EVALUATION OF IMPLANTED RADIO TRANSMITTERS IN DUCKS

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Radiotelemetry has been used extensively to study free-ranging waterfowl by use of externally mounted radio packs (Patric et al. 1982). Although such mounts (Dwyer 1972) are suitable for many species, they may cause weight loss, feather wear, and abnormal behavior (e.g., Greenwood and Sargeant 1973, Gilmer et al. 1974, Perry 1981). For some species, especially diving ducks, the problems caused by external mounts have outweighed the usefulness of the technique. Perry (1981) described abnormal behavior of canvasbacks (*Aythya valisineria*) fitted with back-mounted transmitters and discussed problems associated with disruption of insulating body feathers caused by the harness. Woakes and Butler (1975) observed that back-mounted transmitters interfered with normal diving behavior in tufted ducks (*A. fuligula*) and pochards

(*A. ferina*). Transmitters attached to nasal saddles caused fewer problems than body-mounts (Perry 1981), but we question the advisability of using nasal mounts on diving ducks that obtain their principal foods by probing for benthic root stalks, tubers, and invertebrates. C. E. Korschgen (unpubl. data) and J. R. Serie (pers. commun.) found that wild canvasbacks released with nasal-mounted transmitters had enlarged nares and abraded and softened mandibles when recaptured. Also, nasal-mounted radios must be small, which greatly restricts the operating life of the transmitter.

Researchers have successfully used intraperitoneal implants on certain fossorial (Smith and Whitney 1977) and semiaquatic mammals (Melquist and Hornocker 1979, Melquist et al. 1981) and on many species of fish (Hart and Summerfelt 1975, Warden and Lorio 1975, Johnsen and Hasler 1977). Abdominal implants have been used in physiological studies of birds (Southwick 1973, Woakes and Butler 1975). This report describes an evaluation conducted in 1982 of radio transmitters that were surgically implanted in the body cavity of captive and wild ducks. Our objectives were (1) to develop surgical procedures that could be used under field conditions to eventually implant radio transmitters in diving ducks and (2) to test the feasibility of using implanted radios in field studies.

METHODS

Telemetry Equipment

The transmitter implants we used were 19-mm diameter cylindrical capsules that varied from 42 to 56 mm in length and weighed 17–23 g. We tested two types, one with an extruding whip antenna and one with an internal coiled antenna. Extruding antennas were 26-gauge teflon-covered wire about 15 cm long and, when implanted, were completely in the abdominal cavity. Internal antennas were coiled on one end of the capsule. Transmitters were powered by a ½ A lithium battery and had an expected operational life of 75–135 days. Each was encapsulated in Minnesota Mining and Manufacturing (3M) Scottcast #5, an electrical resin (use of trade names does not imply U.S. Government endorsement). Receivers were 164-Mhz scanning models and receiving antennas were four-element Yagis. For aerial searches, twin Yagi antennas were mounted on an aircraft as described by Gilmer et al. (1981).

Surgical Procedures

Several anesthetics and modes of injection were tested: intravenous general anesthetic drugs alone (pentabarbitol) and in combination (ketamine hydrochloride [Ketaset: Bristol Laboratories, Syracuse, N.Y.] and xylazine [Rompun: Haver Lockhart, Inc., Shawnee, Kans.]), and a local subcutaneous drug (2% lidocaine hydrochloride [Med Tech, Inc., Elwood, Kans.]). During initial tests birds given local anesthetic in the surgery site exhibited no more muscular response during surgery than birds completely anesthetized. Thereafter, we used local anesthetic only.

Although our implant procedures were not aseptic, efforts were made to minimize gross contamination. Hands were cleaned and surgical gloves were worn. Surgical instruments and transmitters were kept in a cold sterilization tray containing zepharin chloride. Surgical scalpels and blades, 1-cc hypodermic syringes and needles, suture needles, 2-0 chromic gut suture material, scissors, hemostat, forceps, and gauze were used to perform the surgery.

A 70% ethyl alcohol solution was used to soak feathers along the ventral midline. The feathers were then separated to expose the underlying skin. An oval area about 3 × 2 cm between the posterior end of the sternum and the pubic bones was scrubbed twice with zepharin chloride solution and then rinsed with additional alcohol. If feathers still obscured the area of the incision after wetting again with alcohol, they were plucked. A subcutaneous injection of lidocaine hydrochloride was applied around the incision area 10 minutes prior to surgery.

A 2-cm incision was made in the skin layer. The muscle layer was lifted with a forceps before cutting to prevent damage to internal organs. The transmitter was inserted into the right side of the bird's abdominal cavity (away from the ovary in females). The muscle layer and skin were closed separately using standard surgical stitches and knots. A long-acting intramuscular antibiotic was injected into the pectoral muscle to prevent infection. Excluding the 10-minute wait for the anesthesia to take effect, the entire operation took 15 minutes.

Evaluation Procedures

Four groups of birds (A–D) were used in our evaluation. On 22 February 1982, four captive male mallards (*Anas platyrhynchos*) (Group A) were implanted with dummy transmitters of the size, weight, and similar materials of operational transmitters. These birds were given an ad libitum diet of corn and other small grains. They were weighed periodically and sacrificed after 16 days to visually determine their internal response to the surgery and implanted transmitter.

On 18 March, a total of 10 canvasbacks, redheads (*Aythya americana*), game farm mallards, and northern pintails (*Anas acuta*) was implanted with dummy or real transmitters with internal or extruding antennas (Group B). Two additional mallards and two pintails served as controls. All were held in an indoor-outdoor pen as described by Greenwood and Sargeant (1973). Each bird was weighed weekly from 19 March to 21 May 1982.

Female mallards from this group (two with transmitters and two controls) were placed in individual pens with a mate. The two control females mated and began laying, at which time a dummy transmitter was implanted in each. One was allowed to incubate and hatch a clutch of eggs. All birds in Group B were sacrificed to evaluate their body condition and the position of the implanted transmitter.

On 3 August 1982, three male common goldeneye (*Bucephala clangula*) and three male ring-necked (*Aythya collaris*) ducklings (Group C) were captured by nightlighting on a 30-ha pond near Bemidji, Minnesota. These birds were transported to the research laboratory in Bemidji where transmitters with coiled or whip antennas were implanted the following morning. Ramcote paint was applied to cheek patches to facilitate visual identification in the field. The birds, which weighed between 490 and 720 g, were released on the pond 0.5–3.0 hours after completion of surgery. From 5 to 25 August, time budget information was obtained by instantaneous sampling (Altmann 1974) at 15-second intervals during 30-minute sample periods to compare behavior patterns of implanted and unmarked (control) birds. Observations were made from a vehicle using binoculars and an 80× telescope; behavior was classified as foraging, preening, resting, swimming, flying, miscellaneous, or unknown. The control bird selected for each sample period was the individual of the same species and age-class nearest the radio-implanted bird at the start of the sample period. Implant effects were examined using analysis of variance (ANOVA), which was performed by regression analysis with dummy variables. Samples were omitted from the analysis if the total number of data points in the unknown category exceeded 10 for either bird. Prior to analysis, data were converted to percentage of time visible. The ANOVA model used allowed us to test for an overall implant effect, and also individual differences, time period of observation, and the interaction of individuals and time. Aerial searches were conducted to locate birds after they fledged.

During 14–31 October 1982, nine male and two female canvasbacks (Group D) were captured by nightlighting on Lake Onalaska on the Upper Mississippi River near La Crosse, Wisconsin. The birds were implanted the following morning with radios having internal antennas and released on the lake 1.0–3.0 hours later. Aerial searches were conducted twice weekly until most birds had migrated.

RESULTS AND DISCUSSION

Lidocaine hydrochloride was the local anesthetic used in all surgical procedures. Incisions were largely healed within 18 hours following surgery. Autopsies of the captive Groups A and B birds revealed that the transmitters had become encapsulated by fibrous connective tissue and adhered to adjacent viscera, a normal situation.

One male mallard from Group A had a large accumulation of fibrous connective tissue, inflamed tissues, and several pockets of liquid exudates around the transmitter with an internal coiled antenna. A female redhead from Group B developed an infection immediately following surgery and lost weight. It was given a second injection of intramuscular antibody and recovered within 7 days. No other birds showed noticeable external or behavioral reactions to the implants.

The four Group A mallards each gained 40–114 g during the 16 days after surgery. Weights of the 10 Group B birds fluctuated during the testing period but, except for the redhead that developed an infection, changes could not be attributed to the implanted radios. Weights of these birds typically increased during the first week following surgery. All Group A and B birds appeared to be in excellent physical condition when sacrificed.

The four game farm mallard females all produced eggs after being moved to the individual pens. The two females implanted in prebreeding condition produced clutches of normal eggs. Both females implanted during laying laid an egg 1–2 days after surgery. One female's cycle was interrupted for 7 days following its initial egg, but then it resumed daily laying. This may have been a result of placing the implant over the oviduct. It subsequently laid 12 eggs, but 3 of those had deformed shells indicating that the implant was interfering with egg passage. The other female laid eggs daily until it had a complete clutch. It incubated her second clutch, hatched five ducklings, and exhibited normal brooding behavior.

The six Group C wild ducklings exhibited normal swimming and diving behavior immediately following release. They returned to groups of other ducklings of similar age and appeared to maintain normal social relationships throughout the experiment. Occasionally they were observed scratching at their cheeks where paint had been applied. No undue amounts of preening near the incision or signs of discomfort were observed.

On 13 August 1982, four of the ducklings were recaptured by nightlighting, weighed, and released. All appeared to be in good condition. Three had gained 14–48 g, and one (with a whip antenna) had lost 25 g since initial capture.

First observed flights of the ducklings

occurred 9–18 August 1982; all had dispersed from the natal pond by 25 August. Timing of these flights for both species appeared similar to that of unmarked ducklings on the same pond. After dispersing, one common goldeneye was located by aerial search the next day on a large lake 9.7 km south of the natal pond. The following day it had moved again and radio contact was lost. One of the three tagged ring-necked ducks was shot by a hunter on 8 October 1982, 138 km southeast of the natal pond, and one common goldeneye was shot 16 October 1982 16 km south of the natal pond. Both hunters reported that the birds appeared to be normal.

The ANOVA tested a total of 32 and 75 bird-hours of time budget data on common goldeneyes and ring-necked ducks, respectively. No significant differences were found between implanted and control birds for time spent foraging, preening, or resting; behaviors that made up 90–95% of the total time budget. An overall implant effect ($P < 0.05$) was found for time spent swimming because implanted birds swam more than controls; however, little time (<6%) was spent swimming by either group.

Each of the 11 Group D canvasbacks on Lake Onalaska was relocated at least once following release; one was relocated nine times. The birds were located 3–32 days after release and had a mean minimum stay on the lake of 16.5 days. Assuming that the radios continued to transmit, all of the birds migrated from this staging area. Two birds were found about 85 km south of the release site in typical habitat with other canvasbacks.

Transmitters were range-tested by line-of-site observations with hand-held Yagi antennas and portable receivers before and after implanting. Output stages for both transmitter types had been tuned for maximum power with the transmitter outside the bird. Both types were detuned when inserted into the body cavity because of the proximity of body fluids. The performance of transmitters having internal coil antennas varied depending on how tightly the antenna was coiled. Those having loosely coiled antennas (larger size) had greater range. Strong signals were routinely received at 0.8 km from radios having loosely coiled antennas. Weak signals, adequate to determine general direction, were heard up to 1.6 km in flat, open terrain. Transmitters in common goldeneye and ring-necked ducklings having external whip antennas clearly produced the strongest signals prior to implanting. Range of transmitters with extruding external antennas decreased to <0.4 km after implanting. Part of the loss in range was because it was impossible to keep the 15-cm whip fully extended in the bird's abdomen. During aerial tests at an altitude of 300 m, transmitters with loose coil antennas could be routinely heard up to 2.4 km. Transmitters implanted in canvasbacks had a range of 0.4–0.6 km from a boat. At close range (<100 m) the signal could be heard when the birds were diving. Reception from the Mississippi River bluffs exceeded 3.0 km, but the signal was irregular at that distance.

Active or dummy radio transmitters were surgically implanted in 31 birds during this investigation. One captive bird probably would have died due to the surgery had it been in the wild. Seventeen wild birds with implanted radios were capable of flight and migrated from the two study areas. Overall, the implant procedures and transmitter capsules we used appeared to have potential in studies where external-mounted packages may not be appropriate. Surgery can be performed under field conditions in a short time without undue trauma to the birds.

The technique should prove useful in studies of diving ducks or other waterfowl where harnesses may not be appropriate. It may also prove useful in studies of ducklings where, because of growth, harnesses are not suitable. With proper placement, implanted radio transmitters will have little or no effect on laying based on results with game farm mallards. There is also an electronic advantage of implants in that the radio transmitter is in a thermally stable environment. The principal drawback, at present, is that the range of implants is probably 50% less than externally mounted transmitters. Future refinements in transmitter design may increase the range of implants. The possibility also exists of placing implants subcutaneously in the dorsal mantle area of some birds so that the radio will not be transmitting through the body mass.

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