IMPLANTING RADIO TRANSMITTERS IN WINTERING CANVASBACKS

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Abstract: To conduct telemetry studies of wintering canvasbacks (*Aythya valisineria*) on Chesapeake Bay, we needed to devise a suitable method of radio transmitter attachment. We describe an aseptic, intra-abdominal surgical technique, using the inhalation anesthetic isoflurane, to implant 20-g radio transmitters in free-ranging canvasbacks. We evaluated the technique over 3 winters (1987–89), when an annual average of 83 female canvasbacks received implant surgery during a 9-day period in mid-December. Of 253 ducks, 248 (98%) were implanted successfully, and 200 (80.6%) completed the 70-day study until early March. No mortality or abnormal behavior from surgery was identified post-release.

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A conventional back-mounted transmitter (Dwyer 1972) has been used successfully for various species of dabbling ducks (*Anatini*) (e.g., Dwyer et al. 1979, Talent et al. 1982, Ringelman and Longcore 1982, Conroy et al. 1989), but has not been suitable for diving ducks (*Aythyini*). Back-mounted transmitters interfered with diving in tufted ducks (*Aythya fuligula*) and common pochards (*A. ferina*; Woakes and Butler 1975), and caused canvasbacks to behave abnormally (Perry 1981). An alternative neck-collar attachment proved unsuccessful with redheads (*A. americana*; Sorenson 1989).

Implantation of radio transmitters (Korschgen et al. 1984) offers an alternative way to use telemetry with canvasbacks. An internal transmitter does not impair diving, feeding, or flight, and does not disrupt plumage that might affect thermoregulation in winter. More importantly, it offers no surface for ice formation. However, an implanted transmitter must operate over a suitable range without an elevated external antenna, and canvasbacks must demonstrate an ability to undergo and recover from surgery with negligible risk to survival.

We developed an intra-abdominal procedure to implant radio transmitters with aseptic surgical techniques and general anesthesia that complies with animal welfare regulations for major surgical procedures (Animal Welfare Act Public Law 99-198 and 9 CFR Parts 1, 2, and 3); evaluated use of the gaseous anesthetic agent isoflurane on waterfowl; and evaluated physiological and behavioral responses of canvasbacks to the surgical procedure and transmitter implants.

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METHODS

We developed and evaluated surgical techniques and procedures with 10 pen-reared canvasbacks before methods were applied to wild, live-trapped ducks. Wild female canvasbacks were captured at various sites on the upper Chesapeake Bay, Maryland, following Haramis et al. (1982, 1987). Ducks were weighed, banded, and examined at the trap site before they were transported to the veterinary hospital at Patuxent Wildlife Research Center, Laurel, Maryland. Ducks were captured in early morning, transported for implantation surgery in late morning and afternoon, held overnight for recovery, and released to a flock in the same area the following day. Average length of time between capture and release after surgery was 18–24 hours.

We used a 164-MHz implantable transmitter (model IMP/150/L with S5 temperature-sensitive mortality circuit, Telonics Inc., Mesa, AZ 85204; use of manufacturer's name does not imply government endorsement). Each transmitter was powered by a non-venting lithium battery that provided a nominal operational life of 90 days. Each unit was cylindrical in shape (2 cm thick × 5 cm long), had a mass of about 20 g ($\bar{x}$ = 19.6 g, range = 18.1–21.9 g, n = 90), and was coated with biologically inert wax. A temperature-sensitive mortality circuit doubled the

output pulse frequency (from 1 to 2 pulse/sec) when a bird's body temperature dropped below 36 C. Wax-coated magnets were attached by rubber bands to deactivate the transmitters while they underwent a minimum 24-hour disinfectant soaking in chlorhexidine diacetate solution (Nolvasan Solution, Aveco Co., Fort Dodge, IA 50501).

Anesthesia

We used isoflurane (Aerane, Anaquest, Madison, WI 53713), a non-flammable, non-explosive inhalation anesthetic commonly used for dogs, horses, and humans, to induce and maintain surgical anesthesia. Isoflurane was delivered with an Isotec 3 vaporizer (Ohmeda, Madison, WI 53707). A non-rebreathing apparatus was hooked directly to the anesthetic machine and consisted of a hose connected to a 0.5-L bag with a second flexible hose connected to the anesthetic machine. Ducks were mask-induced to a surgical plane of anesthesia using a mask made from a 60-cc syringe case (Monoject Div. of Sherwood Med., St. Louis, MO 63103). The closed end of the case was cut to fit snugly over the end of the hose from the Ayer's T-piece on the non-rebreathing apparatus. The open end was modified with Microform surgical tape (3M Co., Med.-Surgical Div., St. Paul, MN 55144) to cushion the plastic and to make an opening just large enough to receive the duck's bill.

Anesthesia was delivered at a flow rate of 4% isoflurane in an oxygen flow of 800–1,000 cc/minute. Induction typically lasted 1–3 minutes. We frequently observed a period of voluntary apnea shortly after the duck first inhaled the anesthetic mixture. Following mask induction, ducks were intubated with 3.6-mm Murphy endotracheal tubes. We maintained anesthesia with a 2–2.5% flow rate of isoflurane and the same oxygen rate as during induction. Recovery to consciousness and sternal recumbancy ensued within 2–4 minutes after cessation of anesthetic agent. Oxygen flow rate during recovery remained 800–1,000 cc/minute until the duck started to wake, at which time the endotracheal tube was removed. Ducks were hand held until fully recovered and subsequently placed with other post-surgical ducks in poultry crates.

Surgical Procedure

We positioned each canvasback on its back while anesthetized, and centered the surgical site on the ventral midline midway between the caudal end of the sternum and the pelvis. Contour and down feathers were removed from an area 2.5 cm along the ventral midline and 0.5 cm wide to expose the skin. Preliminary surgeries indicated that no more than 0.5 cm width of feathers be removed so that adjacent plumage met over the surgical site and protected it from exposure to cold water after release of the duck. Adjacent feathers were held away from the surgical site by adhesive tape.

We soaked the entire surgical area, including adhesive tape, with a 1% povidone–iodine solution (Betadine solution, The Purdue Frederick Co., Norwalk, CT 06856). During initial testing of antiseptics with penned canvasbacks, we used various conventional surgical soaps that resulted in loss of water repellency of the plumage. Such soaps contained surfactants that acted as wetting agents. When placed in water, ducks treated with these soaps became wet and were at risk of exposure. Therefore, we avoided surgical soaps, scrubs, or other materials containing surfactant agents.

We covered the surgical site with a suitable disposable surgical drape large enough to cover the duck and adjacent surgical table, and held it in place with Bakhaus towel clamps (surgical instruments were steam autoclaved prior to surgery). A skin incision was made along the ventral midline, starting 2 cm caudal to the synsternum and extending for 5 cm using a number 15 blade in a number 3 Bard Parker scalpel handle. Subcutaneous tissues and fat were dissected using Metzenbaum scissors. The peritoneum was tented using Adson tissue forceps and then incised with the scalpel. Tenting, or pulling up on the peritoneum prior to making the incision, prevented accidental cutting of underlying organs in the abdominal cavity. Hemorrhage from these incisions was controlled by clamping smaller (<1 mm diameter) vessels with mosquito forceps. Larger vessels (>1 mm diameter) were clamped and then ligated with absorbable polyglycolic acid suture (No. 5217-3, 4-O Dexon Plus, Davis and Geck, Div. of Am. Cyanamid Co., Danbury, CT 06810).

Next, the abdominal incision was spread using gloved fingers and the intestines were manually pushed aside to create a space for the transmitter dorsally and to the right of the ventriculus. During preliminary surgeries, we found this site to be preferred over more ventral locations where the transmitter would be in contact with, and cause a subsequent irritation of, the liver. Also,

during preliminary surgeries, we found the dorsal location, adjacent to the ventriculus, provided a stable implant location. Therefore, it was not necessary to suture the implant in place. Placing the transmitter next to the ventriculus not only provided a stable implant away from the liver, but also prevented the transmitter from lying directly under the incision. We selected this site for all subsequent surgeries on canvasbacks.

The transmitter was removed from cold sterilization and activated by removal of the wax-coated magnet. After transmitter operation was verified, the transmitter was rinsed (using sterile water or physiological saline) and inserted into the abdominal cavity. Tissues moved aside to expose the implant site were repositioned after placement of the transmitter. The surgical site was closed with a 3-layer closure technique (Hoffer and Jensen 1973:58), using Adson tissue forceps and an Olsen-Hegar needle holder. Absorbable polyglycolic acid suture was used for all layers. First, the abdominal fascia and peritoneum were sutured with a simple interrupted suture pattern. Second, the subcutaneous tissue was closed with a simple interrupted or simple continuous pattern, depending upon the extent of the involved tissue. Third, the skin was closed with a simple interrupted pattern. All birds were given postoperative, subcutaneous fluid injections (2.5% dextrose and 0.45% NaCl) in the axial area equal to 5% of body mass. These injections served to replace body fluid lost during surgery and prevent dehydration. Tape placed adjacent to the incision was removed after surgery, while it was still moist. Once the transmitter warmed to the duck's body temperature, we made a final check of transmitter operation to verify deactivation of the mortality circuit, i.e., that the output pulse rate of the unit returned from 2 to 1 pulse/second. Occasionally, when a spent transmitter needed to be retrieved from the abdomen, we used Allis tissue forceps to grasp and hold the unit. However, because the Allis tissue forceps would pit the surface of the transmitter, neither this instrument nor any other was used to grasp the transmitter when doing the implant procedure.

RESULTS

During 3 years, 253 canvasbacks received surgery and 98% were successfully implanted and released to the wild. Five ducks (2%) died during or immediately following surgery. Of these 5, 1 duck died from excessive hemorrhage in the airways, and 1 death was attributed to lung congestion. Three ducks died from respiratory complications caused by lung flukes (*Typhocoelum cucumerinum*).

Immediately after release, transmitter-marked canvasbacks joined wild flocks and were observed to exhibit normal behavior including swimming, diving, resting, preening, and daily crepuscular flights to and from nighttime foraging and diurnal roosting sites. Daily flights of some transmitter-marked ducks were documented as far as 40 km. During the mild winters of 1987 and 1988, only 1 transmitter-marked canvasback continued migration from the upper Chesapeake Bay south to Pamlico Sound, North Carolina. During the severe winter of December 1989, at least 9 transmitter-marked ducks migrated to Virginia or North Carolina within 10 days after release, a maximum distance of 420 km. During spring migration in March 1989, an aerial reconnaissance flight located 2 transmitter-marked canvasbacks at Long Point, Ontario, on Lake Erie (515 km from Chesapeake Bay), and a third duck was located at Lake St. Clair near Detroit, Michigan (640 km from the Bay).

During trapping in December 1988 and 1989, 13 canvasbacks that had previously been implanted during the study were recaptured. Nine of these ducks had been carrying a transmitter for 1 year, and 4, for 2 years. The transmitters of these 13 ducks were surgically removed and the ducks released. Except for a thin layer of mesentery tissue that was attached to some of the transmitters, no apparent changes had occurred at the site of implant nor was there any movement of the implants since placement.

For the combined 3-year study, 80.6% of released ducks (200/248) successfully completed the 10-week monitoring period. Whereas no surgery-related mortalities could be identified at anytime during the study, such losses might account for a portion of the 15.3% of losses tallied under "deaths of unknown cause" and "lost" categories (Table 1).

DISCUSSION

The ultimate cause of death of the 2 ducks dying from hemorrhage in the airways and from lung congestion is unknown, but might be related to trauma during capture or subsequent handling. For the 3 ducks dying from respiratory complications caused by lung flukes, we believe the anesthetic agent may have caused

Table 1. Disposition of transmitter-marked canvasbacks implanted in December and tracked over 3 70-day winter study periods on Chesapeake Bay, 1987–89.

Yr	Implanted *n*	Completed study *n*	Deaths: Cause known	Deaths: Cause unknown	Lost[a]
1987	78	65	2	3	8
1988	87	75	4	3	5
1989	83	60	4	1	18
Total	248	200	10	7	31
%	100	80.6	4.0	2.8	12.5

[a] Disposition unknown.

the flukes to detach from their normal location along the walls of the bronchi and subsequently to block air passages. Our knowledge of canvasback behavior, radio performance, and the timing of losses in relation to weather events and hunting season, suggests that the majority of losses during the study were related to emigration and hunting, and not to surgery-related death, predation, or transmitter failure.

Whereas the surgical procedure and radio implant had negligible effect on behavior and survival of wintering canvasbacks, there were disadvantages due to the limited range of the transmitter (5–11 km from an aircraft flying at 300 m), the time it took to perform the surgery (about 25 min/duck), and the overnight, post-surgery holding period. Use of general anesthesia was critical to efficient surgical operations, and isoflurane seemed ideal in being rapid in both induction and recovery and having no detectable side effects on canvasbacks. The technique holds promise for field study of birds that adapt poorly to external radio packages. Surgery need not be performed in a veterinary hospital, if a mobile surgical unit that meets aseptic standards is set up in the field. Anesthesia machines and oxygen tanks are readily portable to remote field locations. Proper ventilation of the designated surgery room is required to minimize human exposure, especially when using a non-rebreathing anesthetic apparatus. General anesthesia and aseptic techniques for major surgical procedures, such as abdominal radio-transmitter implants, are required under current animal welfare regulations.

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