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TELEMETRY OF GASTRIC MOTILITY DATA FROM OWLS

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Avian gastric motility has been studied using a variety of methods (e.g., direct observation, cineradiography, electrical potentials, pressure sensitive transmitters), including recording from implanted strain gauge transducers wired to physiological recorders (Duke 1982). In this paper we describe a telemetry system for sensing and recording the muscular contractions of the ventriculus of owls. Long range telemetry (e.g. > 1km) of muscular contractions facilitates study of wildlife physiology, behavior, and ecology.

MATERIALS AND TECHNIQUES

Foil strain gauge transducers (SGT) have been used successfully to detect muscular contractions from gastrointestinal tracts of birds in the laboratory (Duke et al. 1976, Fuller and Duke 1979). We initially used semiconductor SGTs in the present study because they were available in higher resistance values (typically 5000 ohms per leg versus 350 ohms for foil) and higher gauge factor (150 versus 2 for foil). These factors are desirable in a telemetry device where power requirements and size are critical. Unfortunately, the semiconductor gauges did not perform reliably under the unpredictable flexing conditions encountered in this application. Laboratory testing and trials with wild barred owls (Strix varia) revealed that semiconductor SGTs broke within a few hours to 17 days after implant. When the owl ventriculus contracts, gastric motility exhibits vigorous and frequent displacement, bending the semiconductor gauges beyond their limits. After these trials, we selected foil SGTs for use in the present study.

Basic SGT preparation was described by Bass and Wiley (1972). The foil SGTs were prepared by first bonding individual elements back to back using strain gauge adhesive. This configuration produced the desired opposing change for SGT flexure. Flexible teflon leads with a plug on one end were then soldered to the SGT elements. The foil SGTs were encapsulated in silicon rubber using a mold to give the finished gauge a curved surface. The resulting SGT was approximately 8 x 10 x 3 mm. Gauges were tested by clamping one end and hanging 0 to 10 gm weights on the other end. We checked for leakage by submerging the SGT in saline solution and measuring current flow to an external electrode. Complete assembly details are available from V. B. Kuechle or G. E. Duke.

Transmitter design

We used intermittent sampling to help reduce power drain and still achieve the desired field life with a small battery providing sufficient current to achieve a reliable sensitivity. Sampling allowed duty cycling of power consumptive elements of the circuit. A sample duration of one second was chosen as a reasonable compromise between event duration and battery life.

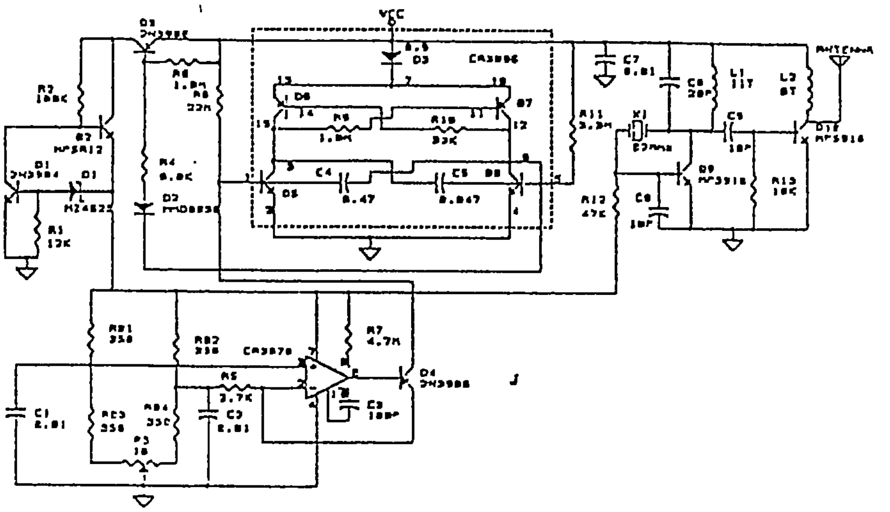

Figure 1: Circuit diagram for foil strain gauge transducer and transmitter.

In the circuit (Fig. 1) Q3 is the sampling switch, turning on voltage regulators D1, Q1 and Q2. This circuit supplies current to the bridge and turns on the transmitter. Integrated circuit IC1 and Q4 form a voltage-to-current converter that removes current from the base of Q5 proportional to SGT deformation. The voltage-to-current converter and current-controlled pulse width modulator give a linear output dependent on SGT deflection. Transistors Q5 to Q8, and D3 form a complementary astable multivibrator controlling the sample interval and pulse width. These transistors are contained in IC2 and thus are quite immune to temperature and voltage changes. The voltage regulator, bridge and amplifiers are on only during this pulse period. Pulse widths of signals from the transmitter varied from 15 to 250 ms, resulting in current drain from 0.3 to 1.0 ma. The radio frequency portion of the circuit is a standard design commonly used for radio location studies. Power is supplied by three 2.8-volt Lithium batteries. Using 1/2-AA size batteries, life is nominally 45 days and results in a package weight of 40 grams.

Attachment

The transmitter and batteries were encapsulated as a unit. This unit was mounted on the back of the bird using flat (1 cm wide) teflon ribbon as harness material. The leads from the SGT to the unit were implanted subcutaneously, running from an incision under the unit to the abdominal cavity. No problems with this arrangement were encountered.

The SGT was implanted in an anesthetized bird by suturing the silicon rubber covering of the SGT to the serosal surface of the ventriculus. After the bird healed for several days the transmitter was attached and the SGT leads and transmitter were connected via a plug. A bridge offset control was used to set the quiescent pulse width. The transmitter of each bird had to be adjusted differently depending on the amount of SGT flexure after implantation.

Receiving

Signals were received using either a loop or a yagi antenna mounted on a 6 m mast and standard telemetry receivers of the type used for location tracking. The receivers we used included phase-locked tone decoders to make the system more immune to noise. These decoders also made receiver gain setting less critical.

The received pulses of varying width were sent to a pulse width-to-voltage decoder. Although any pulse width-to-voltage decoder can be used to demodulate the signal, the decoders we used had a digital counter inputting to a digital-to-analog converter. This technique was chosen because it maintains its calibration under varying field conditions. Its basic operation is to gate a fixed frequency with the pulses of varying width to a counter with a display. The counter counts while the pulse is on, giving a count proportional to pulse width. At the end of the pulse the counter data are latched into the digital-to-analog cycle to start over. If no signal occurs, a time-out signal resets the output to zero to give an indication of a "no signal" condition. The output of the decoder was sent to a paper chart recorder for display.

RESULTS AND DISCUSSION

Trials with captive birds demonstrated that foil SGTs and transmitter provided adequate sensitivity and reliability. A foil SGT in the first captive barred owl failed after data were recorded for 49 days and tests of a second foil SGT were terminated after 42 days with SGT still functioning. Foil SGT's in barred owls held in outdoor pens functioned for 32 and 23 days each before we terminated tests. Battery life in the outdoor pens ranged from 17-24 days and signals were recorded regularly at the receiving station 1.0 km from the owls.

Gastric motility data were obtained from the SGTs in free-flying owls from 5 to 20 days ($\bar{x}$ = 13.5 days). Four foil SGTs and transmitters were used with 3 wild barred owls monitored in east central Minnesota (U.S.A.) in November and December. Wires in one SGT broke after 5 days, but the owl was recaptured and a new SGT was implanted and provided data from the bird for 20 days.

Gastric motility data were recorded 88.4% of the time when SGTs and transmitters were working. Data were lost 8.8% of the time because the owls flew more than 2.3 km from the receiving antennae where signal strength was too weak to be recorded. Receiving and recording equipment malfunction accounted for the remaining 2.8% of the lost data. We were able to interpret 73.8% of the data recorded. The remaining 14.6% of the recordings were erratic or cluttered by interference.

Telemetry of gastric contractions monitored with SGTs provided data that allowed us to recognize all the motility patterns previously identified from owls in the laboratory (Kostuch and Duke 1975, Rhoades and Duke 1977, Fuller and Duke 1979). In addition, some new motility patterns occurred regularly in the wild owls (M. R. Fuller, K. A. Daniels, G. E. Duke, and K. E. Zinnel, unpubl. data). These results demonstrate that transducers can provide reliable results when incorporated in long-range telemetry systems.

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