RADIO-TAGGING FALCONIFORM AND STRIGIFORM BIRDS

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This paper describes techniques for radio-tagging and monitoring birds of prey. Several recent papers briefly discuss radio-telemetric techniques for studying behavior of raptorial birds. Nicholls and Warner (1966, 1968) commented on the use of radio-telemetry for studying the natural history of Great Horned Owls (*Bubo virginianus*), Barred Owls (*Strix varia*), and Saw-whet Owls (*Aegolius acadica*). Southern (1963, 1964, 1965) commented on radio-tagging and tracking of wintering Bald Eagles (*Haliaeetus leucocephalus*). These authors briefly discussed problems of tagging and monitoring but little information was given comparing different receiving systems or concerning methods of harnessing other raptors.

Applications of the Technique

By using radio-tagging one can gather data on raptorial birds without visual contact. As with banding, color-marking, or tagging by other means, the investigator must realize that the data are from a tagged subject. A radio-tagging study must be planned carefully before it is initiated in order to avoid loss of equipment or life of the subject.

The radio-telemetric techniques described in this paper can be used to determine: (1) territory and home range, (2) daily activity rhythms, (3) habitat utilization, (4) nest location, (5) physiological measurements such as heart rate, core temperature, and respiration rate, (6) feeding habits, (7) post-fledging activities such as family relationships, dispersal, migration, and survival, (8) pesticide and parasite fluctuations in time, and (9) interspecific and intraspecific interactions.

Transmitters

I radio-tagged 17 species (56 individuals) of captive or wild raptors (Table 1) with self-pulsed, crystal-controlled transistor oscillators operating at frequencies above 100 MHz. Continuous signal transmitters were also used in this study but were found to be inferior in regard to life and sensitivity to the bird's body movements.

Transmitters can be purchased or built to suit one's needs. Commercially-available circuitry is frequently changed and varies with the supplier. The transmitter circuitry used in my study was similar to that used by Cochran (1967).

Transmitter weight, size, and shape varied with the components, harness materials, and amount of embedding material. The smallest transmitter that I used

Table 1. Package types, harness materials and sizes, and package weight to body weight ratios for radio-tagging 17 species of raptorial birds.

Scientific name	Package type	Harness material*	Harness loop sizes (in) neck	Harness loop sizes (in) body	Mean % package weight to body weight male	Mean % package weight to body weight female
Accipiter striatus	BP	1/8 in	**	**	6	4
Accipiter cooperii	BP	1/8 in	**	**	2	2
Accipiter gentilus	BP	1/4 in	5½	7¾	3	2
Buteo lagopus	BP	20 ga.	7	9½	6	5
Buteo swansoni	BP	20 ga.	8½	9½	6	5
Buteo platypterus	BP	1/8 in	7 3/8	9 3/8	6	7
Buteo jamaicensis	BP	1/4 in 18 ga.	8¼	11½	4	3
Circus cyaneus	BP	1/4 in	5½	7¼	6	6
Falco sparverius	BP	1/8 in	**	**	4	4
Otus asio	BP BRP	1/8 in	**	**	7	5
Asio flammeus	BP	1/4 in	6¾	8½	7	6
Asio otus	BP	1/4 in	6¾	8¾	7	6
Strix varia	BP BRP	1/4 in	9¾	12¾	6	6
Bubo virginianus	BP BRP	1/2 in 18 ga.	10	12¾	5	4
Nyctea scandiaca	BP	1/2 in	**	**	4	3
Pandion haliaetus	BP	1/4 in	**	**	4	3
Haliaeetus leucocephalus	BP	1/2 in	20 19	22 22	3	2

*Flattened width of woven teflon tubing or ga. of stranded wire with rubber insulation.
**Single adjustable body loop.
BP Back package; BRP breast package.

weighed three grams and the total package weight (transmitter, antenna, harness, and embedding material) of all my radio-tags varied from five to 118 g. All package weights were less than seven percent of the bird's total body weight (Table 1). My transmitters were embedded in acrylic or epoxy. The transmitter shape varied depending upon the application and components. I found it best to streamline the whole package. Most of my packages were small enough to be placed under the feathers. I painted the packages in cryptic color patterns with acrylic paints (RamCote) and placed them under the feathers to minimize sibling pecking and also to keep them warmer.

Transmitter life is a function of battery type and energy consumed. My transmitters had actual field lives that varied from 31 to 510 days. Range varies with frequency, transmitter antenna length, numerous environmental factors, and with the receiving system. In general a transmitter with a whip antenna operating above 100 MHz has greater efficiency than one with a small loop antenna.

Harnesses

Two harness designs were used. A double loop harness (Figs. 1 and 2) was used to hold back or breast packages on all species except Sparrow Hawks (*Falco sparverius*), Cooper's Hawks (*Accipiter cooperii*), Sharp-shinned Hawks (*Accipiter striatus*), and Screech Owls (*Otus asio*). The preferred package type is

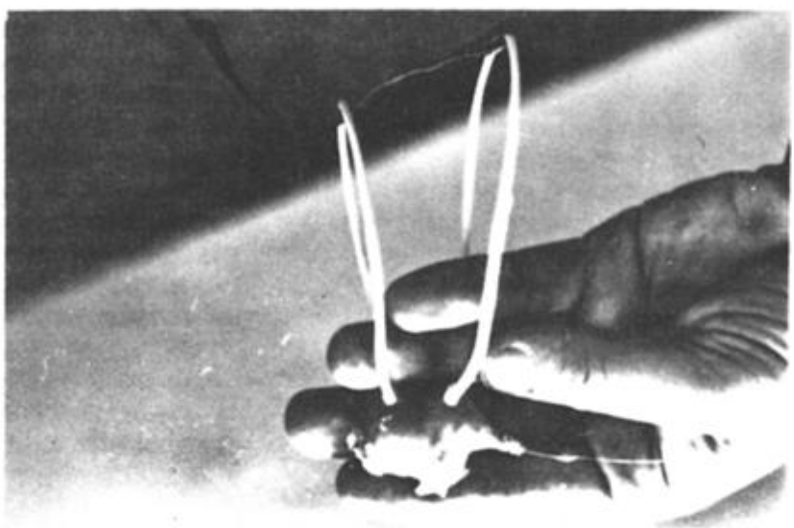


Figure 1. A completely assembled pre-fitted back package showing double loop harness, cross strap, whip antenna. This package weighed 40 grams and had a life of 230 days.

Figure 2. Back package in proper position at anterior margin of wings and showing spring at base of whip antenna and cryptic coloration to blend with back color of Rough-legged Hawk (*Buteo lagopus*).

given in Table 1.

The double loop harness was modified after that of Nicholls and Warner (1968). They used 12-ga. insulated solid strand wire for harnessing Barred and Great Horned Owls. I found that this was too rigid for comfort, caused callouses on the skin, broke body feathers, and damaged developing feathers during molt more than did flexible stranded wires.

I used stranded 18 gauge wire with rubber insulation to harness all larger hawks and owls (Table 1). Twenty and 24-ga. wires were used to harness the smaller hawks, owls, and falcons. However, teflon tubing was preferred. Red-tailed Hawks (*Buteo jamaicensis*) easily broke the smaller gauge wire.

The harnesses were prefitted in the laboratory and adjusted for close fit while in the field. The neck-loop end of the cross strap was adjusted and sewn or rivetted in the field. I used fine steel wire or cotton thread to sew this junction when I wanted the package to drop off after the power supply failed. When these materials decomposed, the package either dropped off or the bird pulled it off. This also minimized the chance of the body loop-cross strap junction breaking first which could cause strangulation by the neck loop. Dead transmitters were removed from the birds that could be recaptured in live traps.

I used a single body loop harness to attach relatively short-lived back packages to small Accipiters, Sparrow Hawks, and Screech Owls. A body loop of narrow teflon tubing or small gauge wire was fitted in the field. The field life of these transmitters was about 30 days and therefore they had to be replaced often. One wild female Sparrow Hawk was retagged seven times and her activities were monitored continuously for 187 days.

All harnesses were loose enough to allow a 4 mm diameter rod to pass between the harness and the skin. This minimized the chance of restricting breathing or blood circulation, or causing strain or damage to muscles. It also allowed for some change in body size during molt.

Woven teflon tubing was superior to insulated wire for attaching back packages with whip antennas. This material is more flexible at temperatures below freezing and is stronger and softer than insulated wire. The flat widths of tubing that I used are given in Table 1.

Harness material was embedded into the package and a nylon cushion was glued to the surface of the back package adjacent to the skin. The cushion minimized abrasion and moisture accumulation. Sponge rubber did not serve this purpose well because of its absorbent qualities and rapid rate of decomposition.

Transmitter Antennas

I used transmitters with either loop or whip antennas depending upon the mounted position of the transmitter and the harness material.

Whip antennas were used on all back package transmitters and loop antennas were used on all breast packages. A combination whip and loop antenna was used on transmitters that had wire harnesses.

The resonant whip antenna gave a stronger signal than the loop antenna when used on transmitters with the same circuitry. Transmitters with the combination whip and loop antennas gave a signal as strong as the whip antenna. This combination was the most sensitive to the bird's movements and gave the best signals for remote interpretation of activities.

Gold or copper-plated steel wire (.006 in diameter or larger) was used for whip antennas. The diameter varied depending on the size of the bird. The optimum antenna length depended on transmitter frequency. The smallest diameter wire was used for tagging birds weighing less than 150 g. The smaller wires minimized the rebounding action to sudden movements by the bird while perched or in flight.

A small spring was embedded into the package at the base of the antenna (Fig. 1). This minimized the chance of the bird breaking the antenna. All birds preened or pulled on the antennas occasionally but none broke off.

The type of loop antenna wire for the breast packages was determined by the harness material (Table 1). The stranded rubber insulated wires that I used were more flexible and of smaller gauge than that used by Nicholls and Warner (1968) and about as efficient.

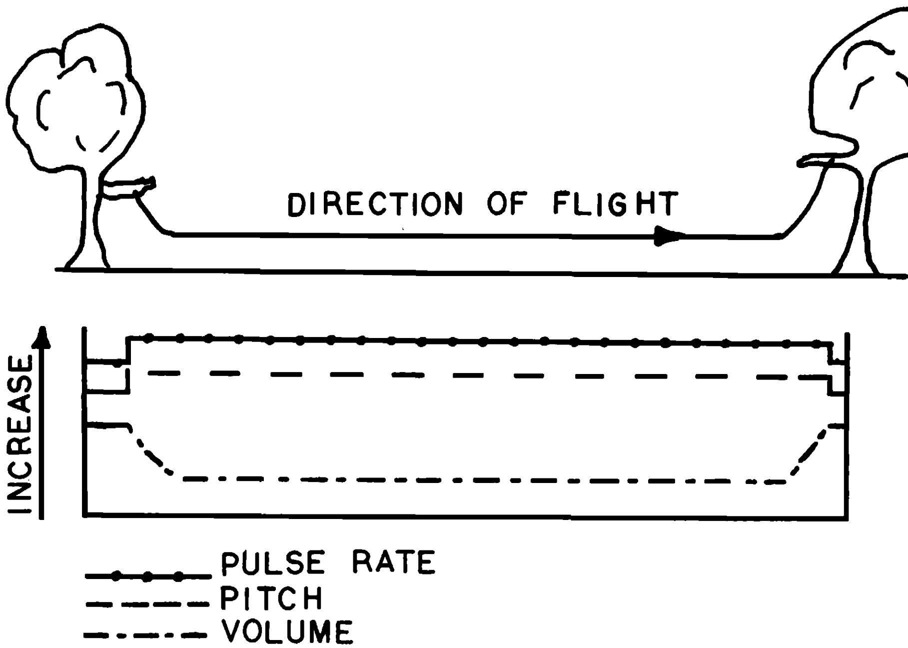


Figure 3. Diagram of flight path of Great Horned Owl and simultaneous signal changes that result from the spreading of the two loop antennas that also serve as a harness. Distance, direction, and speed of flight and location of the bird can be determined remotely by audio signal change. From Dunstan, 1970.

Receiving Systems

I used four different receiving systems that varied in ability to be moved and receiving and directional characteristics. My comments will be based on the use of several Model 11-S Tracking Receivers (AVM Instrument Co.) working above 100 MHz. Changes in signal strength, pulse rate, and frequency detected by the receiver enabled me to determine the occurrence of flight (Fig. 3), preening and feeding from a perch, in addition to orientation to the receiving system. A signal of constant pitch, pulse rate, and frequency indicated that the bird was stationary.

Four receiving systems were used: (1) hand-held portable, (2) temporary fixed station, (3) receiver-equipped ground vehicle, and (4) receiver-equipped aircraft (Fig. 4).

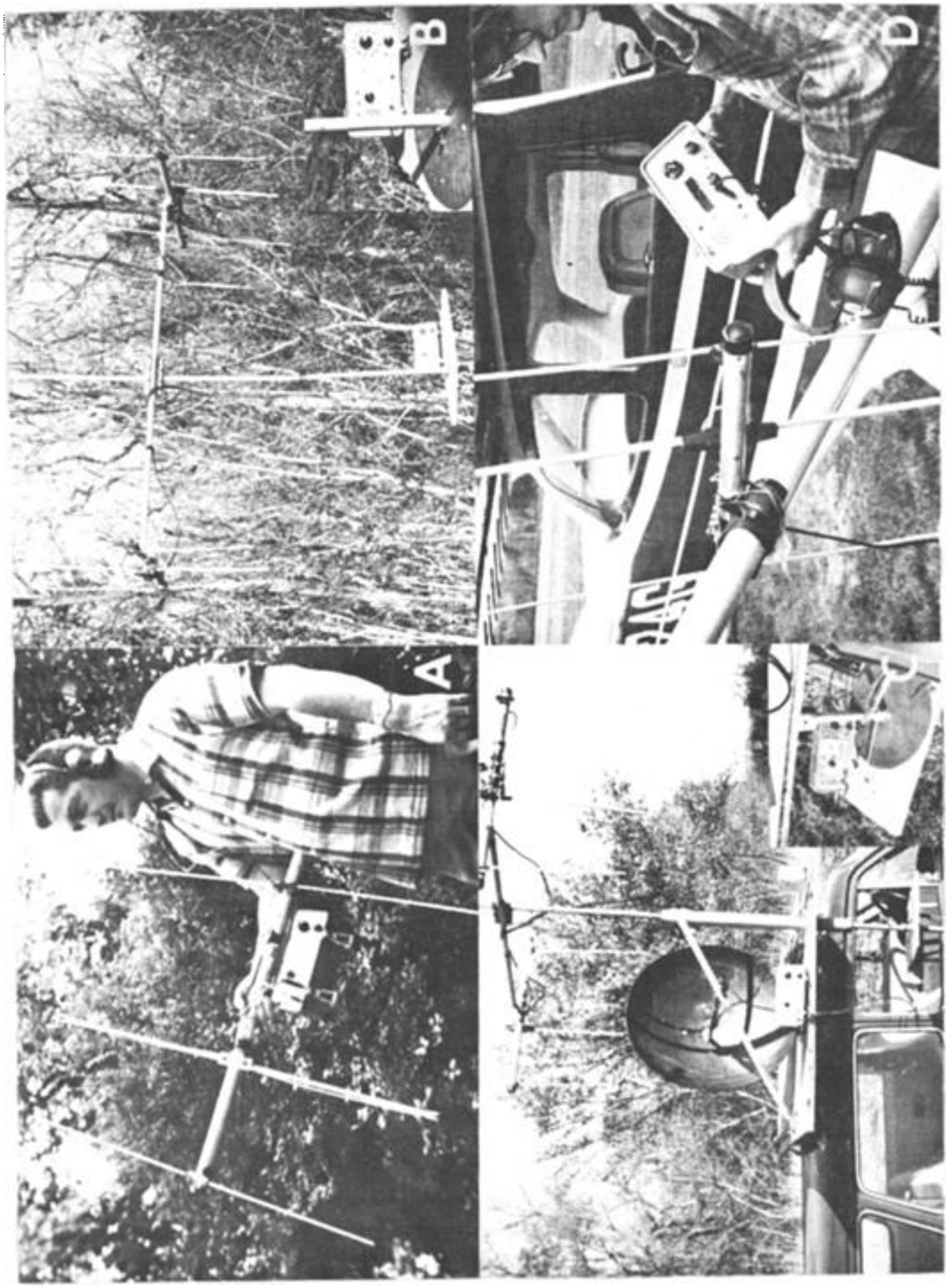
The hand-held system (Fig. 4a) consisted of a receiver and a three-element yagi antenna. This system was used when working from a blind, canoe or boat, or when on foot, and gave the poorest reception and directivity. Birds were detected at distances up to 1½ miles.

The temporary fixed stations (Fig. 4b) had two three-element antennas wired for a signal null or one eight-element antenna. The antennas were supported by vertical masts of various heights. A compass rose and needle were built into the support structure and oriented to true north. Stations were positioned at elevated places around the periphery of the study area. For example stations for Bald Eagles were spaced within two miles of the active nests and antennas were placed on top of tall red or white pine trees (*Pinus resinosa* and *Pinus strobus,* respectively), forest watch towers, and on 40-foot masts positioned on high hills. Readings were taken simultaneously from different stations by a team of field personnel and the locations of birds were determined by plotting two intercepting lines. These fixed stations provided accurate locations and readings were more consistent than those from other systems. Signals were received up to 20 miles.

The receiver-equipped ground vehicle system (Fig. 4c) can be moved more rapidly and provided accuracy of one degree at ¾ mile. Either two three-element yagi antennas wired for a null signal or one 14-foot eight-element yagi was mounted on an automobile. The nulling arrangement was used for monitoring activities of birds within a territory or home range and gave sharper directivity than two yagi antennas wired for a signal peak. The single eight-element antenna was used for tracking high flying birds over long distances and for this purpose was superior in reception and directivity to the double antenna arrangement.

The increased mobility was necessary for following low flying birds such as owls over long distances. Birds flying above tree top level (approximately 80 feet) such as the buteos were easily followed and signals were received at ranges up to 20 miles. Signals from soaring hawks and eagles were good at 15 miles and the rhythm and tightness of the circle flights could be determined by counting the signal peaks per unit time.

A car-top carrier and antenna mounts can be fitted to almost any model of


A
B
C
D

vehicle. A compass rose and needle were attached to the window portion of the automobile and the antenna was turned manually (Fig. 4c).

The receiver-equipped aircraft was used to locate birds out of signal range. Either one or two yagi antennas were mounted on high or low fixed-wing airplanes (Fig. 4d). Occasionally an antenna was held out a window. Double antennas were directed forward and mounted at 30 degrees from vertical (Fig. 4d). When checking over large areas (100 square miles) the antennas were directed at right angles to the airplane. Antennas were wired for maximum signal reception and birds were located by maneuvering the airplane.

Birds nesting or roosting on the ground or hunting low in densely wooded areas or hilly terrain were sometimes difficult to detect without an airplane. Birds roosting within 10 feet of the ground and tagged with transmitters with loop antennas could be detected at a distance up to 12 miles from an airplane flying at an altitude of 2,000 feet. One Bald Eagle tagged with a transmitter with a whip antenna was detected soaring at an altitude of 300 feet. The tracking plane was 38 miles away and flying at an altitude of 2,000 feet. I seldom used an airplane except during the dispersal periods or when trying to locate birds temporarily out of signal range.

Acknowledgments

The author wishes to acknowledge the technical assistance of William W. Cochran during portions of the various radio telemetry studies that I have conducted. Financial support was provided by the Zoology Department of the University of South Dakota, the Department of Biological Sciences of Western Illinois University, the Western Illinois University Research Council, and the Frank M. Chapman Memorial Fund of the American Museum of Natural History. M. Kent Froberg and Steve Sample aided in field work. Byron E. Harrell provided constructive criticism on procedures and techniques during the initial studies on owls. E. Bruce Holmes read and offered constructive criticism of the manuscript.

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Figure on opposite page.

Figure 4. Radio-tracking systems used for raptor studies: (a) hand held system, (b) temporary fixed station, (c) receiver-equipped ground mobile, (d) receiver-equipped aircraft. Insets show compass rose and needle arrangements.

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(Manuscript received April 15, 1972.)