Biotelemetry as a Technique in Disease Ecology Studies

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Disease ecology studies frequently demand a detailed knowledge of movements and activity patterns of infected animals, base-line data from apparently healthy individuals and/or inter-action rates between hosts. Additionally, some investigations require periodic examinations of hosts and the recovery of dead animals for necropsy. Until quite recently these data have been obtained primarily by live trapping and marking animals, systematic collections of specimens, or, as in the case of rabies, reports of state public health or veterinary diagnostic laboratories. All of these approaches present difficulties which may limit the quality or quantity of the information gained. For example, the technique of live trapping requires the assumption that movement and activity parameters are not affected by the experimental procedures. Balph (1968), however, has shown that ground squirrels may become "trap happy" in response to a ready source of food or "trap shy" as a result of the noxious experience of being captured and handled. Similarly information obtained from systematic collections of specimens and from laboratory diagnostic reports frequently prove to be of limited value in unraveling the ecological relationships of disease complexes.

The technique of attaching miniature radio transmitters to free ranging wild animals, or "biotelemetry", may prove to be quite useful in disease investigations by reducing or eliminating the above limitations and by providing more data per unit effort than are provided by current techniques. A properly designed biotelemetry system enables the investigator to determine, with minimal disturbance, behavior patterns of unconfined wild animals. It also provides for determination of the time of death of radio-marked animals and thus permits immediate collection of the remains for necropsy. Houseknecht (1969) used this technique to determine the denning habits of striped skunks *(Mephitis mephitis)* and the resulting exposure potential for disease. By quickly retrieving carcasses of succumbed radio-marked fawns *(Odocoileus virginianus)*, Cook *et al.* (1967) determined the cause of death in 49 of 58 cases.

The capability of continuously monitoring the location of radio-marked animals also permits examination of hosts or the collection of specimens at will. Montgomery (1968) attached radio collars to a white-tail deer fawn then recaptured the animal at predetermined intervals in order to investigate the rate of tick attachment. Similarly one could recapture radio-marked striped skunks for monthly bladder traps for an investigation into the ecology of leptospirosis.

The technique of biotelemetry has been employed in animal movement studies since 1959. These first transmitter packages (Le Munyan *et al.*, 1959) measured 7.5 x 4.0 x 1.4 cm, weighed 122.5 gm and were designed for implantation into the body cavity of woodchucks *(Marmota monax)*. Since 1959 great advances in miniaturization of electronic components have resulted in transmitters that are less bulky, more durable and that have considerably longer transmitting life expectancies. Physical characteristics of some representative transmitter packages are given in Table 1.

TABLE 1. *Physical and performance characteristics of selected radio-transmitters.*

Animal	Type of Attachment	Weight (gm)	Range (miles)	Life (days)
Moose	Collar	1000	5	425
Wolf	Collar	600	5	425
Skunk	Collar	75	2	300
Duck	Harness	25	1-2	90
Owls	Harness	7	¼	14

Today, most if not all transmitters designed for telemetering locations of animals are attached externally rather than implanted. Several types of attachments are used. Collars work well for species of mammals that have definite necks but body harnesses must be used for species such as badgers *(Taxidea taxus)*. Hessler *et al.* (1970) and Nicholls (personal communication) used body harnesses on pheasants *(Phasiannus colchicus)* and various species of owls respectively.

The choice of transmitter weight, design and attachment method is determined to a great degree *a priori* by the physical characteristics of the species being investigated. Some options, though, are available. For example, with a given weight of batteries, the investigator can often choose between greater range or longer battery life. A transmitter with a 0.4 milliampere current drain might have a range of one mile. By increasing the current drain to 0.8 milliampere (and thus halving the battery life) the range could be increased to perhaps 1½ mile. The design of the study will determine the choices made.

Design of the receiving portion of the telemetry system is much more adaptable to the specific requirements of the investigation. Telemetry receiving units can be divided into two broad categories, continuous and non-continuous. The ultimate in continuous units is the University of Minnesota's Cedar Creek tracking system located in east central Minnesota. This system has been described in detail by Cochran *et al.* (1965). Briefly, it consists of two yagi-type antennas mounted on towers one-half mile apart. The antennas pick up signals from transmitter-equipped animals and, after amplification and conversion, relay the signals to banks of receivers. Degree bearings for each tower and signals from the receivers are recorded automatically on 16 mm microfilm for later analysis. Under ideal conditions this system has the potential of 1920 locations per day for each of 52 animals.

The installation at Cedar Creek provides certain types of information (e.g. contact rates between animals) that would be impossible to obtain with non-continuous telemetry units. A system such as this is, however, quite complicated electronically and thus costly to set up and maintain. In addition, detailed movement data are gained only at the expense of flexibility and portability. Cochran (1967) described a portable automatic tracking unit which would nullify the last objection; but to the best of my knowledge it has not been completely field tested.

Non-continuous receiving systems can be further subdivided into semi-permanent tower, truck-mounted mobile and hand-held portable types. All of these designs have been used extensively for field investigation of mammals and birds.

The semi-permanent tower design consists of a short (3-4 ft) section of 1½ inch I.D. galvanized conduit with a base plate attached to one end and a compass rose attached to the other end. A 20-30 ft of 1¼ inch O.D. mast bearing a yagi type antenna is inserted into the outer piece of conduit. The mast is supported by guy wires in a manner such that it is free to rotate within the outer pipe. A radio receiver is attached by coaxial cable to the yagi antenna and bearings are obtained by manually rotating the shaft to the position of minimum signal strength. Radio marked animals are located by triangulation of bearings from two or more towers strategically located within the study area. This unit can be quickly disassembled and reassembled in a new location and is relatively inexpensive.

Truck-mounted receiving units work well for species that move considerable distances. This system is functionally the same as the semi-permanent unit described above. Bearings are obtained by manually rotating an antenna-bearing mast attached to or inserted through the roof of a vehicle. Verts (1963) used truck-mounted units to determine movements and activity patterns of striped skunks. The advantage of this system is, of course, extreme portability. It is most useful in open terrain where there is little danger of collision with overhanging tree limbs or power lines.

The last type of receiver that I want to discuss is the portable, hand-held unit designed by Cochran and Nelson (1963). A directional loop antenna gives maximum and minimum signals when the plane of the antenna is respectively pointing toward and is perpendicular to the radio source. The animal is approached by continually moving toward the minimum signal. This type of receiver provides maximum portability and is the design most often used for actually locating animals in the field (Cook *et al.*, 1967). A disadvantage is that for maximum portability the receiving antenna must be small and hence the range is not great. A further disadvantage, and one that is inherent in all manually operated systems, is that a large amount of time is required for observation of a limited number of animals.

The type of receiving unit ultimately selected should depend, of course, on the questions asked of the study. If a knowledge of the minute by minute movements of animals over a long period of time is required then a fully automatic system is indicated. On the other hand, if one wishes only to examine an animal at infrequent intervals a manually operated portable unit would suffice. The performance characteristics and approximate cost of each type of receiving system is given in Table 2.

TABLE 2. *Performance characteristics and approximate cost of receiving systems.*

Type of Receiving system	Receiving Range (miles) with 2" dia. loop transmitter	Accuracy (degrees)	Approximate Cost of Materials
Continuous (Cochran *et al.*, 1965)	2	± 0.5	$10-15,000
Semi-permanent Tower	1	± 2.0	250
Truck Mounted (Verts, 1963)	1	± 1.0	300
Hand Held (Cochran and Nelson, 1963)	½	± 5	200

In conclusion, if we are to understand the ecology of particular disease complexes we must determine, in depth, the behavioral patterns of the associated vertebrate hosts. In addition we must be capable of collecting samples from or examining free ranging wild animals at specified intervals. Biotelemetry represents a valuable tool in this respect. It is only a tool, however, not a panacea. This must always be kept in mind when planning studies involving this technique.

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Literature Cited

BALPH, D. M. 1968. Behavioral responses of unconfirmed uinta ground squirrels to trapping. J. Wildl. Mgmt. 32 (4): 788-794.

COCHRAN, W. W. 1967. Radiolocation and tracking of animals — An inexpensive triangulation recorder. AIBS/BIAC Information Module M14.

COCHRAN, W. W. and E. M. NELSON. 1963. The model D-11 direction-finding receiver. Univ. of Minnesota Museum Nat. Hist. Tech. Rept. #2. 14 pp. mimeo.

COCHRAN, W. W., D. W. WARNER, J. R. TESTER, and V. B. KUECHLE. 1965. Automatic radio-tracking system for monitoring animal movements. BioScience, 15 (2): 98-100.

COOK, R. S., M. WHITE, D. O. TRAINER, and W. C. GLAZENER. 1967. Radiotelemetry for fawn mortality studies. Bull. Wldl. Dis. Assoc. 3: 160-165.

HESSLER, E., J. R. TESTER, D. B. SINIFF, and M. M. NELSON. 1970. A biotelemetry study of survival of pen-reared pheasants released in selected habitats. J. Wildl. Mgmt. 34 (2): 267-274.

HOUSEKNECHT, C. R. 1969. Denning habits of the striped skunk and the exposure potential for disease. Bull. Wildl. Dis. Assoc. 5: 302-306.

LE MUNYAN, D. C., W. WHITE, E. NYBERT and J. J. CHRISTIAN. 1959. Design of a miniature radio transmitter for use in animal studies. J. Wildl. Mgmt. 23 (1): 107-110.

MONTGOMERY, G. G. 1968. Rate of tick attachment to a white-tailed fawn. Am. Mid. Nat. 79 (2): 528-530.

VERTS, B. J. 1963. Equipment and technique for radio-tracking striped skunks. J. Wildl. Mgmt. 27 (3): 325-339.