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Experimental studies of birds exposed to pulsed microwaves has revealed at frequencies of 16 GHz and 9.29 GHz slightly thermal intensity (45 mW/cm^2) that birds become highly agitated and reach a terminal state at which they either collapse or initiate flight^{1,2}. The time from the onset of radiation to the terminal state varies with the species and typical values at 45 mW/cm^2 for a 16 GHz are as follows chickens (Old English Game) 4-10 secs, pigeons 20-60 secs, seagulls (Ringbill) 10-120 secs. At 9.29 GHz these times are somewhat longer although the behavioural events preceding the collapse or initiation of flight remain the same.

The terminal state of collapse indicates gross interaction between the microwave field and the birds muscular system. Since the intensity of radiation is in the slightly thermal range and the time to the terminal state is short (seconds) this event cannot be attributed only to the thermal effect produced by the direct conversion of microwave energy to heat. However it is possible that heat created by a physiological reaction to non-thermal microwave interaction is a causal factor.

Experiments are being conducted to explore such non-thermal factors as induced electric currents, piezoelectric and bio-chemical effects and molecular resonance phenomena, all of which could affect cell biology. One such experiment was aimed at the measurement of muscular activity using electromyographical techniques. Attention was given to those muscles whose action extends the limbs outward as observed in a collapsing bird. The four leg muscles on each side whose activity had to be recorded were chosen after dissection and examination of the role played by each muscle in the region of interest. Many muscles are involved and some overlap in their functions. The muscles responsible for the extension of wing and leg as exhibited by the collapsed bird were found to be

- (1) for the wing:
 - (a) Deltoides Minor: extending the wing outward
 - (b) Dorsalis Scapular: raising up the wing
- (2) for the legs:
 - (a) Sartorius: extending the tibia
 - (b) Gastrocnemius: extending the metatarsus

Because of the favourable position and physical dimensions of these muscles it was possible to implant two sets of differential recording electrodes. The wires from the electrodes were tied to the feathers of the bird and run to a pair of miniature connectors each with 9 contacts attached to the tail by means of adhesive tape. The recordings were taken differentially relative to a common reference or animal ground, consisting of six centimetres of bare stainless steel wire inserted under the skin along the sternum of the animal.

A chicken (Leghorn) was placed in a wooden cage lined with Eccosorb, and the horn antenna was chosen to provide a field intensity of 100 mW/cm^2 at 9.29 GHz (416 pps) pulsed width 2.35 μsec on the axis of the antenna. Muscular activity was recorded using an 8-channel pen recorder.

At the onset of radiation there occurred an unbalance of muscular activity demonstrated by an increase in the activity of the muscles on the side closer to the field and a decrease in activity of the contralateral muscles almost to complete paralysis. The phenomenon was particularly evident in the Sartorius and Deltoides minor, the high tone of the Sartorius indicating pronounced rigidity of the extended leg. On switching off the field the chicken recovered its normal posture after a few seconds and the muscular activity returned to the normal level observed prior to radiation.

The underlying mechanism of this change in the muscular system is not known and could be attributed to many factors, for example changes in the vascular supply to a muscle.

A further consideration is that microwaves stimulate the area of impingement and create vasoconstriction which through the nervous system of the bird produces a contralateral effect. This suggests nerve interaction of a secondary character. There may also be direct interaction.

REFERENCES

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