively large changes in pressure which occur within the artificial air space
during each climax movement (Figs. 2, 3) may be due to an increase in the depth of
breathing, and tarsal movements may be a contributory factor. During the periods
between climax movements the pressure changes are due almost entirely to the
rhythmic breathing of the embryo (Figs. 2, 3) and this is in keeping with data obtained
from the intact egg which indicate that random movements are inhibited during
climax (Corner & Bakhuis, 1969; Kovach, 1970). It should be noted, however, that
random movements may be localized at the head-end of the embryo and not be
visible on the recordings obtained from the artificial air space.

I wish to thank Professor M. G. M. Jukes for helpful advice and for the use of
apparatus.

REFERENCES

Physiol. Psychol. 87, 997–1003.

CORNER, M. A. & BAKHUIS, W. L. (1969). Developmental patterns in the central nervous system of
birds. V. Cerebral electrical activity, forebrain function and behavior in the chick at the time of

life in the domestic chicken, and their relationship to hatching and embryonic motility. In Studies

DAWES, C. M. (1973). The effects of anoxia on the respiratory movements of the hatching chick.


J. exp. Zool. 166, 171–204.

KOVACH, J. K. (1970). Development and mechanisms of behavior in the chick embryo during the last
five days of incubation. J. comp. Physiol. Psychol. 73, 392–406.


OPPENHEIM, R. W. (1972). Experimental studies on hatching behavior in the chick. III. The role of


ROMIJN, C. (1948). Respiratory movements of the chicken during the parasfoetal period. Physiologia

RONOJ, C. & ROOR, J. (1938). The air space of the hen’s egg and its changes during the period of


582–3.

VIVSEDEKIJK, A. H. J. (1968). The air space and embryonic respiration. 1. The pattern of gaseous

WINDLE, W. F., SCHARFENBERG, L. G. & STEELE, A. G. (1938). Influence of carbon dioxide and