INCUBATION TEMPERATURES OF THE NORTH ISLAND BROWN KIWI
(Apteryx australis mantelli)

By BARRY ROWE

ABSTRACT

Incubation temperatures of the North Island Brown Kiwi *(Apteryx australis mantelli)* were studied by telemetry methods. Using the equipment described, the temperature was found to be 37.0°C on the upper surface of the egg in contact with the male's brood patch and 35.0°C at an approximate embryo depth within the egg. Using the temperatures obtained and to test the observation that the eggs are not turned, artificial incubation of a Kiwi egg was successfully carried out.

INTRODUCTION

The successful development of a fertile avian egg depends on the three physical factors of temperature, humidity and mechanical turning frequency being maintained within fairly narrow limits.

Since a Kiwi egg is very large when compared with the size of the incubating male (approximately 20% of the male's mass) it seems likely either that the egg is turned frequently to maintain even temperatures throughout the egg, or that the egg is not turned at all and the embryo tolerates a gradient of temperature which decreases through to the bottom of the egg.

Flieg (1973) gave incubation temperatures of five species of ratites, the eggs of which are, however, incubated by birds whose body is much larger in proportion to the egg than is the Kiwi, so that the heat flow from the incubating parent is not particularly unusual. For example, an Ostrich egg is 1.7% of body weight, according to Welty (1975).

Previous surveys of incubation temperatures refer to " internal egg temperature," " mean egg temperature," or simply " egg temperature," as if this were uniform throughout the egg (Huggins 1941, Drent 1970, White & Kinney 1974). Although this is no doubt adequate for most bird eggs, there can exist a significant vertical temperature gradient within larger eggs, which must reach an extreme in an egg as large in proportion to the incubating adult as a Kiwi's.

METHODS

To obtain temperatures continuously, telemetering equipment was installed in a dummy egg. The transmitter used an integrated circuit

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timer wired up as an audio oscillator with a thermistor which changed frequency when the resistance altered with temperature change. The range was about one metre.

Signals were picked up by an aerial set into the back of the Kiwi's burrow. The aerial was run to the outside of the pen into a covered van, a distance of about ten metres, and connected to a receiver and logic decoder. Readings were recorded on a Metrohm Labograph E428 chart recorder using a chart speed of 20 mm per hour. The egg used was a fibreglass shell approximately 3 mm thick and measured 135 mm x 85 mm. The shell was split longitudinally into equal halves. One thermistor was cemented flush with the shell surface with epoxy resin (Araldite). This was positioned 45 mm back from the " air-cell " end of the egg, which placed it 2 mm below and 10 mm forward of the greatest diameter. This thermistor gave temperatures at the shell surface. The transmitter was then placed in this half of the shell. The second half of the shell was filled with paraffin wax which has a specific heat close to that of egg albumen (Varney & Ellis 1974). Into this matrix, 33 mm from the shell surface and positioned lengthwise so as to be in the centre of the egg, a second thermistor was placed and wired to a double throw switch so that either shell or core temperatures could be monitored. The completed egg weighed 420 g, which is within the normal range for this species. Temperature readings were taken from a single bird nesting in an artificial burrow within a 250m^2 enclosure at the Otorohanga Zoological Society's aviaries at Otorohanga.

The egg was resting on a natural soil base, the top and sides of the " burrow " being built of untreated and unsealed timber 20 mm thick. Kiwis had used this burrow successfully the previous season to incubate six eggs.

Testing was spread over July and August so as to cause least disturbance to the incubating male and covered the period from the first egg laid, up to and including the period when the third egg was laid. No more than two eggs were left with the bird, including the dummy egg. In each test period, the dummy egg (previously warmed) was substituted for one of the bird's eggs.

By rotating the dummy egg, five different readings were possible: (1) top shell temperature (2) bottom shell temperature (3) upper core temperature (4) mid-core temperature (5) lower core temperature.

Each position was tested for three separate periods of 24 hours. The thermistors were calibrated in a still-air incubator with a mercury thermometer held horizontally from the thermistor point, and a water-bath was used to obtain core calibrations. A further check was done by placing copper-constantan thermocouples at each thermistor point and readings were taken direct from an electric thermometer (Model Bailey BAT.4).

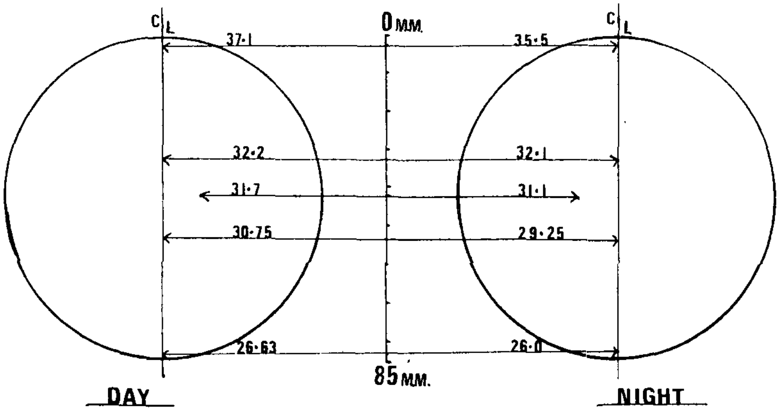

FIGURE 1 — Diagrammatic cross-section of egg showing temperatures obtained at points indicated. Figures are degrees Celsius.

RESULTS

The readings are summarised on the egg cross section (Fig. 1). The variation in temperatures from night to day are opposite to the body temperatures of the Kiwi published by Farner *et al.* (1956). The gradient in temperatures through the egg was consistent. Interference to the radio signal after dusk and again before dawn did suggest the egg may have been turned. Checks, however, showed the egg had been shuffled without being turned over, as the bird left the burrow to feed.

Observations on viable eggs at Otorohanga have shown that the air-cell faces uppermost throughout incubation. (The air-cell in a Kiwi egg lies off-centre at the larger end.)

Typical bird eggs are turned frequently to prevent adhesion of the membranes. On hatching, the chick is able to rotate within the egg and, using its egg tooth, pip its liberating circle of punctures. However, the Kiwi does not hatch in this typical manner. Generally, a single puncture is made in the air-cell end which has a thinner shell than the rest of the egg (Calder, pers. comm.). No egg tooth has been observed at this stage or in two partially developed embryos examined. The hatching chick may pause for as long as two days before finally flexing and rupturing the shell, which usually fractures along the line of the air-cell. It seems, therefore, that the Kiwi egg does not need to be turned because the chick does not have to rotate at hatching.

To test these ideas, a normal Kiwi egg was placed in a still air incubator (Onslow Model 0-90), to give the required gradient in temperature through the diameter of the egg. The temperature at the top of the egg was 35.0°C and the air-cell was kept uppermost. The egg used weighed 402.6g immediately after laying and measured 160 mm x 77 mm. The egg was candled periodically to check progress and was placed in a metal can every two to three days for metabolic experiments, but received no deliberate turning. Humidity was kept at approximately 70% RH until hatching when it was increased to 87% RH. Hatching occurred after 71 days.

Within limits, an embryo develops more rapidly the higher the temperature, and therefore the temperature at which an egg is incubated affects the rate of embryo development and the time of hatching (Welty 1975). Hence, if the temperatures of the incubator are set appropriately, the incubation time should correspond to that observed in nature. In the practical test applied, the incubation time of 71 days falls within the minimum range of that observed for the Kiwi at Otorohanga.

DISCUSSION

Hatching success of domestic hen eggs falls to 15% if the eggs are not turned at least once daily (Welty 1975). A positive statement that Kiwi eggs do not need turning cannot therefore be made on the results of the one egg artificially incubated and further eggs will need to be tried before this can be proved beyond doubt. However, it may well be that the Kiwi embryo by its extreme activity, prevents adhesions in the developing embryo. We have observed that at 49 days a Kiwi embryo is capable of changing its position inside the egg, causing the egg to rock when placed on a flat hard surface. The physical problem of turning an egg as large as a Kiwi's within the small floor area of the natural burrow may have led to the unusual feature of an active embryo inside an egg that is not turned. The Australian megapodes are one of the few species known currently which do not turn their eggs.

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Telemetry circuits are available on request from the author.

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SHORT NOTE

FIJI WHITE-THROATED PIGEON NESTING IN AN EPIPHYTE FERN

The White-throated Pigeon *(Columba vitiensis)* is generally (Mayr 1945: 65, Goodwin 1970: 90) said to build its nest 3-6 metres above the ground in forest trees. Kleinschmidt (Anon. 1876: 173) reported nesting only 4-8 feet above the ground in Fiji. There is one definite record of the New Caledonia race *(C. v. hypoenochroa)* nesting on the ground (Warner 1949: 90), confirming what the Layards (1882: 528) had been told.

On 27 September 1975, 300 m a.s.l. on the cliffed but partially bush-clad southern face of Joske's Thumb, a 442 m volcanic plug in southern Viti Levu, Fiji, I found a White-throated Pigeon's nest in a large " bird's nest fern " *(Asplenium nidus)* 3 m above the ground in a stunted tree. The pigeons had built in the centre of the epiphyte fern. The large surrounding circle of fronds, clustered about the humus and leaf-litter covered rhizome, formed a cup support fully as firm as the ground and completely concealed the nest from below. I discovered the nest only because I glanced down while descending the cliff directly above it, and noticed the incubating bird.

The nest was a typical pigeon's nest of twigs some 25 cm in diameter, and contained a single white egg measuring 40 mm by 28.9 mm, at an early stage of incubation.

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