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NOTES ON HEAT GENERATION AND MANAGEMENT IN THE MOUND OF THE MALLEEFOWL (Leipoa ocellata)

By H. L. Buckingham

Of the three Australian species of the Megapodiidae (i.e. the mound-incubating birds) the Malleefowl alone has its habitat in the temperate zone of southern Australia. Unlike its two congeners, which live and breed in the warmer and more equable climate of tropical and sub-tropical Australia, this bird is confronted with the formidable task of raising and maintaining the necessary incubating temperature of 92^0 plus or minus 2 or 3 degrees, in a region subject to many and at times extreme variations in daily, seasonal and even yearly weather conditions.

During the breeding season here, in the arid, inland Mallee district of North-western Victoria, these extremes can result in a. fluctuation in air temperature at the mound of as much as 60^0 in 24 hours, whilst surface ground temperatures can show a variation of up to 90^0 in only a few hours. A typical and not uncommon change of this nature was recorded at a mound on a day in mid-November. A thermometer laid on the sand at the top of the mound at sunrise registered a sand surface temperature of 43^0. At noon the thermometer, scaled to 120^0, was placed at the same spot and within two minutes the mercury had climbed to the top of the tube, half an inch above the last graduation mark.

Such short changes seem to be of little concern to the birds and they have no measurable effect on the constant temperature of the material surrounding the eggs, as this is protected from them by two feet of insulating sand. On the other hand, changed conditions of longer duration, such as protracted heat-waves or prolonged or unseasonable cold spells with cooling winds, cloudy skies and rain, do have an appreciable effect on the temperature of the mass of the mound and demand definite and precise regulatory measures by the bird.

However, it is in the long term, that is to say in the long, slow march of the seasons through the whole gamut of the meteorological record, that the full extent of efficient heat management practice is revealed. From late August, when the first egg is about to be laid in the dying days of chilly winter, through the vagaries of unpredictable spring and the scorching days of high summer, right on into the falling temperatures of early autumn, when the last eggs in the incubator still have to be hatched, these birds maintain the unchanging temperature around the buried eggs. For all this time, through the widest range of seasonal temperatures and against all the hazards and challenges of nature, they are constantly on the alert.

It is the intention here to record some of the things seen along the way. For convenience and consistency the observations are restricted to those made at one selected mound, over the full breeding season. Although there are minor differences in method due to individual traits, the overall pattern of control is the some in all the mounds in the area under study. It has to be. All temperature recordings were measured in the Fahrenheit scale.

The first signs of fermentation and increase of temperature in the mound were noted in the third week In August. For about a fortnight before this the litter, which had been slowly gathered and raked into the hollow mound over the past four months, had been intermittently worked in a grading process which had brought the coarser material to the top or the heap. The litter consisted largely of Mallee leaves, twigs and bark from the forest floor, together with a very small proportion of tea-tree leaves from a few small bushes growing along the path from which the litter bad been gathered.

During the grading process a light mixture of sand from the mound walls was worked into the upper layers, the material in the egg-chamber consisting solely of the finest leaf litter in a saturated state at a temperature of 48^0. This was on the 15th August. It seemed to be a most unpromising time for preparing for incubation, the maximum shade temperatures in this week ranging from 54^0 to 63^0. The mound walls at ground level were 46^0 and land temperature at a depth of 24" was 48^0. (This was to rise in February to a maximum of 86^0 at the same depth - a condition which would have a considerable influence on heat control methods).

From this day on there was a noticeable change in the activity of the male bird. He began opening the mound daily, mixing more and more sand with the litter and gradually building up the familiar domed shape. It was observed that the litter of the egg-chamber remained undisturbed, only the upper part of the mound being worked. At this stage it was a mound within a mound, the reduced walls of the old mound not being fully incorporated for another three weeks, whether fortuitously or by design being known only to the bird.

Fermentation proceeded slowly. A week later, on 22nd August, the temperature in the egg-chamber had risen 12^0 to 60^0. The daily adding and mixing of more sand from the old walls continued; this was accompanied by accelerated heat generation and the temperature in the egg-chamber litter rose 22^0 to 82^0 over the next- four days. (It was here thought that the rise might have been due to the increased compression of the litter by the additional weight of the sand added daily. This, of course, is entirely speculative, but some point is given to the inference from the observation of a mound which was filled with litter and then abandoned, no other work being done on it. The litter did not ferment although it was gathered and soaked at the same time as that in the mound being discussed.)

Even at this early stage it seemed that the bird was endeavouring to conserve solar heat in the mound. After digging it out each morning to within a few inches of the egg-chamber and probing the underlying litter two or three times, the rest of the day would be spent slowly restoring the sand which had been spread and stored to warm in the mild winter-spring sun.

For some reason fermentation heat was increasing very slowly at this time - up 4^0 to 86^0 over the next six days. It is possible that the daily opening was designed to release excessive heat as well as for other purposes. Temperatures of 86^0 were recorded every morning in the places tested by the bird but a few days later it was found that deeper down, where the eggs would be deposited, the heat was 9^0 higher. Up to this time the temperature of the mass of sand above the egg-chamber had risen by 18^0 to 64^0, showing the effect of the daily mixing and warming. The unworked mound walls were still 48^0.

On the 3rd September, 19 days after preparation began, the male came to the mound soon after sunrise and proceeded to open it. It was a morning of white frost. The hidden hen was heard cooing close at hand, the male clucking in reply as he steadily drove downwards. Two hours later, and about 10" above the egg-chamber, he tested for the first time. The hen was wandering aimlessly around, sometimes on the mound, sometimes disappearing, cooing incessantly.

The male continued digging, testing again and again as he deepened the hole. Getting down into the egg-chamber, he made a niche on one side for the egg. After probing it, he invited the hen down. She tested and rejected it. Covering it up, he dug a niche on the opposite side. Again it was rejected. The invitation and rejection was repeated three more times at different places. At the sixth essay, apparently in the same place as the first trial but a few inches deeper the hen remained in the hole, cooing distractedly and raking back the sand with powerful strokes. Suddenly she crouched, her wings opened to their widest spread, there was a convulsive movement of the body and a pink egg - the first of the season - rolled down the slope into the niche. The temperature of the litter wall behind the egg was 86^0. The whole operation had taken four hours.

The apparently erratic behaviour of the hen seemed to have a reasonable and practical basis a few days later when it was found that the temperature at egg level was 94^0. Every place tested could have been too hot to receive the egg and the delay in laying could have been part of a deliberate cooling down process. It is interesting to note that the male seemed satisfied with every place selected but the final choice rested with the hen. After laying the hen disappeared and the male, after covering the egg with a few inches of sand, left it for an hour before coming back to spend the rest of the day in the normal routine, restoring the sun-warmed sand at intervals. Maximum shade temperature was 63^0, solar heat on the sand surface 85^0.

For the next two days the male dug down and probed and left the mound open for an hour to release heat. He then restored the sand as usual but on the third day the situation down below had him worried. Twelve inches down the temperature was 64^0, six inches deeper it was 78^0, proof of heat rising from below. The bird tested at six inches above the egg, where it was 88^0. Throwing a few inches of sand back into the hole he left it for five minutes before coming back, going deeper and testing again on two places, both 90^0. Coming back a few minutes later he went deeper still and tested again. It was 95^0 at egg level. The mound was then left open for an hour and a half under an overcast sky at a shade temperature of 55^0 before being completely built up – the usual sun-warming procedure being omitted for the first time.

How much heat was released could not be determined, any attempt to insert the thermometer being met with showers of sand from an agitated bird frantically working to raise the height of the mound. Next day, no work at all was done. On the following day the male dug down to the egg-chamber, where it was 98^0 at egg level. It was left open for three hours and then filled in. Opened manually at 3 o'clock in the afternoon, the egg–chamber was found to be still at 96^0. It was hard to see why the bird seemed satisfied with this but it was subsequently learned that this was the peak day in the generation of fermentation heat. From that day on it was to slowly decline. It was difficult to resist the conclusion that the bird was aware of this.

The next day, the 9th September, six days after the first egg, the hen laid again. Everywhere in the egg-chamber it was 92^0, down 4^0 from the previous day. Two days later, it was 90^0. On the 15th September, when the third egg was laid, it was 87^0. For the next 40 days the egg-chamber remained at this heat level, while the temperature of the mass of the mound gradually rose as the male worked to capture and conserve solar heat.

On the 41st day, the 27th October, the temperature of the mass exceeded that of the egg-chamber for the first time. Midway between the top of the mound and the egg-chamber it was 92^0; at egg level it was 90^0. Solar heat had superseded fermentation heat. Shade temperature the day before had reached a maximum of 95^0, the highest for the season to date. Two days later the egg-chamber reached 92^0 and at which it was to remain constant for the rest of the breeding season.

This was also the last day on which the mound was opened solely for testing, except during a cold spell a few weeks later and towards the end of the incubation period in March. Henceforth the only probing was done on egg-laying days, when the egg-chamber was uncovered every sixth day. Temperature supervision and regulation continued, but in a different form and apparently through the employment of a new kind of sensory perception.

Typically, now, the male would come to the mound in the early morning, stir the sand a little and walk off to sit close by in the shade until the time came to start work. This seemed to depend on an appreciation of weather conditions- and an assessment of conditions within the mound. Sometimes it would be two hours later, sometimes earlier. Whenever the chosen time was reached the bird would walk straight to the mound and start working. At no time was there ever any preliminary testing or probing. Sometimes a few inches only would be removed, whilst at other times the bird went much deeper. There always came a time when it appeared that a critical depth had been reached and the bird would stop digging and leave the mound - leaving the surface open to the sun and gradually replacing the cover throughout the day.

Kept under the closest and sustained observation from a distance of 4 feet to 6 feet from the bird, no sign of beak or tongue testing was ever seen in these operations. The state below was known through some other sense. Digging ceased when a critical depth had been reached. Repeated readings showed that where the work stopped the range was from 87^0 to 92^0. Daily observation through the breeding season over several years has solidified the conviction that the information was conveyed by the feel of the sand's warmth beneath the feet of the bird.

It is certain that the bird knew what he was doing and that it was part of an efficient process of heat management. It would be easy to apply the superficial and dismissive term of "instinct" to these processes but as time went on it became just as easy and observationally more proper to see it as a manifestation of a highly specialized intelligence. There would be days when no work would be done, the male sitting in the shade watching over the mound until evening, apparently content to wait.

In mid-November came the first heat wave of the season, temperatures rising day by day over a week to a maximum of 105^0. For three days the mound was untouched, although the male was present every day from early morning until sundown. On the fourth day the top 12" or 15" was raked over a wide area, warmed and returned to the mound at 98^0. The next day brought a cool change which lasted nearly a week, with cloudy skies and some rain. Maximum shade readings were from 68^0 to 74^0.

The following day an egg was laid; heat in the egg-chamber was still 92^0. Three days later the male opened the mound, for testing only, for the first time in three weeks. Despite daily working in the brief periods of sunshine, the temperature of the mass had fallen. 4" from the top it was 74^0, 12" down, 84^0, 9" above the eggs, 90^0 and at egg level, 92^0. The next day dawned clear, warm and sunny. Both birds opened the mound down to the warm layer of 90^0. Leaving it exposed for an hour to the sun, they then commenced to restore the warmed sand at a surface temperature of 98^0. At noon the mound wag completed. Four inches from the top it was 105^0, having been raised 31^0 on a spring morning with a maximum of 81^0 shade and 107^0 sand surface.

Before passing to some other aspects of heat control one other matter of interest should be recorded. It was observed when the male was excavating the mound and had reached the critical depth. If the hen was present or approaching with the intention to assist the male, he displayed all the signs of agitation; crest raised, nervously stirring the sand back and forth and rapidly picking at the surface, mouthing pieces of shell or litter - always a sign of agitation or warning. Often If the hen continued working he would leave the mound and bellow disconsolately. Always within a few minutes the hen would leave and the male would then settle peacefully in the shade to watch and wait and to doze and work for the rest of the day. It was a clear indication of his control of the mound and her confidence in his judgement.

Methods of excavation play an important part in heat regulation. When the mound is opened for testing only, a broad, shallow saucer is scooped out. The bird digs quickly down in the centre to a point just above the egg-chamber. After probing, the small central hole is refilled and the rest of the mound is restored or warmed as conditions demand. It is a quick operation and no heat has been lost.

Another method, used when the mass is to be extensively warmed, is to begin around a wide perimeter, working towards the centre and returning to the outside to start again. This is repeated until a very broad, deep saucer has been formed. The greatest area has been exposed to the sun and the largest mass or sand shifted.

A very different method was first observed one cold November morning. Both birds began work at 7am. There was a clear sky, a cold south wind blowing and shade temperature was 46^0. This time they created a steep-sided bowl with a high rim and much smaller diameter. As they dug from outside to centre a small hill was left in the centre, above the eggs. Gradually the bowl deepened and the little hill went down with it. When the proper depth was reached the little hill was pushed aside, the area above the eggs was probed and then the last sand removed was immediately raked back over the egg-chamber. This was two hours after beginning, the cold south wind was still blowing and, surprisingly, the 9" of sand above the eggs was still 92^0. The birds then left the mound open to the sun and the cold air. The hen left and an hour later the male began to rebuild the mound, keeping well down in the bowl and raking the sand in from the steep sides, never mounting to the rim. The sand surface, in full sunlight outside the bowl, was 80^0, inside it was 98^0.

On this cold morning the birds had made a sheltered sun-trap, the high rim protecting it from the cold wind and capturing all the available heat from the sun's rays. By mid-day the mound was finished, the cold wind was still blowing, the shade reading was 67^0 and the mound, 4" below the top, was 104^0. If the necessary constant incubation temperature was subject to wide fluctuation arising from the frequent opening of the mound the incubation process would be a very hazardous one, but always the practices of the birds were seen to be perfectly adjusted to prevailing conditions.

As the season were on into January's higher temperatures working methods changed again. The mound was not worked as frequently as before and often it was untouched for two or three days. Also it became noticeably lower, as if the birds were maintaining the balance more by the penetration of solar heat than by active means. The top 9" could rise by 10^0 during the day and cool off at night. Often the mound would be left incomplete overnight as if to cool, and the height would be restored early next morning.

In February the heat of the summer reached its peak. Land temperatures had risen to 86^0 24" below the surface. Solar penetration was intensified; the top 10" of one mound - a flat top - rose by 15^0 in three hours one very hot morning. At this time the birds changed to an early morning cooling routine. The height of the mound was not raised but often in the coolest hour of the day, at dawn, they dug quickly and deeply, throwing the sand high and wide to cool as it fell. In rebuilding they began at the outer edge, throwing the coolest sand inwards, digging into the unworked outer wall for cooler material. There was no sand available below 86^0 but the temperature of the egg-chamber never exceeded 93^0. The cooling process would be finished by sunrise.

Egg laying ceased early in February but heat regulation continued for another nine weeks. At the end of March, two weeks after the last egg was hatched, the male showed the first signs of waning interest or the first time in 8 months he deserted his guardianship of the mound, wandering away with the hen for 2 or days at a time. Early In April they opened the mound for the last time, probing it deeply all round the egg-chamber and into the encircling wall. At egg level it was still 85^0. They closed it up and left it for the last time. It was all over.

In this outline of heat control much has been omitted. At times the temptation to draw conclusions has proved a little too strong but always the endeavour has been to adhere closely to observations made at the mound site. A few final observations may be of interest in conclusion.

Reliable winter rainfalls are not as essential to successful fermentation as had been thought. In the great drought of 1987 only 380 points of rain were recorded in the area studied. A chance thunderstorm bringing 70 points of rain in early August proved adequate for the purpose; the litter was saturated. In another year the winter rainfall had been light and infrequent; the litter had not been soaked and felt no more than slightly damp to the touch whenever it was examined. In another year, one of normal rainfall, the litter, although never saturated, remained in a moist condition for several weeks up to the time of preparation of the mound. In all cases fermentation followed the same course, reaching the same temperatures.

Days when no work is done on the mound seem to have no relation to external weather conditions. Temperatures may be in the low 70's or around the century mark. Conditions within the mound alone dictate the processes. Contrary to a popular belief, birds have been seen to open a mound when rain is imminent and to rebuild it during the course of a rainy morning.

Another widely held but erroneous belief is that or the birds coming to the mound in the early morning and plunging their beaks into the sand to test the heat. Such a procedure would tell the birds nothing. Except in full sunlight the temperature of the top 2" is the same as that of the surrounding air. In any case, the birds are much more knowledgeable than that.

Lastly, it brings a rare kind of pleasure to watch these wise and gentle birds at their ancient mysteries in the solitary wilderness.

The Malleefowl's a mighty bird,
Its legs are full of sinews,
A condition that is caused no doubt
By endless kicking dirt about
As long as life continues.

Anon.