A System for Gathering Small Mammal Mortality Data

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Abstract

As an aid to studying vertebrate predators of the gypsy moth, a radio telemetry system was designed to detect the death of small mammals and facilitate recovery of the remains. An intraperitoneally implanted radio transmitter is triggered by the drop in body temperature when the animal dies. The device was tested in white-footed mice.

PREDATION by the white-footed mouse, *Peromyscus leucopus* (Raf.), is important in the population dynamics of the gypsy moth, *Porthetria dispar* (L.).

Observations on many forest pests not only suggest that predation processes are a principal deterrent to outbreaks of forest insects, but also support the notion that much of this predation is by birds and mammals *(Knight 1958, Buckner 1967, Hamilton and Cook 1940, Morris et al. 1958, Holling 1959)*.

The white-footed mouse preys on the larger larvae and pupae of the gypsy moth; and among sparse populations of the insect, this predation determines whether these populations will remain innocuous or will increase to dangerously high levels *(Campbell 1967, Bess et al 1947)*.

This latter fact raises the possibility that we could achieve more rational management of the gypsy moth population system through measures designed to promote and maintain more dense populations of this predator. Thus we have become interested in what might be termed "Peromyscus management." And we think that any rational scheme for managing these mammals should be based, in part, on a thorough understanding of the sources of *their* mortality.

But unfortunately, very little is known about the role of naturally occurring mortality in the population dynamics of *Peromyscus* spp. In fact, Terman *(1968)* in a recent monograph on *Peromyscus*, stated: "The data presently available on [*Peromyscus*] populations are suggestive of sensitive controlling mechanisms which are by no means understood" and that "the demonstration of factors characteristic of or associated with population control in nature is extremely difficult and almost non-existent in the literature of *Peromyscus*."

We think a new approach, which incorporates the following premises, might shed new light on this problem:

1. A transmitter could be developed, which would be small enough for implanting intraperitoneally, in a white-footed mouse. This transmitter would remain effective for at least 2 years and would switch on when the host died.
2. The transmitter unit would not interfere with the life processes of the host animal.
3. A receiver grid could be developed that would assure reception of transmitter signals.
4. Careful autopsy of the animal's remains would reveal cause(s) of death.

Our progress to date in meeting the above objectives is reported here.

Background

Although the success of a mortality monitoring system for small mammals is, to a large extent, an inverse function of the size of the implanted radio transmitter, some guidelines are needed to establish a working frame of maximum acceptable size and weight. Transmitter size, in the case of *Peromyscus*, was conceptually constrained by the size of the mature bot fly larva, a generally non-fatal parasite of this genus. Pending results of intensive biological testing, a weight limit for the transmitter was set at about 1 g, which is about 5 percent of the average weight of an adult mouse.

The transmitter must have a shelf life of 2 years, a reasonable transmitting range, and some way of "sensing" when its host is dead. Ideally, a continuously running transmitter would not only allow us to track the living animal, but would also allow us to locate the remains after the animal dies.

Unfortunately, the amount of energy available from present energizers, within the size restriction, cannot approach that necessary to power an active oscillator for 2 years. Thus the oscillator must remain passive while the mouse is alive, and switch on after death to meet the 2-year availability requirement.

Most of the possible ways to build a "death switch" were rejected because of surgical complexity, size restriction, and electrical limitations. Mathematical investigation of several bimetallic thermoswitch configurations demonstrated feasibility of this method and led to the final shape design. Empirical trials were used to determine the minimum dimensions of the switch for reliable control of the oscillator.

Several types of blocking oscillators were considered; the chosen circuit was selected on the basis of simplicity, peak power from a 1.3-volt source, and relatively narrow band width. Physical layout of the circuit, component values, and coil dimensions were optimized for small size and stability.

Nonmetallic housing was needed to provide operating space for the thermoswitch and to protect the circuitry against both corrosive body fluids and direct bites by predators. The best housing shape was visualized as one that would allow maximum payload insertion through a small incision while minimizing irritation to internal organs. This shape was found in the form of a standard medication capsule. Both glass and high-purity alumina ceramic were investigated as housing materials, but the problems involved in construction and sealing encouraged the use of epoxy for potting the transmitter, followed by a layer of paraffin to seal out body fluids *(Mackay 1970)*, and a final coating of silicone rubber to facilitate handling and surgical implantation.

Results

The transmitter consists of an energizer, a thermoswitch, and an oscillator (fig. 1). These are secured together with epoxy, connected electrically, and encapsulated. The completed unit is sterilized with a standard solution of zephiran chloride and surgically placed in the peritoneal cavity.

A mercuric oxide energizer, type 212, provides power for the oscillator. Connections to the energizer are made by capacitive-discharge wire welds that are strain-relieved with epoxy cement.

The thermoswitch (fig. 2) is based on .127 mm thick bimetal stock (Chace #6650)[1]

[1]Mention of a product is for information only and should not be considered a recommendation or endorsement by the U. S. Department of Agriculture or Forest Service.

Figure 1. — Electronics assembly: transmitter parts mounted with epoxy on small wafer.

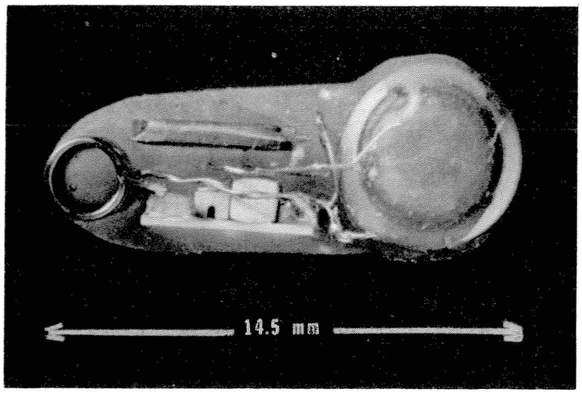
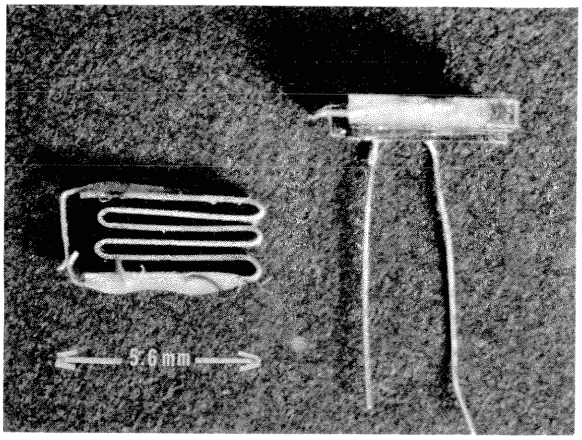


Figure 2. — Thermoswitch: side and top views.



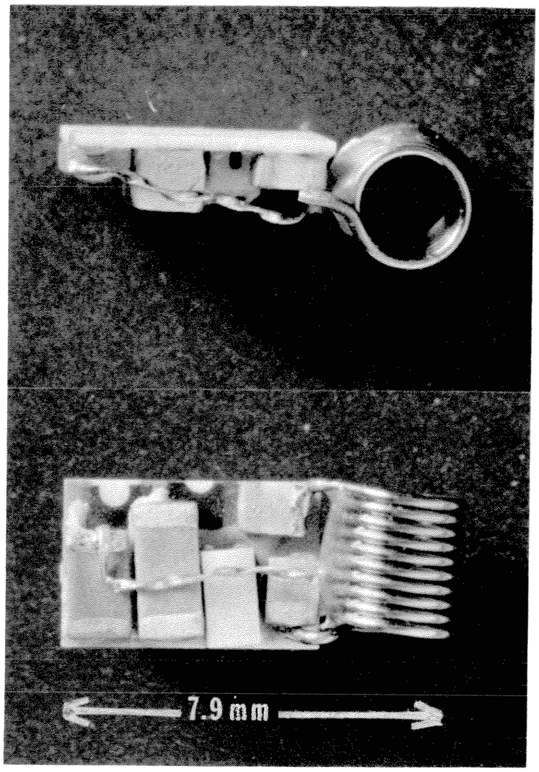
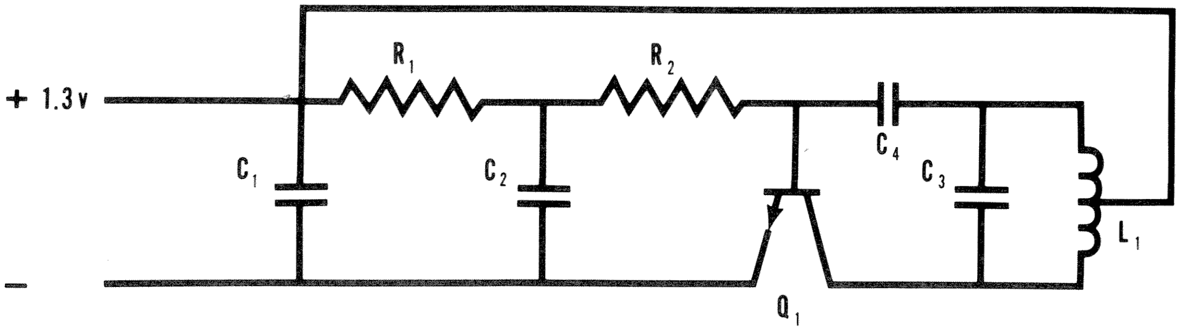


Figure 3. — Oscillator: side and top views.

Figure 4. — Schematic diagram: oscillator. C_1 — .01 uf, K 1800 ceramic, chip. C_2 — .03 uf, K 1800 ceramic, chip. C_3 — 100 pf, NPO ceramic, chip. C_4 — 100 pf, NPO ceramic, chip. R_1 — 91K ohm, thick film. R_2 — 7.5k ohm, thick film. Q_1 — 2N2369, chip. L_1 — Air core, 2.54 mm. O. D., 10 turns #30 enameled wire, close-wound, tapped at 4 turns from collector.



sheared to a width of .66 mm and folded accordion-like into six sections, 5.08 mm in length. Contacts are fastened to the bimetal body by spot welds and epoxy cement. The epoxy provides strain relief for the weld joints associated with one contact and secures the second contact while insulating it from the bimetallic body. A decrease in temperature closes the contacts; contact closure is tentatively set at 26°C. (Normal body temperature of *Peromyscus* is about 34°C). Platinum wire is used for the switch contacts to increase the reliability of electrical contact.

The blocking oscillator (fig. 3 and 4) produces bursts of radio frequency energy at 46.8 MHZ with a repetition rate of about 600 pulses per sec. Maximum transmitting range is about 45 m, with no external antenna connected to the oscillator, and with a quarter wave (whip) antenna connected to the receiver. (Low-band VHF monitor, with an AM detector and input sensitivity of .7 uv for 10:1 signal to noise ratio.)

The transmitter components are protected by carefully encapsulating the electronics assembly. A heat lamp is used during this process to create a microclimate of about 30°C at 40 percent or less relative humidity to promote optimum curing of the epoxy and to prevent closure of the switch contacts and subsequent draining of the energizers. If a fast-setting epoxy (Armstrong A-36) is used, walls can be formed around the switch, to allow sufficient clearance for unhindered motion of the mechanically active switch contact.

After the switch is completely enclosed, the oscillator and energizer are potted with the epoxy and the unit is washed in acetone for 5 seconds, then filed to remove any sharp protrusions. The epoxy capsule is covered with paraffin by dipping both ends separately into a paraffin bath, allowing sufficient time between applications for the first to cure to handling consistency. An overlap between coatings assures adequate sealing. Silicone rubber (Dow-Corning 3110 RTV) is then applied in two steps as above, but a small spatula is used to apply the material. Weights of the transmitter and its components are listed in table 1.

Table 1. — *Weight of transmitter parts*

Part	Weight (g)
Oscillator	0.09
Thermoswitch	.03
Energizer	.32
Epoxy	.33
Paraffin	.06
Silicone rubber	.13
Transmitter	.96

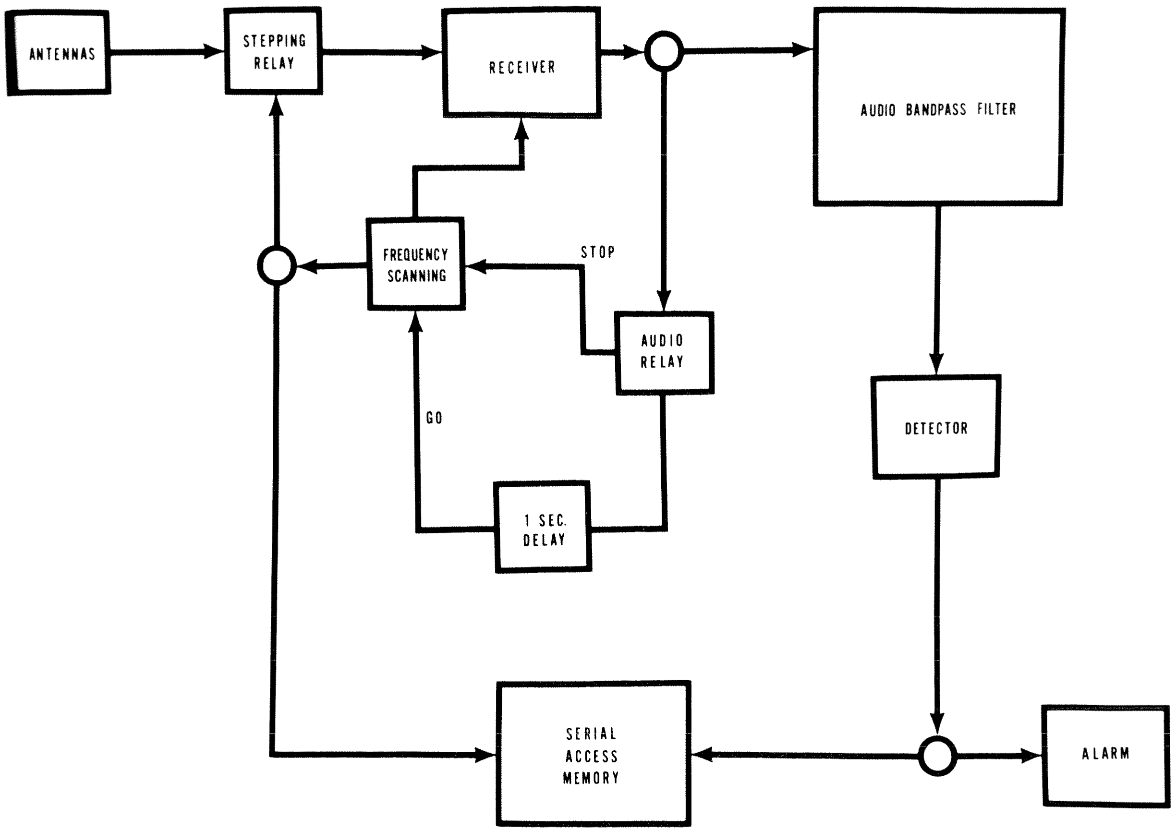
Values indicated are nominal. Total weight may vary ± .04 g.

Signals are received from the transmitter by a grid system of antennas arranged close enough together (about 15 m) to assure reception of signals from implanted transmitters anywhere within the grid boundary. The antennas are connected sequentially to a receiver, which is modified to scan a frequency spectrum around the operating point to compensate for carrier frequency differences between the transmitters. The frequency scanning mechanism also controls the antenna stepping relay so that, after each frequency scan, the next antenna in the interrogation sequence is connected to the receiver input.

If a signal is present at an antenna when it is sequenced onto the receiver input, an audio relay stops the frequency scanning as the receiver is tuned onto the signal. A delay circuit allows about 1 second for analysis of the signal before the scanning process is resumed. An active audio bandpass filter followed by a detector determines whether the signal is from an implanted transmitter or whether it is extraneous. The input of the bandpass filter includes a limiter circuit to maintain a constant-amplitude input to the filter. In the detector, rectification and integration of the filter output converts the frequency-dependent AC amplitude to DC amplitude, which is detected by a Schmitt trigger. If a valid signal is detected by the receiver, the Schmitt trigger switches to the "on" or "1" state.

This logic level of "1" is stored in a serial access memory at the address dictated by the antenna interrogation sequence. The "1" state also activates an alarm, which may be transferred via telephone lines, to summon an

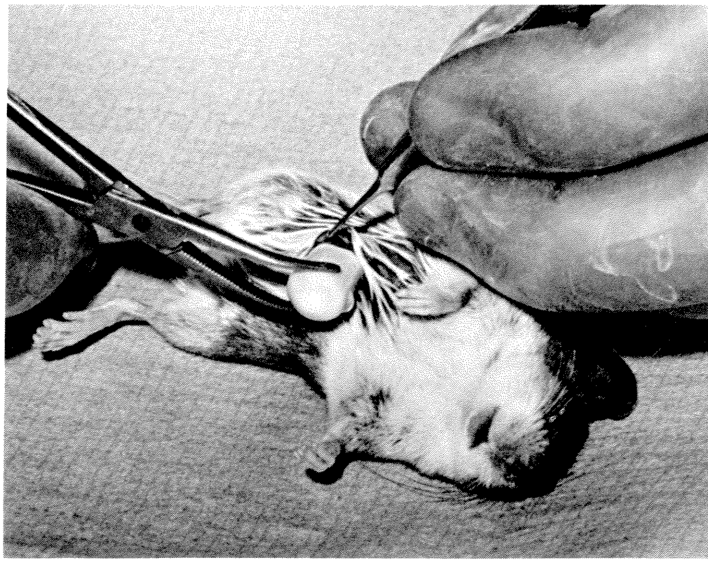
Figure 5. — Receiving system: block diagram.



attendant to the area. (Block diagram of receiving system appears in figure 5.) Using the recorded antenna identification and a portable receiver, the attendant pinpoints the location of the dead animal and collects the remains.

Surgical procedure for successfully implanting the capsules depends to some extent on careful administration of anesthesia. Metofane[2] is administered initially in a closed cage, then during the operation as needed, using a nose cone. The incisions in the skin, muscle wall, and peritoneum are made just large enough to slip the capsule in (fig. 6); sutures are then placed separately in the muscle wall and skin.

Figure 6. — Inserting the transmitter into the peritoneal cavity.



[2]Metofane, brand of methoxyflurane, inhalation anesthetic, Pitman-Moore Division of Dow Chemical Company.

Responses by P. Leucopus to Transmitter Implant

The first implants were subcutaneously located just left of the dorsal midline between the shoulders in two adult, 21 g specimen *Peromyscus leucopus*. One of these implants was expelled after 8 days, while the other remained for 16 weeks.

Six intraperitoneal (IP) implants were then made. Of these, one was a failure, one animal was sacrificed and examined, and the four remaining mice have shown no noticeable abnormality after 42 weeks. Examination of the sacrificed mouse disclosed no visible tissue irritation after 12 weeks of implantation. The unsuccessful IP implant involved an 8.1-g juvenile, which died 5 days after the operation. Cause of death was not determined, but no lesions or visible signs of irritation were found in the peritoneal cavity. Weights of the five successfully implanted mice ranged from 12 to 19 g.

Discussion

Extensive biological testing is planned to elucidate any subtle effects of the implant on *P. Leucopus*. A preliminary test of the basic system was conducted on a ½-acre island from November to December 1971. During this time, signals were received from two mice; and their remains were recovered. No attempt was made to determine the cause of death.

The general system outlined here for obtaining mortality data on small mammals is sufficiently feasible to warrant further development and implementation. This system is being evaluated through further laboratory tests and field trials.

Literature Cited

Bess, H. A., S. H. Spurr, and E. W. Littlefield. 1947. FOREST SITE CONDITIONS AND THE GYPSY MOTH. Harvard Forest Bull. 22. 56 p.

Buckner, C. H. 1967. AVIAN AND MAMMALIAN PREDATORS OF FOREST INSECTS. Entomophaga 12(5): 491-501.

Campbell, R. W. 1967. MEASURING AGE SPECIFIC MORTALITY FACTORS OF THE GYPSY MOTH. Entomol. Soc. Amer. N. Cent. Branch Proc. 22: 53-56.

Hamilton, W. J., Jr. and D. B. Cook. 1940. SMALL MAMMALS AND THE FOREST. J. Forest. 38: 468-473.

Holling, C. S. 1959. THE COMPONENTS OF PREDATION AS REVEALED BY A STUDY OF SMALL PREDATION OF THE EUROPEAN PINE SAWFLY. Can. Entomol. 91: 293-320.

Knight, F. B. 1958. THE EFFECTS OF WOODPECKERS ON POPULATIONS OF THE ENGELMANN SPRUCE BEETLE. J. Econ. Entomol. 51: 603-607.

Mackay, R. S. 1970. BIOMEDICAL TELEMETRY: SENSING AND TRANSMITTING BIOLOGICAL INFORMATION FROM ANIMALS AND MAN. John Wiley, New York. 2nd ed., pp. 101-104.

Morris, R. F., W. F. Cheshire, C. A. Miller, and D. G. Mott. 1958. THE NUMERICAL RESPONSE OF MAMMALIAN AND AVIAN PREDATORS DURING A GRADATION OF THE SPRUCE BUDWORM. Ecology 39: 487-494.

Terman, C. R. 1968. POPULATION DYNAMICS. *In* Biology of Peromyscus (Rodentia). Amer. Soc. Mammal. Spec. Publ. 2: 412-450.